Essays on consumption behaviour related to health and retirement

Submitted by

Rodrigo Lluberas

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Declaration

I, Rodrigo Lluberas, hereby declare that Chapter 1, 2 and 3 of this thesis are entirely my own research work. Part II (Chapter 4, Appendix A and Appendix B) is based on research conducted in collaboration with Prof. Rachel Griffith and Dr. Melanie Luhrmann. My contribution to the joint work has been in preparing the data for analysis, performing the first step of the imputation procedure, writing parts of the paper and participating in discussions to exchange research ideas. Where I have consulted the work of others, this is always clearly stated.

Signed...(Rodrigo Lluberas)
Date:

To Carla Maria and Tomasito

Abstract

This dissertation is concerned with the empirical study of households' decisions on consumption and time use over the life-cycle. The first chapter presents evidence on the role of shocks around the time of retirement as a potential explanation of the retirement-consumption puzzle. We address this issue by studying how expenditure of households in different quartiles of the pre-retirement wealth distribution behaves around the time of retirement and how this is related to health shocks.

In the next chapter we focus on consumption over the life-cycle and show how different consumption patterns between workers and pensioners translates into different inflation experiences. We first document the expenditure life-cycle profile in the UK and show how differences in the consumption bundle of pensioners and workers translates into different inflation experiences. In the second part of the chapter we estimate cost of living indexes for pensioners and workers in order to better understand pension income requirements. We estimate a demand system and compute the change in the cost of living and the substitution effect for both pensioners and workers for the period 1990-2009.

The last chapter focuses on household decisions related to food consumption and the use of time. Using a combination of food diary data and information on its nutritional content, we compile a unique time series of microdata on calorie and food purchases in England spanning over more than 30 years. We measure calories from food at home purchases over the whole time series, but using a combination of observed and imputed data, are also able to fill the gap of knowledge about calories from other foods and drinks: eating out and alcohol. In addition to this, we also show data on bodyweight, calorie purchases and calories expended in different activities.

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Chapter 1

Introduction

The focus topics of this dissertation are consumption and time use. Across three self-contained chapters I empirically study British households' decisions on consumption and time use over the life-cycle. The thesis is divided in two parts. In the first part of the dissertation, comprised of two chapters, I focus on the latest stages of the life-cycle and study consumption at and during retirement. The second part focuses on food consumption and time use and studies the long term evolution of diets and physical activity in England.

Part I: Consumption, health and retirement

Chapter 2, titled *"Consumption at Retirement: The Role of Health Shocks"*, presents evidence on the role of shocks around the time of retirement as a potential explanation of the retirement-consumption puzzle. The drop in consumption at retirement has been largely studied in the empirical literature and has been labeled as the retirement-consumption puzzle. There is consent in the empirical literature on the drop of consumption at the time of retirement but there is still no agreement about the explanation of the puzzle. In this chapter we contribute to the literature by showing how the drop in consumption at the time of retirement is associated with health shocks and low savings.

In theory, the effect of shocks on consumption depends on the persistence of the shock, the completeness of the markets and the timing of the shock. Households that accumulated substantial wealth relative to future income - i.e prudent households - are more likely to be able to smooth consumption after a shock than those that accumulated a low stock of assets. If that is the case, we should expect a drop in consumption as a reaction to shocks around the time of retirement among households with low accumulated wealth while no effect among more prudent households who accumulated a large stock of assets.

A first contribution of this study is to present empirical evidence of the expenditure behaviour around retirement in the UK not only of food but of total non-durable expenditures. Previous studies for the UK have shown evidence of a reduction in food spending at retirement [1]; in this paper we use an imputation procedure and provide an analysis of a broader measure of non-durable expenditures. A second contribution is that we analyze the effect of retirement taking into account the potential heterogeneity in the expenditure behaviour according to the position of the household in the wealth distribution. It could be the case that, on average, individuals smooth their consumption at retirement but a substantial proportion of the population, due to low private savings have to reduce their spending while experiencing shocks around retirement. We address this issue by studying how expenditure of households in different quartiles of the pre-retirement wealth distribution behaves around the time of retirement and how this is related to health shocks.

We exploit the rich set of household wealth and health condition questions in the English Longitudinal Study of Ageing (ELSA) and assess whether households with different levels of private savings react differently to shocks at the time of retirement. First, we find a diverse reaction of individuals' expenditure immediately after retirement when controlling for pre-retirement accumulated wealth. Agents in the lowest quartile of the wealth distribution decrease their non-durable expenditure while those in the highest wealth quartile are able to smooth consumption when retiring. Indeed, while non-durable expenditures do not react to retirement for the second, third and fourth wealth quartiles, we find that the transition to retirement is associated with a decrease in non-durable expenditures for those in the lowest quartile. Moreover, in line with the predictions from the theory, we found that those in the first wealth quartile that experienced a health shock decline their consumption by almost 13% at the time of retirement while we found no evidence of a decline in consumption for the rest of the groups. This suggests lack of insurance against shocks around retirement for a siezable proportion of the population.

An open question is why there is such heterogeneity in the stock of accumulated assets. There are several explanations for this. Wealth at the time of retirement is likely to be correlated with lifetime income. Then, those who arrive to retirement with a low accumulated stock of assets are those that had a low level of income through their working life. Second,

[1] See Banks et al. (1998) and Smith (2006).

low wealth could be explained by the number and level of persistence of negative shocks during the time previous to retirement. Finally, low wealth could also be associated with ill-planning. A relatively new strand of studies (Bozio et al. (2011), Banks et al. (2010), Lusardi and Mitchell (2007), Ameriks et al. (2003) among others) have studied the role of numerical and cognitive ability and financial literacy in explaining the propensity to plan and if the latter is associated with retirement preparedness. A better understanding of wealth accumulation and retirement preparedness is key as the responsibility of retirement resources moves towards the individuals.

Chapter 2 focuses on the latest stages of the life-cycle and studies consumption at retirement. In Chapter 3, titled *"Life-cycle Expenditure and Retirees' Cost of Living"*, we focus on consumption over the life-cycle and show how different consumption patterns between workers and pensioners translates into different inflation experiences.

How do we measure changes in the cost of living? In general, governments and statistical agencies use consumer price indexes as measures of the true cost of living. Price indexes measure the proportional change in the cost of buying a fixed basket of goods as prices change. It is implicitly assumed that consumers do not modify their behaviour when experiencing price changes and thus price indexes as measures of the cost of living suffer from the so called "substitution bias". When prices change, consumers could substitute away from the goods that have become relatively more expensive and shift their consumption towards goods that have become relatively cheaper. A true economic cost of living index measures the cost of maintaining a given utility or welfare level after a change in prices. A second aspect to consider is whether price indexes are representative of specific segments of the population. By construction, price indexes aim to represent the average consumer in the economy and not necessarily are representative of segments of the population. This is important because Social security benefits and State pension are usually adjusted by the change in a representative price index, but is the a price index an accurate measure of the cost of living of pensioners?

In order to address these questions we first document the expenditure life-cycle profile in the UK and show how differences in the consumption bundle of pensioners and workers translates into different inflation experiences during the period 1987-2009. We show that there are differences in the consumption bundle of pensioners and workers and that results in different inflation experiences. Albeit substantial differences in given years, the inflation experienced by the two groups is not significantly different over a long time period.

In the second part of the chapter we estimate cost of living indexes for pensioners and workers in order to better understand pension income requirements. Using expenditure microdata from the UK, we estimate an Exact Affine Stone Index (EASI)implicit Marshallian demand system and compute the change in the cost of living and the substitution effect for both pensioners and workers for the period 1990-2009. According to our results, not considering the substitution effect amounts to an error in the measure of the average cost of living of between -0.01 (or -0.30%) - estimated in 1995 - and 0.38 (or 11.0%) percentage points - in 2008. This masks some differences between workers and pensioners substitution behaviour, which is closely related with the differences in own and cross price elasticities of the two groups of consumers. Although we do not find important differences over the long run, there are major differences in terms of cost of living between pensioners and workers in given years.

Finally, we show how pension income would evolve during the period 1990-2009 under three alternative indexation measures: headline inflation - measured by the Retail Price Index (RPI) -, household specific inflation and cost of living estimated from the demand system. At least during the period 1990-2009, adjusting pension income by the RPI results in a higher income than adjusting by the cost of living index or household inflation.

Part II: Diets and physical activity in England

Part II of the dissertation, comprised of Chapter 4 *"Gluttony or Sloth?: Long-run Changes in Bodyweight, Diet and Activity"*, focuses on household decisions related to food consumption and the use of time.

There has been a marked increase in bodyweight and the rates of obesity and overweight in the UK during the last three decades. Over 25% of adults are obese and over 60% are overweight in the UK. So far the literature has focused on excess calorie consumption and less importance has been given to changes in time use and physical activity over time. A first contribution of this study is using a combination of food diary data and information on its nutritional content, we compile a unique time series of microdata on calorie and food purchases in England spanning over more than 30 years. The second unique feature of our data compilation is that we measure calories from food at home purchases over the whole time series, but are also able to fill the gap of knowledge about calories from other foods and drinks: eating out and alcohol. Using a combination of observed and imputed data, we are able to fill the gap of knowledge about calories from alcohol and from eating out. In addition to this detailed household-level data on food and calorie purchases, we also jointly document data on bodyweight, calorie purchases and calories expended in different activities exploiting various data sources.

We estimate a decline in calorie purchases of between 39 and 22% over the last three decades. Moreover, we find that calories from food at home represent about 80% of calorie purchases, calories from eating out a further 17% and calories from alcohol the remaining 3%. We estimate a decrease of calories from alcohol and an increase of calories from eating out. Our results point to an increase in calories from eating out of 34% between 1980 and 1990, a subsequently stagnation at around 1,000 calories per household per day between 1990 and 2000 and a sharp decline since 2001. The overall decline in calories is due to the reduction in calories from food consumed at home. We provide evidence that diets have become less calorie dense over time, with an increase in the proportion of calories from fruit and vegetables, cereals and other foods, and a decrease in the calorie-dense fats and sugary products.

We also show that concurrently with this decline in overall calorie purchases, time use and the strenuousness of daily activities has changed in important ways. Together with these changes in diets we observe dramatic changes in the time use and the strenuousness of daily activities. We compute gender-age specific means of time use and strenuousness for each sample year for three physical activities: i) work, ii) housework, and iii) leisure, and show also evidence of changes in time use for sleeping and traveling. We show that there has been large changes in patterns of work, in labour force participation, hours of work and the strenuousness of work that result in changes in energy spend at work. Due to the combination of constant employment, a small decline in the number of hours worked and a large drop in the strenuousness of work energy spend at work declined substantially for men. For women, on the other hand, a large increase in employment and hours of work together with a small decline in the strenuousness of work result in an increase in energy burnt at work. We then provide evidence of changes in time use that point to an increase in time devoted to sedentary activities. Indeed, a common pattern between men and women is the shift from leisure to sleeping time and a dramatic increase in time watching TV. We also show increases in time devoted to sports and exercise, but the average is still very low.

Our aim is not to suggest that food is not a problem but to point out that physical activity, defined broadly as energy burnt in all daily activities, is also part of the explanation of the increase in bodyweight in England over the last 30 years.

Part I

Consumption, health and retirement

Chapter 2

Consumption at retirement: the role of health shocks

2.1 Introduction

In this paper we study how consumption reacts to unanticipated shocks around the time of retirement. Recent changes in pension provision in developed countries transferred risks from firms and governments to employees. Among the risks that the workers face and would like to insure against are: inadequacy of retirement income to maintain pre-retirement living standards, social security cuts, longevity, poor health, poor performance of pre-retirement investments and inflation risk. Employer provided pension provision beyond Social Security could be seen as an insurance mechanism to mitigate retirement income risks (Bodie (1990)). A second mechanism to self-insure against those risks is through private savings.

The drop in consumption at retirement has been largely studied in the empirical literature and has been labeled as the retirement-consumption puzzle. There is consent in the empirical literature on the drop of consumption at the time of retirement but there is still no agreement in the explanation of the puzzle. Among the suggested explanations are: insufficient accumulated wealth or less than expected retirement income, increase in home production, unexpected shocks around retirement (illness, redundancy, among others) that force earlier than expected retirement, increase of leisure time and the association of the decrease in consumption with the reduction of work related expenses.

In a separate path, a growing literature [1] uses data on income and consumption to

[1] See Meghir and Pistaferri (2011) for a survey of the literature.

better understand the risk faced by households and to assess to what extent they are insured against income shocks. The idea is that households with substantial precautionary wealth are more able to smooth consumption when faced to income shocks than households with low levels of wealth relative to future income.

This paper links the two literatures: the retirement consumption-puzzle literature and the income risk and insurance literature. We study shocks around the time of retirement and assess to what extent the drop in consumption at retirement documented in the literature is associated with lack of insurance against risks. Theoretically, the effect of shocks on consumption depends on the persistence of the shock, the completeness of the markets and the timing of the shock. Households that accumulated substantial wealth relative to future income - i.e prudent households - are more likely to be able to smooth consumption in the presence of shocks than those that accumulated a low stock of assets relative to future income. Then, we should expect to observe a drop in consumption as a reaction to shocks around the time of retirement among households with low accumulated wealth while no effect among more prudent households who accumulated a large stock of assets.

A first contribution of this study is to use longitudinal data of the expenditure behaviour around retirement in the UK not only of food but of total non-durable expenditure. Previous studies for the UK have either use cross-sectional data on total non-durable expenditure (Banks et al. (1998)) or longitudinal data on food spending (Smith (2006)); in this paper we use an imputation procedure and provide an analysis of a broader measure of non-durable expenditures by exploiting the longitudinal dimension of the English Longitudinal Study of Ageing (ELSA). A second contribution is that we analyze the effect of shocks around retirement taking into account the potential heterogeneity in the expenditure behaviour according to the position of the household in the wealth distribution. It could be the case that, on average, individuals smooth their consumption at retirement but a substantial proportion of the population, due to low private savings have to reduce their spending while experiencing shocks around retirement. We address this issue by studying how the expenditure pattern of households in different quartiles of the pre-retirement wealth distribution differs around the time of retirement and how this is related to health shocks.

We exploit the rich set of household wealth and health condition questions in the ELSA and assess whether households with different levels of private savings react differently to shocks at the time of retirement. First, we find a diverse reaction of individuals' expenditure immediately after retirement when controlling for pre-retirement accumulated wealth. Agents in the lowest quartile of the wealth distribution decrease their non-durable expenditure while those in the highest wealth quartile are able to smooth consumption when retiring. Indeed, while non-durable expenditure do not react to retirement for the second, third and fourth wealth quartiles, we find that the transition to retirement is associated with a decrease in non-durable expenditure for those in the lowest quartile. Moreover, in line with the predictions from the theory, we found that those in the first wealth quartile that experienced a health shock decline their consumption by almost 13% at the time of retirement while we found no evidence of a decline in consumption for the rest of the groups. This suggests lack of insurance against shocks around retirement for a siezable proportion of the population.

The chapter is organized as follows. Section 2.2 presents a discussion of existing literature on the topic and stresses the major contributions of this study. Section 2.3 is structured in three subsections. First, the data used in the empirical analysis is introduced together with a descriptive analysis of the different pattern of consumption between workers and retirees. In the third subsection we study the effect of retirement on consumption and how this is associated with private savings and shocks around retirement. We present robustness checks in section 2.4. Finally, section 2.5 concludes.

2.2 Literature Review

Since Hall (1978) seminal work, consumption over the life cycle has been an active topic of research among applied micro and macro economists. In the simple version of the life cycle-permanent income model, perfect forward-looking agents chose consumption in order to maximize their utility subject to their lifetime budget constraint. As a result, households smooth their consumption over their lives in order to maintain a constant marginal utility of consumption in each time period. Without restrictions to borrow and lend and in the absence of uncertainty, consumption in a given period is not determined by current income but by lifetime or permanent income [2].

Contrary to the life cycle-permanent income hypothesis, a number of empirical studies found that consumption drops at retirement. The documented fall in consumption at retirement has been labeled as the retirement-consumption puzzle. This finding is independent of the country and the empirical strategy adopted. A number of possible explanations have been given for the retirement-consumption puzzle. Banks et al. (1998) suggest that the fall

[2] See Deaton (1992) for a detailed theoretical and empirical analysis of consumption.

in consumption not explained by the non-separability between consumption and leisure may be accounted for unexpected shocks around retirement, among them: less than expected pension income and health shocks. Smith (2006) uses a sample of UK households and finds that food expenditure experience a significant drop only when retirement is involuntary, either due to redundancy or illness, suggesting that unexpected early retirement implies a shock to household wealth and, in consequence, a reduction in consumption.

The topic has been studied in more detail in the US. In a pioneer study, Hamermesh (1984) finds that households' accumulated wealth is insufficient to maintain their pre-retirement standard of living. The typical reaction to the insufficient resources is the reduction of consumption at the time of retirement. More recently, Bernheim et al. (2001) study food consumption for a sample of US households and find that there is a correlation in wealth-income replacement and the decrease of consumption at the time of retirement. Their estimations suggest that less wealth and income replacement implies a greater reduction in consumption. Both Hamermesh (1984) and Bernheim et al. (2001) findings imply that households arrive to retirement with insufficient resources to meet their needs, challenging the life cycle-permanent income hypothesis that agents are forward looking. On contrary, Hurd and Rohwedder (2006) find that less than half of the retirees included in their sample suffers a fall of consumption at retirement and that the reduction is anticipated by almost two thirds of workers. They suggest a mix of explanations to the drop of consumption at retirement: the presence of health shocks that induce an early retirement, the reduction of work related expenses and the increase of leisure time. In a recent paper, using panel data on non-durable spending, Hurd and Rohwedder (2013) find that the drop in consumption at retirement is between 1% and 6%, depending on the measure considered. They use data from the HRS supplemented with data from the Consumption and Activities Mail Survey (CAMS) and find substantial heterogeneity in spending change, both across the wealth distribution but also across different planning horizons and health status of the respondent. In a regression framework, though, and consistent with our results, they find that wealth quartile per se is not important in explaining the drop in consumption but whether health was an important reason for retirement and the planning horizon of the respondent.

Using micro data for Italy, Miniaci et al. (2010) find similar results as those found for the UK and the US. Indeed, the authors find that consumption decreases at retirement and they associate that reduction with a decrease in work related expenses and the increase in home production. The focus of the study is in the substitution of consumer expenses by home production to partly explain the drop in consumption at retirement. Consistent with these findings, Battistin et al. (2009) estimate a 9.8 percent drop in non-durables consumption at retirement and a larger decrease (14.1 percent) in food expenditure. They use micro data for Italy and identify the effect of retirement on consumption using a regression discontinuity approach that exploits the exogeneity of retirement eligibility. As Miniaci et al. (2010), the authors conclude that the drop of consumption at retirement could be explained by the reduction in work-related expenditures and the increase in home production. Borella et al. (ming) looks at the retirement-consumption puzzle by using information on the expected retirement age to distinguish between expected and unexpected retirement. They find a 4% drop in non-durable consumption at retirement. When adding wealth to the empirical model they find that unexpected retirement behaves as a negative shock for household with limited assets. In that sense, they find a 9% drop in consumption at the time of retirement among households that retire unexpected and have wealth below the median.

The case of Germany is studied by Schwerdt (2005) and Lührmann (2010). Using data from the German Socio-Economic Panel and indirectly measuring consumption by using data from income and savings, Schwerdt (2005) finds a drop in consumption at retirement of 8.5 percent. The author also finds heterogeneity in the effect of retirement on consumption across individuals; while high replacement rates are associated with a 10 percent increase in consumption, low replacement rates are associated with a drop of just above 30 percent. In a similar line, using the German Expenditure survey Lührmann (2010) finds a similar reduction in consumption as for the US, the UK and Italy and argues that a proportion of this reduction may be compensated by an increase in home production.

Finally, using household panel data for Spain, Luengo-Prado and Sevilla (2013) find that there is no drop of consumption at retirement when looking at total non-durable expenditure and a decline for work related categories. After separating their sample in two time periods they find that food expenditure declines at retirement in the period 1998 to 2004. They justify this finding showing that households do more shopping and pay lower prices at retirement, which is consistent with the hypothesis of a substitution between market and non-market time at retirement.

A first attempt to reconcile the theory and the empirical evidence is Blau (2008). First, the author shows using a simple theoretical model that consumption does not decline at the time of retirement if retirement is expected and it drops if it is caused by an unexpected event. Second, Blau develops a life cycle model of consumption with uncertainty about the time of retirement and calibrates the model using Health and Retirement Study data for the US. The model suggests that the causal effect of retirement on consumption is zero. The calibration of the model accounts for a small proportion of consumption fall at retirement and leaves a substantial fraction of the drop unexplained. The idea behind a life cycle model of consumption with uncertainty is that consumption may change as a result of new information about lifetime income. Thus, the retirement date may be seen as the realization of new information about lifetime income and thus consumption fall could be seen as the household behaviour adjustment to this new information.

Hurst (2008) presents a complete survey of the empirical evidence highlighting five points that have been studied in the literature and in which he states there is some consensus. First, there is consensus that expenditure in certain categories of goods decline at the time of retirement. As already noted this is an empirical fact and is independent of the country of origin of the study and the empirical strategy adopted.

A second point highlighted by the author is that the drop of expenditure at retirement has been documented within two categories of goods: those that are work related, such as clothing and transportation, and food. Expenditures in work-related commodities are likely to be reduced as individuals transit from work to retirement but the decline in food spending could be seen as a puzzle. Until recent years, due to the lack of data on broad measures of consumption, the literature has focused its attention on food expenditure. Though, more recent literature has studied the effect of retirement on different types of commodities. For example, Aguiar and Hurst (2013) study expenditure along the life-cycle defining a broad measure of non-durable expenditure as the aggregate of spending on food at home, food away from home, transportation, clothing, personal care, housing services, utilities, entertainment, domestic services, charitable giving, alcohol, tobacco, gambling and business services. They find substantial heterogeneity in the expenditure behaviour of the different commodities and argue that the declining pattern of expenditures after middle age is driven by spending on work-related goods and food. In that sense, they state that the "categories that exhibit declining expenditures during the peak retirement years (60-68) are the same categories that exhibit declining expenditures over the second half of the life cycle". They justify the reduction in clothing and transportation spending due to their complementarity with work and the reduction in food expenditure by the increase in home production. Along this idea, Fisher et al. (2008) use data from the US Consumer Expenditure Survey (CES) and find that the reduction in consumption at the time of retirement depends on the definition of consumption used in the analysis.

A third point raised by Hurst (2008), is that food consumption does not actually decline at retirement, what is actually found is a reduction in food expenditure. In a well known study, Aguiar and Hurst (2005) claim for the distinction between consumption and expenditure and using data on food intake show that "neither the quantity nor the quality of food intake deteriorates with retirement status". Thus, they argue that even though food expenditure declines at retirement there is no evidence of a decline in food consumption. The reduction in food expenditure is justified by an increase in home production associated with a rise in the "time spent shopping and preparing meals".

Fourth, there is not only heterogeneity in the expenditure behaviour across different type of goods but also there is substantial heterogeneity in the effect of retirement on expenditure across different individuals. In particular, there is evidence that individuals with low accumulated wealth previous to retirement suffer from a larger decline in expenditure after retirement. Even though it seems that a large proportion of individuals smooth their consumption at the time of retirement, the lowest group's expenditure behaviour can not be explained by the permanent income hypothesis. This may suggest that some households are financially ill-prepared for retirement. Evidence on the heterogeneity of expenditure behaviour with contrary findings is documented by Bernheim et al. (2001) and Scholz et al. (2006).

Finally, Hurst (2008) states that individuals that reduce their consumption at retirement are mostly those who suffer negative shocks around the time of retirement and retire involuntarily. Involuntary retirement is associated with health shocks but also with redundancies around the time of retirement and the impossibility of finding a new job. In either case, involuntary retirement is associated with a negative shock to wealth or lifetime resources, possibly due to lower than expected pension income and the impossibility of insuring against income falls. Evidence on this particular fact was found by Smith (2006) for the UK and by Hausman and Paquette (1987) for the US.

In sum, there is consensus in the empirical literature on the drop of consumption at the time of retirement. Though, there is still no agreement in the explanation of the puzzle. Among the suggested explanations to the consumption-retirement puzzle are: insufficient accumulated wealth or less than expected retirement income, increase of home production, unexpected shocks around retirement (illness, redundancy, etc) that force earlier than expected retirement, increase of leisure time and the association of the decrease in consumption with the reduction of work related expenses.

A first contribution of this study is to present empirical evidence - using longitudinal data - of the expenditure behaviour around retirement in the UK not only of food but of total non-durable expenditure. Previous studies for the UK have shown evidence of a reduction in food spending at retirement using longitudinal data (Smith (2006)) and a reduction of total non-durable expenditure using cross-sectional data (Banks et al. (1998)); in this paper we use an imputation procedure and provide an longitudinal analysis of a broader measure of non-durable expenditures. A second contribution is that we analyze the effect of retirement taking into account the potential heterogeneity in the expenditure behaviour according to the position of the household in the wealth distribution. It could be the case that, on average, individuals smooth their consumption at retirement but a substantial proportion of the population, due to low private savings have to reduce their spending while experiencing shocks around retirement. We address this issue by studying how expenditure of households in different quartiles of the pre-retirement wealth distribution behaves around the time of retirement and how this is related to health shocks.

2.3 Empirical Evidence

2.3.1 Data

In this section we present empirical evidence of the change in non-durable expenditure at retirement. The analysis is based on data from two sources: the English Longitudinal Study of Ageing (ELSA)[3] and the Expenditure and Food Survey (EFS) [4].

ELSA is a multidisciplinary survey whose aim is to allow the study of older people in England in terms of health, retirement, work, wealth, income, pensions and many other aspects of ageing. We use data from the first four waves of the survey: a first one with data collected between March 2002 and March 2003, a second wave with information collected between June 2004 and July 2005, a third wave collected between May 2006 and August 2007 and a fourth wave collected between May 2008 and July 2009.

There are many advantages of working with ELSA database. First, as it is a longitudinal panel it allows us to track individuals over time. Second, it has a rich set of questions regarding retirement, particularly in terms of pension coverage and reasons for retirement. Third, the questionnaire also digs into household wealth. Finally, the survey has a rich set of questions on subjective measures, both of health status and retirement expectations.

[3] Marmot (2013).

[4] In 2008, the Expenditure and Food Survey (EFS) became the Living Costs and Food Survey (LCF). We will use the acronym EFS to refer indistinctly to the Expenditure and Food Survey (previous to 2008) and the Living Costs and Food Survey (for 2008 onwards).

The goal of using the EFS is to be able to estimate total expenditure instead of focusing only in particular components of non-durable household expenditure. Empirical evidence using longitudinal data so far has been focused on non-durables and particularly in food expenditure. We make use of an imputation procedure (Skinner 1987) that allows us to impute total expenditure from EFS in the ELSA sample [5]. Following Attanasio and Weber (1995) we define total non-durable expenditure as the sum of expenditures in food at home, food away from home, alcohol and tobacco, clothing and footwear, transports, communications, recreation, housing services and miscellaneous. The imputation procedure implicitly assumes that the relationship between food at home and food out and total expenditure remains constant through retirement. The changes in the relationship between food expenditure - both at home and out - and total expenditure across the life-cyle are captured by age dummies. This could be problematic if retirement affects the composition of the consumption basket independently than through age, a similar problem that arises when using age as an instrumental variable for retirement. See Appendix for a detailed description of the imputation procedure. All expenditure variables are reported in real terms and were deflated using the corresponding Consumer Price Index from the Office for National Statistics. Table 2.18 in the Appendix reports the deflators used in each year.

Exploiting the longitudinal dimension of ELSA we are going to focus our analysis on the change in consumption during the transition from work to retirement. The initial sample contains 7,096 households. From this initial sample we construct an unbalanced panel with households whose head is observed either working in all the waves of the survey or observed working and then retired. We eliminate from the sample head of households that are observed always being sick or unemployed, always retired or those who transit from retirement back to work or directly from being sick and unemployed to retirement. After eliminating households with missing demographic characteristics, the final sample contains 2,231 households, of which 591 are observed transiting from work to retirement.

We define a household as being working if the head of household considers himself as being either employed or self-employed, while we consider households as being retired if the head self-reported work status is retired or semi-retired. The exact wording of the question is: “Which one of these would you say best describes your current situation?”. Being the answering options: Retired, Employed, Self-employed, Unemployed, Permanently sick or disabled and Looking after home or family. Respondents are also allowed to give an

[5] A similar approach was followed by Bernheim et al. (2001)

spontaneous answer; being Semi-retired one of the most common.

Net wealth is defined as households' total non-housing net wealth [6], which is the sum of net financial and net physical wealth. Net financial wealth is computed as the net of debts sum of household holdings in savings accounts, current accounts, Individual Savings Accounts (ISA), Tax Exempt Special Savings Accounts (TESSA), Personal Equity Plans (PEP), stocks, share options, shares, bonds, gilts and other investments. Net physical wealth is the sum of the value of farm or business properties, value of any businesses, value of second home or other property and the value of other physical assets.

2.3.2 Econometric Analysis: Do retirees spend less than workers?

In this section we study in more detail the change of consumption as individuals transit from work to retirement by exploiting the longitudinal dimension of the ELSA database. We present a dynamic analysis of expenditure focusing on the difference between retirees and workers. We calculate expenditure changes between consecutive waves of the survey and relate these changes to changes in the labour market status of the respondent as well as to shocks around the time of retirement.

Preliminary evidence

In order to asses the effect of retirement on the change in log non-durable expenditure, we need to control for individual and household characteristics. We start our analysis focusing on the transition from working to retirement and assuming that the retirement decision is uncorrelated with any shock that is not controlled for by the inclusion of a set of demographic regressors and the change in the subjective health status. Following Banks et al. (1998), we can express consumption growth as a function of demographic variables aiming to capture heterogeneity in the household discount rates, risk aversion and taste shifters. Then, we first estimate:

$$\triangle ln(C_{it}) = \boldsymbol{\gamma}\mathbf{X}_{it} + \boldsymbol{\phi}\triangle\mathbf{H}_{it} + \beta\triangle r_{it} + \mu_t + \epsilon_{it} \tag{2.1}$$

Where $\triangle ln(C_{it}) = ln(C_{it}) - ln(C_{it-1})$, is the change in log non-durable expenditure of individual i at time t, r_{it} is a dummy variable that takes the value 1 if the respondent is

[6] For the computation of the net wealth quartiles we use the Financial Derived Variables databases available at the UK Economic and Social Data-service: www.esds.ac.uk. See the web-page for a detailed description of the questions used for the computation of the different variables.

retired at time t and 0 if the respondent is working, then, $\triangle r_{it} = r_{it} - r_{it-1} = 1$ captures the transition from working to retirement [7]. Note that we are contrasting the change in expenditure only of workers and retirees and are not considering respondents with other labour market status. We include two set of demographic controls. First, $\mathbf{H}_{it}$ is a vector of individual and household characteristics affecting the level of consumption; among them household size and self-reported health status. A second set of demographic controls, $\mathbf{X}_{it}$, aim to capture differences in the consumption profile. For this, we include: age, age squared, marital status (single male, single female and couple) and the level of education (degree or above, some college education and no qualifications at all) of the household head. Finally, we control for aggregate shocks to individual consumption by including a set of time dummies (μ_t).

Results are summarized in Table 2.1.

Table 2.1: *Pooled OLS Regression of Change in Log Non-Durable Expenditure*

	Non-Durables
$\triangle r_{it}$	-0.017 *(0.008)*
Demographic, Health and Time Controls	Yes
R^2	0.3547
No. Obs	4,106

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses. Regressions also include age, age squared, gender, marital status, change in household size, change in self-reported health status, level of education and time dummy variables.

We find that households reduce their consumption in the transition from work to retirement: the coefficient associated with retiring is -0.017 and statistically significant. We also find that the increase in household size results in a temporary raise in consumption growth, that consumption growth decreases with age and being single and no statistical differences

[7] Respondents that report being retired and subsequently go back to work are not considered in the sample. In other words, we never observe $\triangle r_{it} = -1$ in our final sample. Note that we still consider those respondents in the transition from work to retirement but are not considered at the time they return back to work. Only 39 respondents are observed transiting from work to retirement and then back to work.

according to change in self reported health status or level of education[8].

These results are consistent with early evidence (Banks et al. (1998), Bernheim et al. (2001), Smith (2006), among others) and suggest that on average households are not able to smooth their consumption as they enter retirement. If retirement is anticipated and there are no shocks around the time of retirement, these results are against the predictions of the life-cycle theory in the sense that changes in consumption should be associated only with unexpected changes in life-time wealth. A second explanation for this finding, which is explored in the next section, is that individuals have different experiences in their transition to retirement. While the majority of people do not experience a drop of consumption at retirement, there is a non-negligible fraction of workers who are forced to retire earlier than planned experiencing a negative shock to their lifetime wealth and thus suffering a reduction in consumption at the time of retirement. We will explore this hypothesis by analyzing the heterogeneity in the consumption response to retirement according to the respondent's position in the pre-retirement wealth distribution [9].

Shocks around retirement

The focus of the analysis in this section is on unexpected shocks around the time of retirement. In order to give theoretical background to our empirical analysis, assume an agent maximizing a time-separable utility function subject to a budget constraint [10]. Let y_t be non-financial income - either pension or labour income - , c_t consumption and $\delta_t = \frac{1}{(1+r_t)(1+r_{t-1})...(1+r_2)}$ discount factors with $\delta_1 = 1$ and $t = 2, ..., T$, being T the time of death assumed to be known by the agent. Assume that at each point in time the agent can invest in a single asset, A_t, that yields a real return r_t. Then, the lifetime wealth - or current assets plus the present value of the expected future income - of an agent at time t, W_t, can be expressed as:

$$W_t = A_{t-1}(1 + r_t) + \delta_t^{-1}\mathbb{E}_t\left[\sum_{i=t}^{T}\delta_i y_i\right] \qquad (2.2)$$

[8]Results are reported in Table 2.12 in the Appendix

[9]We only look at discrete changes of consumption at the time of retirement but it could be the case that there is a gradual adjustment. Consumption drops on average 5% at the time of retirement, 2% the following period and 0.1% two periods after retirement. A period in this case is defined as the survey wave, with a wave every two years. This suggests that most of the adjustment in consumption during retirement is in the period immediately after retirement.

[10]The discussion is based on Deaton and Muellbauer (1980)

Assuming that returns on assets are paid at the beginning of each period, at each point in time the agent's budget constraint is given by,

$$A_{t-1} = (1 + r_{t-1})A_{t-2} + y_{t-1} - c_{t-1} \tag{2.3}$$

Which combined with the wealth equation (2.2) and after some algebra [11] gives:

$$W_t = (1 + r_t)\left[W_{t-1} - c_{t-1}\right] + \delta_t^{-1}\left\{\mathbb{E}_t\left[\sum_{i=t}^{T}\delta_i y_i\right] - \mathbb{E}_{t-1}\left[\sum_{i=t}^{T}\delta_i y_i\right]\right\} \tag{2.4}$$

Assume for simplicity that the agent consumes each period a constant fraction α of her lifetime wealth, $c_t = \alpha W_t$, then, we can express equation (2.4) as:

$$c_t = (1 + r_t)(1 - \alpha)c_{t-1} + \alpha\delta_t^{-1}\left\{\mathbb{E}_t\left[\sum_{i=t}^{T}\delta_i y_i\right] - \mathbb{E}_{t-1}\left[\sum_{i=t}^{T}\delta_i y_i\right]\right\} \tag{2.5}$$

The last term of equation 2.5 represents unanticipated changes in income expectations. Thus, consumption can be affected not only due to changes in preferences or interest rates, but also due to unforeseen revisions in income expectations. Particularly in the case of the transition from working to retirement, a lower than expected pension income - which is equivalent to an unanticipated permanent income shock - results in a downgrade in lifetime wealth and subsequently in a reduction of consumption. The lower than expected pension income could be due to an earlier than planned retirement as a result of, for instance, health problems or redundancy, or directly due to errors in the process of planning for retirement.

We are going to analyze empirically the relevance of unanticipated shocks at retirement by exploiting the longitudinal dimension of the ELSA data and the rich set of questions about retirement and wealth holdings.

Shocks and Household Wealth

Despite suffering negative shocks, households would be able to smooth consumption at retirement if they had sufficient accumulated pre-retirement wealth. Indeed, previous stud-

[11] Note that plugging the budget constraint in the wealth equation gives: $W_t = (1 + r_t)\left[(1 + r_{t-1})A_{t-2} + y_{t-1} - c_{t-1}\right] + \delta_t^{-1}\mathbb{E}_t\left[\sum_{i=t}^{T}\delta_i y_i\right]$. Given that $W_{t-1} = A_{t-2}(1 + r_{t-1}) + \delta_{t-1}^{-1}\mathbb{E}_{t-1}\left[\sum_{i=t-1}^{T}\delta_i y_i\right]$ can be expressed as $W_{t-1} = A_{t-2}(1 + r_{t-1}) + y_{t-1} + \delta_t^{-1}\mathbb{E}_{t-1}\left[\sum_{i=t}^{T}\delta_i y_i\right]$ it follows expression (2.4).

ies found substantial heterogeneity in the effect of retirement on expenditure according to household wealth [12]. Thus, even though on average retirees smooth their spending, a great proportion of them - i.e. those in the lower quartiles of the wealth distribution - substantially reduce their expenditure at the time of retirement.

Wealth distribution

Taking into account that there is no consensus in the literature regarding what definition of wealth to use [13], we will focus our analysis on total non-housing wealth but provide similar results for net financial wealth in the Appendix.

Net wealth is defined as households' total non-housing net wealth, which is the sum of net financial and net physical wealth. Net financial wealth is computed as the net of debts sum of household holdings in savings accounts, current accounts, Individual Savings Accounts (ISA), Tax Exempt Special Savings Accounts (TESSA), Personal Equity Plans (PEP), stocks, share options, shares, bonds, gilts and other investments. Net physical wealth is the sum of the value of farm or business properties, value of any businesses, value of second home or other property and the value of other physical assets. Note that we do not include pension wealth in our definition. It could be the case that the low net wealth is associated with high pension wealth. In our sample, net wealth is positively correlated with pension wealth [14].

Wealth is usually more concentrated than income. While wealth Gini coefficient is 0.80, household income Gini coefficient is 0.49. Average wealth is equal to GBP 123,288 and median wealth amounts to GBP 2,456. Table 2.2 shows average wealth by decile, the corresponding share in total wealth and the wealth to income ratio. A non-negligible proportion of households arrive to older age with low or even negative private wealth. Not only average wealth is negative for the lowest wealth decile but also represents less than 1 year of income for deciles 2 to 5. In other words, half of the population aged between 50 and 80 have accumulated wealth, apart from pension wealth, that is not enough to cover 1 year of income.

[12] See Hurst (2008) for a general survey of the literature and Bernheim et al. (2001) for an application using US data.

[13] While Poterba et al. (1996) consider financial assets when analyzing household private savings prior to retirement, Engen et al. (1996) consider total wealth.

[14] A simple OLS regression of net wealth on pension wealth results in a statistically significant coefficient of 0.47. Moreover, while average pension wealth is £131,320 for the lowest wealth quartile it is £256,108 for the top wealth quartile.

Table 2.2: *Wealth distribution*

Decile	Mean wealth and share			Wealth-income ratio
	Mean (in £)	Share	Cum. share	
Lowest	-7,235	-0.6%	-0.6%	-0.26
2nd	346	0.0%	-0.6%	0.02
3rd	4,166	0.3%	-0.2%	0.2
4th	10,499	0.8%	0.6%	0.4
5th	20,040	1.6%	2.2%	0.8
6th	34,182	2.8%	5.0%	1.1
7th	55,696	4.5%	9.5%	1.8
8th	90,826	7.4%	16.9%	2.9
9th	171,102	13.8%	30.8%	4.1
Top	854,951	69.2%	100%	16.8

Notes: Data were obtained from the English Longitudinal Study of Ageing (ELSA).

Consumption and wealth

Theoretically, the effect of shocks on consumption depends on the persistence of the shock, the completeness of the markets and the timing of the shock. Households that accumulated substantial wealth relative to future income - i.e prudent households - are more likely to be able to smooth consumption in the presence of shocks than those that accumulated a low stock of assets relative to future income [15]. Then, we should expect to observe a drop in consumption as a reaction to shocks around the time of retirement among households with low accumulated wealth while no effect among more prudent households who accumulated a large stock of assets.

Table 2.3 shows the average change in log non-durable expenditure between consecutive waves by respondent labour status and position in the wealth distribution. $Work-Retired$ refers to individuals working at time $t-1$ and retired at t, or $\triangle r_{it} = 1$, while $Work-Work$ refers to those working in the two consecutive waves, or $\triangle r_{it} = 0$. We found a statistically significant difference in the mean percentage change in consumption between

[15]See Blundell et al. (2008) and Meghir and Pistaferri (2011) for a detailed discussion of the effect of permanent and transitory shocks.

Table 2.3: *Change in Non-durable Consumption According to Change in Labour Status and Wealth*

	All	Wealth Quartiles 1st	2nd	3rd	4th
Work-Retired	-5.0%	-7.5%	-5.0%	-4.9%	-3.4%
	(0.008)	*(0.021)*	*(0.016)*	*(0.017)*	*(0.015)*
Work-Work	-2.8%	-2.5%	-2.7%	-2.8%	-3.3%
	(0.004)	*(0.008)*	*(0.007)*	*(0.006)*	*(0.007)*
p-value of difference in means	0.0505	0.0324	0.1970	0.2280	0.9493

Notes: The table shows the average change in log expenditure according to respondent's labour status. Data were obtained from the English Longitudinal Study of Ageing (ELSA). Standard errors are reported in parenthesis.

those who retired between waves and those who stayed at work in both waves. While those who transition from work to retirement experience a 4.8 percent decline in non-durable expenditure, the figure is 2.8 percent for those who remain working. When looking at the different quartiles, it is clear that the result is driven by households in the lowest quartile of the wealth distribution. Indeed, while those in the lowest quartile who retired between waves reduce their consumption by just above 7 percent, the reduction in consumption is between 3.4 and 5 percent for those in the second, third and fourth wealth quartiles. It is worth noting that there are no significant differences across wealth quartiles in the change in log consumption among those who worked in subsequent waves.

Thus, it seems that respondents in the lowest quartile of the wealth distribution are not able to smooth consumption as they transit from work to retirement. In order to capture the heterogeneity in expenditure changes across wealth quartiles, we estimate the following consumption growth model:

$$\triangle ln(C_{it}) = \boldsymbol{\gamma}\mathbf{X}_{it} + \boldsymbol{\phi}\triangle\mathbf{H}_{it} + \sum_{j=1}^{4}\beta_j\delta_i^j\triangle r_{it} + \mu_t + \epsilon_{it} \tag{2.6}$$

Where $\{\delta^j\}_{j=1}^4$ is a set of dummy variables that takes the value 1 if respondent's net wealth at $t-1$ corresponds to the j quartile of the sample net wealth distribution and 0 otherwise. The rest of the variables are defined as before.

Note that the benchmark is the (log) change in consumption of those that worked in the two consecutive waves. Estimation results are summarized in Table 2.4. We find substantial heterogeneity in the change of non-durable spending at the time of retirement, particularly between the 1st wealth quartile group of retirees and the rest. While non-durable expenditure do not react to retirement for the second, third and fourth wealth quartiles, we find that the transition to retirement is associated with a drop in non-durable expenditure for the lowest wealth group.

Thus, the effect of retirement on non-durable expenditure depends on household wealth, with a large consumption discontinuity for those in the lowest quartile and no significant effect for the wealthier respondents. This result is consistent with evidence found by Bernheim et al. (2001) for the US and in line with the theoretical argument; those in the lowest wealth quartile are not able to self-insure against negative shocks around the time of retirement.

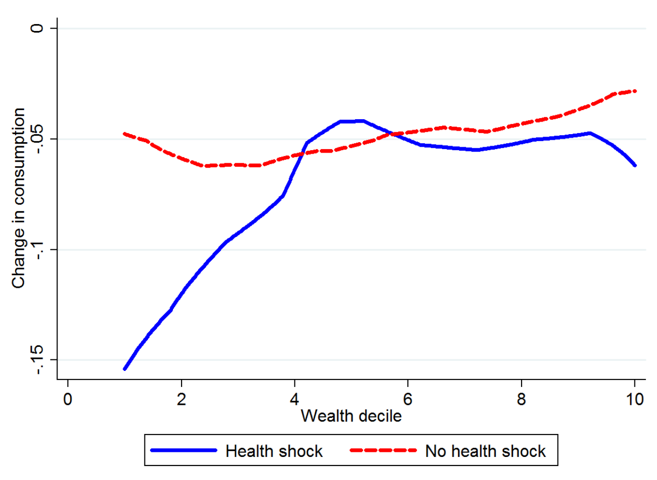
Table 2.4: *Change in Log Non-Durable Expenditure by Wealth Quartile*

	Non-Durables
1st Quartile	-0.038
($j = 1$)	*(0.019)*
2nd Quartile	-0.018
($j = 2$)	*(0.015)*
3rd Quartile	-0.020
($j = 3$)	*(0.014)*
4th Quartile	-0.002
($j = 4$)	*(0.012)*
Demographic, Health and Time Controls	Yes
R^2	0.3551
No. Obs	4,106

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses. Regressions also include age, age squared, gender, marital status, change in household size, change in self-reported health status, level of education and time dummy variables.

Besides the increase in home production, so far the literature has explained the consumption-retirement puzzle by considering early than expected retirement (Smith (2006)) and het-

Figure 2.1: *Consumption growth, wealth and health shocks*



erogeneity in the change of consumption at retirement according to the position of the household in the wealth distribution (Bernheim et al. (2001)). Following Smith (2006), we show in the Appendix that involuntary retirement is associated with a drop of consumption which can be explained by lower than expected lifetime wealth; retirement can be seen as the arrival of new information and the consumption drop as a reaction to it. But, is the drop of consumption among those that accumulated little stock of assets associated with shocks around the time of retirement? If that is the case we should observe a discontinuity in consumption only for those in the lowest quartiles of the wealth distribution that suffer shocks around the time of retirement. We consider health shocks around retirement (see below for definition) controlling for the position of the household in the wealth distribution.

Figure 2.1 shows consumption change between t and $t-1$ for those working at time $t-1$ and retired at t. We split respondents by those that experienced a health shock in the period previous to retirement and those that did not. Respondents that suffered a health shock previous to retirement and are in the lowest deciles of the wealth distribution reduce their consumption by between 10 and 15% while there are no statistical significant differences between those that experienced a health shock and those that did not in deciles 3 and above.

With the inclusion of health shocks around retirement we estimate the following consumption growth model:

$$\triangle ln(C_{it}) = \boldsymbol{\gamma}\mathbf{X}_{it} + \boldsymbol{\phi}\triangle\mathbf{H}_{it} + h_{it}\left[\sum_{j=1}^{4}\beta_j\delta_i^j\triangle r_{it}\right] + nh_{it}\left[\sum_{j=1}^{4}\alpha_j\delta_i^j\triangle r_{it}\right] + \mu_t + \epsilon_{it} \quad (2.7)$$

Where h_{it} is a dummy variable that takes the value 1 if the respondent experienced a health shock between $t-1$ and t, and 0 otherwise; and nh_{it} is a dummy variable that takes the value 1 if the respondent had no health problems between $t-1$ and t, and 0 otherwise. We consider as health problems: (i) chronic diseases such as lung disease, asthma, arthritis, osteoporosis, cancer or malignant tumor, Parkinson's disease, emotional, nervous or psychiatric problems, Alzheimer's disease, dementia, senility or any serious memory impairment, (ii) stroke or cerebral vascular disease, (iii) heart attack and (iv) any long-standing illness, disability or infirmity that limits work. Then, we consider that a respondent experience a health shock is she reports having any of the these health problems between $t-1$ and t. In other words, if a respondent is diagnosed having, for instance, cancer between $t-1$ and t we say that the respondent experienced a health shock. Note that we only consider new diagnosed health problems as health shocks[16].

If the theoretical argument is correct, our estimate of β_1 should be negative and statistical significant while we should not obtain any significant estimates for the rest of coefficients - i.e β_2, β_3 and β_4 as well as α_1,α_2, α_3 and α_4. Looking at Table 2.5, we can notice that retiring is associated with a drop in consumption only for those in the lowest wealth quartile that suffered a health shock. Indeed, those in the first wealth quartile that experienced a health shock decline their consumption by almost 13% at the time of retirement. Also notice that we find no evidence of a decline in consumption for the rest of the groups.

Yet, it is hard to interpret this finding. It could be that those in the lowest wealth quartile are bad planners and thus not well prepared for retirement when experiencing a shock. The reason why health shocks matter in this case is because it prevents them from continuing working. Another potential explanation is that low wealth levels are sign of a severe health shock that caused the respondent to retire earlier than planned. Under this interpretation, households plan their retirement but they are subject to shocks that affect their consumption. We do not attempt to answer this important question in this paper but distinguishing between these two interpretations is important from a policy perspective and

[16]It could be the case that retirement with low wealth causes poor health. We show below as a robustness check that health shocks are distributed evenly across the wealth distribution suggesting that health shocks at old age are not correlated with wealth.

Table 2.5: *Health Shocks and Change in Consumption at Retirement (by Wealth Quartile)*

	No Health Shock (α_j)	**Health Shock (β_j)**
1st Quartile	-0.020	-0.128
($j = 1$)	*(0.019)*	*(0.051)*
2nd Quartile	-0.019	-0.007
($j = 2$)	*(0.016)*	*(0.040)*
3rd Quartile	-0.023	-0.001
($j = 3$)	*(0.015)*	*(0.044)*
4th Quartile	0.003	-0.054
($j = 4$)	*(0.012)*	*(0.050)*
Demographic, Health and Time Controls	Yes	
R^2	0.3564	
No. Obs	4,106	

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses. Regressions also include age, age squared, gender, marital status, change in household size, change in self-reported health status, level of education and time dummy variables.

is subject of future research.

2.4 Robustness checks

Intrahousehold risk-sharing

It could be the case that consumption smoothing at retirement among households in the top deciles of the wealth distribution is the consequence of risk-sharing within the household. As a consequence of a health shock to the head of the household the partner could either increase the number of working hours or, if already retired from the labour market could return either in a part or full time basis.

We can check for this possibility by observing the head of household partner labour market status before and after the head of household retirement. Of the 587 respondents observed working at time $t-1$ and retired at time t, 33 partners that were not working at $t-1$, are observed working at time t . Due to the low number of observations we can not study differences across wealth quartiles but we can asses whether the fact that the partner returns to the labour market acts as an insurance mechanisms and results in households smoothing consumption at the time of retirement of the head of the household. For the sample of households that transit from work to retirement, we regress the change in consumption on the covariates described above and a dummy variable that takes the value 1 if the partner was either not working or retired at time $t-1$ and is working at time t. We find no evidence of intrahousehold risk-sharing via partner labour supply: the coefficient on the partner change in working status is -0.03 and statistical not significant (standard error equal to 0.023). Results are summarized in the Appendix.

Health shocks and wealth

According to the literature, health problems are correlated with income and wealth and, as expected, health deteriorates with age (Deaton and Paxson (1998)). What is surprising is that at certain age - 60 in Deaton and Paxson' study - the negative correlation between health and income diminishes. Income is certainly positively correlated with life expectancy (Rogot et al. (1992)). Assuming income and wealth are highly correlated we should expect to see a correlation between health status and wealth, at least until certain age.

First, prevalence of health problems at any point in life are highly correlated with wealth. Table 2.6 shows the percentage of respondents with health problems at any point during their life and the percentage with health problems between interview periods. There is a negative correlation between wealth and health problems at any point in time; while 54.1% of those in the lowest wealth quartile suffer a health problem during their life time only 28.5% in the top wealth quartile have health problems. Second, we find no statistical significant differences in terms of health problems at old age across wealth quartiles. Health shocks at old age are distributed across the whole range of the wealth distribution.

Summary of Results

Table 2.7 summarizes our results. We started by studying the effect of retirement on consumption and found that retirement is associated with a 1.7% decrease in non-durable expenditure. This result is consistent with Banks et al. (1998) who find a 3% drop in total non-durable expenditure at the time of retirement. We argued that this decline is explained by the decline in consumption only for those that enter retirement unexpectedly. Indeed, while those who retire involuntarily decrease their expenditure by 7.5% we found no decline among those that enter retirement as planned. The magnitude of the decline is marginally lower to that found by Smith (2006). While we find a decline of 7.5% in non-durable

Table 2.6: *Health and wealth*

	Health problem at any point	**Health problem in old age**
1st Quartile	54.1%	10.1%
	[52.4% : 55.8%]	[9.0% : 11.1%]
2nd Quartile	40.6%	10.4%
	[38.7% : 42.4%]	[9.3% : 11.5%]
3rd Quartile	36.1.%	10.3%
	[34.4% : 37.8%]	[9.2% : 11.4%]
4th Quartile	28.5%	8.8%
	[26.8% : 30.1%]	[7.8% : 9.9%]

Notes: 95% confidence level intervals are shown in parenthesis.

expenditure among those that retire involuntarily, Smith (2006) finds a 10% drop in food expenditure. This difference might be explained not only because we are considering total non-durable expenditure instead of food but also because of the definition of voluntary vs. involuntary retirement used in the two studies. The lower decline in total spending relative to food spending has also been found by Battistin et al. (2009) using data for Italy. They find that while non-durable expenditure declines by 9.8% at the time of retirement, food expenditure decreases by 14.1%.

Then, we analyzed how the change in consumption at retirement varies across pre-retirement accumulated wealth. We found that only those in the lowest quartile decrease their consumption at the time of retiring. While those with low stocks of assets decline their consumption by almost 4%, households in the higher quartiles smooth their consumption at retirement. Finally, in order to understand the heterogeneity in the consumption response to retirement we analyze the role of health shocks. We found that households with low private savings that experienced health shocks previous to retirement decrease their consumption by 13% while no change was found for the rest of the households.

2.5 Conclusion

The effect of retirement on consumption has been widely studied in the empirical literature. The proximity of a massive retirement of baby boomers in the US together with substantial changes in the pension provision to current workers are major changes that stress the need of a better understanding of retirees' financial preparedness.

Table 2.7: *Summary of Results*

		Non-Durables
Work-Retired		-0.017
		(0.008)
Voluntary		-0.014
		(0.008)
Involuntary		-0.075
		(0.029)
1st Quartile		-0.038
		(0.019)
2nd Quartile		-0.018
		(0.015)
3rd Quartile		-0.020
		(0.014)
4th Quartile		-0.002
		(0.012)
Health Shock	1st Quartile	-0.128
		(0.051)
	2nd Quartile	-0.007
		(0.040)
	3rd Quartile	-0.001
		(0.044)
	4th Quartile	-0.054
		(0.050)
No Health Shock	1st Quartile	-0.020
		(0.019)
	2nd Quartile	-0.019
		(0.016)
	3rd Quartile	-0.023
		(0.015)
	4th Quartile	0.003
		(0.012)

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses. Regressions also include age, age squared, gender, marital status, change in household size, change in self-reported health status, level of education and time dummy variables.

We addressed this matter focusing on two issues raised by Hurst (2008). A first contribution of this study is to present empirical evidence of the expenditure behaviour around retirement in the UK not only of food at home but of total non-durables; in this paper we use an imputation procedure and provide an analysis of a broader measure of non-durable expenditure. A second contribution is that we analyze the effect of retirement taking into account the potential heterogeneity in the expenditure behaviour according to the position of the household in the wealth distribution. It could be the case that, on average, individuals smooth their consumption at retirement but a substantial proportion of the population, due to low private savings have to reduce their spending while experiencing shocks around retirement. We address this issue by studying how expenditure of households in different quartiles of the pre-retirement wealth distribution behaves around the time of retirement and how this is related to health shocks.

First, we analyze the change in spending at the transit from work to retirement. Consistent with previous literature we found evidence of a decrease in expenditure immediately after retirement. Secondly, we find that involuntary retirement is associated with a decrease in expenditure. This is consistent with the idea that involuntary retirement is associated with a reduction of expenditure due to a negative shocks to wealth or lifetime resources, possibly due to a lower than expected pension income. This is consistent with the life cycle model augmented by considering uncertainty about the time of retirement; earlier than expected retirement is associated with a negative shock to lifetime income and thus with a reduction in expenditure. Moreover, we found that those who retire voluntarily smooth their consumption at the time of retirement.

Third, we exploit the rich set of household wealth and health condition questions in ELSA and assess whether households with different levels of private savings react differently to shocks at the time of retirement. First, we find a diverse reaction of individuals' expenditure immediately after retirement when controlling for pre-retirement accumulated wealth. Agents in the lowest quartile of the wealth distribution decrease their non-durable expenditure while those in the highest wealth quartile are able to smooth consumption when retiring. Indeed, while non-durable expenditure do not react to retirement for the second, third and fourth wealth quartiles, we find that the transition to retirement is associated with a decrease in non-durable expenditure for those in the lowest quartile. Is this reduction in consumption among household with low private savings associated with shocks around retirement? We found that those in the first wealth quartile that experienced a health shock decline their consumption by almost 13% at the time of retirement while we found no evidence of a decline in consumption for the rest of the groups.

A question that still remains open is why there is such heterogeneity in the stock of accumulated assets. There are several explanations for this. Wealth at the time of retirement is likely to be correlated with lifetime income. Then, those who arrive to retirement with a low accumulated stock of assets are those that had a low level of income through their working life. Second, low wealth could be explained by the number and level of persistence of negative shocks during the time previous to retirement. Indeed, health shocks, unemployment or even low investment returns could explain the dispersion of wealth at retirement. Finally, low wealth could also be associated with ill-planning. Recent literature (Bozio et al. (2011), Banks et al. (2010), Lusardi and Mitchell (2007), Ameriks et al. (2003) among others) have studied the role of numerical and cognitive ability and financial literacy in explaining the propensity to plan and if the latter is associated with retirement preparedness. A better understanding of wealth accumulation and retirement preparedness is key as the responsibility of retirement resources moves towards the individuals.

2.6 Appendix

Descriptive Statistics

Table 2.8: *Descriptive Statistics*

						Wealth			
	All	**Working**	**Retired**	**Vol.**	**Invol.**	**Quartile 1**	**Quartile 2**	**Quartile 3**	**Quartile 4**
C_t (£)	323.2	331.2	275.3	274.9	284.0	301.5	304.5	325.2	356.5
	(2.032)	*(2.209)*	*(4.703)*	*(4.798)*	*(23.77)*	*(4.252)*	*(4.067)*	*(3.664)*	*(4.069)*
$\triangle lnC_t$	-3.1%	-2.8%	-4.8%	-4.5%	-10.2%	-3.0%	-2.9%	-3.1%	-3.2%
	(0.003)	*(0.004)*	*(0.009)*	*(0.009)*	*(0.032)*	*(0.008)*	*(0.007)*	*(0.006)*	*(0.006)*
Age	59.2	58.5	63.4	63.5	60.6	58.6	59.6	59.1	59.6
	(0.074)	*(0.073)*	*(4.694)*	*(0.198)*	*(0.567)*	*(0.142)*	*(0.159)*	*(0.137)*	*(0.149)*
Household Size	2.2	2.3	2.0	1.9	2.3	2.3	2.2	2.2	2.2
	(0.015)	*(0.016)*	*(0.033)*	*(0.033)*	*(0.175)*	*(0.034)*	*(0.030)*	*(0.029)*	*(0.027)*
Graduate	20.4%	20.3%	21.3%	22.2%	3.6%	12.0%	14.1%	21.1%	32.6%
	(0.006)	*(0.007)*	*(0.017)*	*(0.017)*	*(0.036)*	*(0.011)*	*(0.011)*	*(0.012)*	*(0.014)*
Single Male	10.8%	10.5%	12.2%	12.1%	14.3%	11.5%	11.8%	11.5%	8.5%
	(0.005)	*(0.005)*	*(0.013)*	*(0.014)*	*(0.067)*	*(0.010)*	*(0.010)*	*(0.010)*	*(0.008)*
Single Female	14.4%	13.7%	18.8%	19.2%	10.7%	23.2%	16.6%	10.5%	8.7%
	(0.005)	*(0.006)*	*(0.016)*	*(0.017)*	*(0.060)*	*(0.014)*	*(0.012)*	*(0.009)*	*(0.009)*
Self-Reported Health Status									
Excelent/ V.Good/Good	85.1%	86.4%	77.8%	79.2%	50.0%	77.4%	82.6%	88.0%	91.2%
	(0.006)	*(0.006)*	*(0.017)*	*(0.017)*	*(0.096)*	*(0.014)*	*(0.012)*	*(0.010)*	*(0.009)*
Fair	13.3%	12.4%	18.3%	17.4%	35.7%	19.6%	15.5%	10.9%	8.3%
	(0.005)	*(0.006)*	*(0.016)*	*(0.016)*	*(0.092)*	*(0.013)*	*(0.012)*	*(0.009)*	*(0.008)*
Poor	1.6%	1.2%	3.9%	3.4%	14.3%	3.0%	1.9%	1.1%	0.6%
	(0.002)	*(0.002)*	*(0.008)*	*(0.008)*	*(0.067)*	*(0.005)*	*(0.004)*	*(0.003)*	*(0.002)*
No. Obs	4,127	3,536	591	563	28	949	967	1,110	1,001

Imputing total expenditure in ELSA using data from the EFS

Imputation procedure:

The imputation procedure used in this paper follows Skinner (1987). Given we have data on a limited number of expenditure items in ELSA, we use expenditure in food consumed at home and expenditure in food consumed away from home to construct a measure of total expenditure using data from the EFS. We have data on total non-durable expenditures and all its components in EFS but only on food at home and food away from home in ELSA [17]. Thus, we have an exhaustive list of goods, $i = 1, ..., n$, in the EFS and a non-exhaustive list in ELSA, $i = 1, ..., m$, with $n > m$. The procedure is equivalent to estimate linear Engel curves for expenditure in each good that is available both in ELSA and EFS:

$$x_i = \beta x + \epsilon_i$$

Where x_i is expenditure in good i and x is total non-durable expenditure. Then, with the estimated parameters we can obtain a measure for total non-durable expenditure, $\hat{x}(i)$:

$$\hat{x}(i) = \frac{x_i}{\hat{\beta}}$$

Note that we have data on food at home and food away from home and thus we are able to obtain two estimates of total expenditure. As suggested by Browning et al. (2003), with 2 goods, one can take weights (ω_1, ω_2) and define the imputed value of total expenditure as:

$$\widehat{x} = \omega_1 \hat{x}(1) + \omega_2 \hat{x}(2)$$

The issue is how to choose the weights optimally. Browning et al. (2003) state that running a regression of total expenditure on each of the components (available in both surveys) to impute total expenditure is equivalent to first estimate linear Engel curves,

[17] In order to make use of the available 4 waves of ELSA we opted to only use food at home and food away from home. Note that starting in the second wave, ELSA respondents are asked about consumption on clothing and footwear as well as consumption on fuel for heating and cooking purposes. As we make use of the longitudinal feature of ELSA and in order to maximize the number of respondents that transit from working to retirement we only use the food components in the imputation. The advantage of using consumption on clothing and fuel besides consumption on food would be an increase in the explanatory power of the total non-durable expenditure model. The adjusted-R^2 would slightly increase from 0.57 to 0.62.

obtain the $\hat{x}(i)$ and use the estimated coefficients in the total expenditure regression as weights to compute $\widehat{x}$. Using data from the EFS, we follow Skinner (1987) suggestion and regress total expenditure on expenditures in the components also available in ELSA, i.e food at home (x_1) and food away (x_2) , and add also a set of demographic characteristics, $\boldsymbol{X}$, together with time effects, d_t, (with $d_t = 1$ if wave is equal to t and 0 otherwise, $t = 1, ..., 4$):

$$x = \alpha + \omega_1 x_1 + \omega_2 x_2 + \gamma \boldsymbol{X} + \sum_{t=1}^{3} \delta_t d_t + \epsilon$$

Sample:

In order to impute total non-durable expenditure in ELSA using data from the EFS, we start by selecting a comparable sample. The aim of the sample selection is to focus on a sample of households headed by older individuals who are close to retirement. Thus, we only work with households where the head is aged between 50 and 79. We also drop from the sample respondents with food consumption equal to 0. Finally, we make use of the 4 available waves of ELSA (2002-2003, 2004-2005, 2006-2007 and 2008-2009) and of data from the EFS for the following years: 2002-2003, 2004-2005, 2005-2006 and 2008.

We pooled the EFS data and start with 62,738 individuals corresponding to 26,353 households. After eliminating those households which head is younger than 50 (12,662) and older than 79 (1,744), those with food expenditure equal to 0 (52) and those with incomplete data on demographic characteristics (40), we end with a sample that contains 11,855 households. Similarly for ELSA data, we start with a sample of 26,700 observations corresponding to 7,910 households. After eliminating the observations for those households in which the head is younger than 50 (338) and older than 79 (682), those with food expenditure equal to 0 or missing (627) and those with incomplete data on demographic characteristics (118), we end with a sample that contains 21,935 observations corresponding to 7,083 households for which we are able to impute total non-durable expenditure using data from the EFS.

Table 2.9: *Comparing the two data-sets (means)*

	Wave 1		Wave 2		Wave 3		Wave 4	
	ELSA	**EFS**	**ELSA**	**EFS**	**ELSA**	**EFS**	**ELSA**	**EFS**
Food at Home	55.3	50.5	54.8	51.5	57.3	49.4	54.4	48.1
Food Out	11.6	15.0	9.7	16.3	10.9	15.7	10.2	15.7
Age	63.3	63.3	64.4	62.9	63.5	63.4	64.2	63.1
Family Size	2.0	1.9	1.9	2.0	2.1	2.0	2.0	2.0
Graduate	0.13	0.10	0.14	0.11	0.13	0.10	0.11	0.12
Single Male	0.13	0.13	0.13	0.14	0.13	0.15	0.15	0.15
Single Female	0.26	0.26	0.25	0.26	0.21	0.26	0.16	0.23
No. Obs	6,476	3,049	5,150	3,037	4,928	3,059	5,381	2,710

Empirical results:

We follow Attanasio and Weber (1995) and define total non-durable expenditure as the sum of expenditures in food at home, food away from home, alcohol and tobacco, clothing and footwear, transports, communications, recreation, housing services and miscellaneous. In order to impute non-durable expenditure in ELSA we use data from the EFS and run a regression of total non-durable expenditure on food consumed at home, expenditure in food away, time dummies and a vector of demographic characteristics that includes: age dummies - age 50 is omitted -, household size, household size square, whether the head of household is a college graduate and dummies for single female and single male - couple is the omitted category. Results are summarized in Table 2.10.

Table 2.10: *Total Non-durable Expenditure Estimation*

Variable	Estimate	Variable	Estimate	Variable	Estimate
Food at Home	0.359 (0.008)	**62**	-0.012 (0.034)	**75**	-0.189 (0.037)
Food Out	0.070 (0.002)	**63**	-0.075 (0.035)	**76**	-0.300 (0.037)
51	0.011 (0.033)	**64**	-0.088 (0.035)	**77**	-0.313 (0.037)
52	0.033 (0.032)	**65**	-0.102 (0.034)	**78**	-0.336 (0.038)
53	0.008 (0.032)	**66**	-0.098 (0.034)	**79**	-0.262 (0.038)
54	0.037 (0.033)	**67**	-0.122 (0.035)	**HH. Size**	0.288 (0.022)
55	0.057 (0.032)	**68**	-0.150 (0.035)	**HH. Size Square**	-0.026 (0.003)
56	-0.015 (0.032)	**69**	-0.197 (0.035)	**Graduate**	-0.233 (0.015)
57	-0.007 (0.032)	**70**	-0.153 (0.035)	**Single Male**	-0.172 (0.018)
58	-0.019 (0.032)	**71**	-0.206 (0.035)	**Single Female**	-0.205 (0.016)
59	-0.039 (0.032)	**72**	-0.214 (0.035)	**Wave 1**	-0.079 (0.013)
60	-0.025 (0.033)	**73**	-0.220 (0.036)	**Wave 2**	-0.05 (0.013)
61	-0.016 (0.032)	**74**	-0.261 (0.036)	**Wave 3**	-0.054 (0.013)
Constant	3.697 (0.048)				
R^2	0.5641				
No. Obs	11,855				

Budget Shares - Workers and Retirees

Table 2.11: *Budget Shares of Selected Goods - Workers vs. Retirees*

	Workers	**Retirees**
Food at Home	18.2%	23.6%
	(0.01)	*(0.02)*
Alcohol and Tobacco	3.87%	3.82%
	(0.001)	*(0.001)*
Communications	3.94%	4.22%
	(0.001)	*(0.0004)*
Housing	7.58%	9.50%
	(0.001)	*(0.002)*
Clothing and Footwear	7.29%	6.14%
	(0.001)	*(0.001)*
Recreation	*18.2%*	18.2%
	(0.002)	*(0.002)*
Restaurants and hotels	9.95%	7.67%
	(0.001)	*(0.001)*
Transport	17.5%	11.6%
	(0.002)	*(0.002)*

Preliminary Evidence - Change in consumption at retirement

Table 2.12: *Pooled OLS Regression of Change in Log Non-Durable Expenditure*

	Non-durables
$\triangle r_{it}$	-0.017
	(0.008)*
Single male	-0.036
	(0.009)**
Single female	-0.021
	(0.009)*
Age	-0.026
	(0.011)*
Age squared	0.000
	(0.000)*
Change in household size	0.216
	(0.007)**
Good-Fair	-0.005
	(0.010)
Good-Poor	-0.004
	(0.052)
Fair-Good	-0.002
	(0.010)
Fair-Fair	-0.005
	(0.013)
Fair-Poor	-0.011
	(0.037)
Poor-Good	-0.113
	(0.060)
Poor-Fair	-0.051
	(0.028)
Poor-Poor	0.029
	(0.056)
G	-0.010
	(0.007)
Wave 2	-0.014
	(0.007)*
Wave 3	-0.027
	(0.007)**
Constant	0.909
	(0.329)**
R^2	0.3547
N	4,106

* $p < 0.05$; ** $p < 0.01$

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses.

Voluntary vs Involuntary Retirement

The empirical strategy adopted in this section is based on Smith (2006) with two main differences: (*i*) in the fact that we are estimating the effect of retirement on total non-durable expenditure while Smith (2006) studies only food, and, (*ii*) in the definition of both voluntary and involuntary retirement.

We classify retirements as either voluntary or involuntary based on Smith (2006). Smith (2006) uses the first 11 waves of the British Household Panel Survey (BHPS) and define involuntary retirees as those who retire from a non-work labour status - unemployed or ill -, are observed working prior to being observed unemployed or ill and are not observed working after being retired. We define involuntary retirement as the transition from working to unemployment or illness and then to retirement. On the other hand, while Smith (2006) defines voluntary retirees as those who retire from working and are observed working at least for 2 consecutive periods prior to retiring, we define voluntary retirees as those retiring from working, without considering the labour status prior to being observed working. The reason of this difference is just due to the fact that we only have 4 waves of ELSA and thus the number of retirees would be too low. Of the 591 household heads that we observe retiring, only 28 are considered as involuntary retirements. Table 2.13 shows the pre-retirement sequence of employment states. We are using the 4 available waves of the ELSA so the maximum number of pre-retirement states is 3. Note that W means working - i.e. either employed or self-employed -, NW means not-working - unemployed, sick or disabled, looking after home or family - and NA means missing observation.

Table 2.13: *Transition to Retirement*

Pre-retirement	Retirement Type	Number of Obs.
W	*Voluntary*	*266*
W_W	*Voluntary*	*145*
W_W_W	*Voluntary*	*101*
NW_W	*Voluntary*	*25*
NW_W_W	*Voluntary*	*6*
NW_NW_W	*Voluntary*	*7*
W_NW_W	*Voluntary*	*8*
W_NA_W	*Voluntary*	*3*
NW_NA_W	*Voluntary*	*2*
Total Voluntary		*563*
W_NW	*Involuntary*	*16*
W_W_NW	*Involuntary*	*12*
Total Involuntary		*28*

We have 591 retirees that are observed in a different employment state prior to reporting themselves as being retired. Of these, 563 are observed working prior to retirement and are considered as voluntary retirees and only 28 are observed as unemployed or ill prior to retirement and are classified as involuntary retirees. As shown in Table 2.14, while involuntary retirees reduce their non-durable expenditure at retirement by 10%, the figure is below 5% for voluntary retirees. It is worth noting that the difference is not statistically significant at 5% level. In terms of demographic characteristics, involuntary retirees are younger, less likely to be college graduate, live in households with more members and are more likely to be in poor health than voluntary retirees.

Voluntary retirement is the common experience in our sample. According to the life cycle model, if retirement is planned there should be no discontinuity in consumption at the time of retirement. On the contrary, unexpected retirement may be associated with a negative wealth shock that results in a drop of consumption as individuals transit from work to retirement.

Table 2.14: *Consumption and Voluntary-Involuntary Retirement*

	Retirement		
	Voluntary	Involuntary	*p-value* of difference in means
$\triangle lnC_t$	-4.7% *(0.009)*	-10.2% *(0.033)*	0.1708
Age	63.5 *(0.194)*	60.7 *(0.553)*	0.0020
Household Size	1.94 *(0.032)*	2.21 *(0.175)*	0.0761
Graduate (%)	22.2% *(0.017)*	6.9% *(0.036)*	0.0502
Self-reported Health Status			
Excellent/very good/good	78.4% *(0.016)*	48.3% *(0.094)*	0.0001
Fair	17.1% *(0.015)*	37.9% *(0.092)*	0.0043
Poor	3.5% *(0.007)*	13.8% *(0.065)*	0.0052

In order to study the effect of unexpected retirement on non-durable consumption growth we disaggregate the transition to retirement into voluntary and involuntary and estimate the following equation:

$$\triangle ln(C_{it}) = \boldsymbol{\gamma}\mathbf{X}_{it} + \boldsymbol{\phi}\triangle\mathbf{H}_{it} + \beta_1\triangle vr_{it} + \beta_2\triangle ir_{it} + \mu_t + \epsilon_{it} \tag{2.8}$$

Where ir_{it} is a dummy variable that takes the value 1 if the respondent retired involuntarily, and 0 otherwise; and vr_{it} is a dummy variable that takes the value 1 if the respondent retired voluntarily from the labour market and 0 otherwise. Then, $\triangle vr_{it} = vr_{it} - vr_{it-1} = 1$ and $\triangle ir_{it} = ir_{it} - ir_{it-1} = 1$ capture retiring voluntarily and involuntarily respectively. The rest of the variables are defined as before. Results are summarized in Table 2.15.

Table 2.15: *Non-Durable Expenditure and Voluntary/Involuntary Retirement*

	Non-Durables
Voluntary	-0.014
	(0.008)
Involuntary	-0.075
	(0.029)
Demographic, Health and Time Controls	Yes
R^2	0.3552
No. Obs	4,106

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses. Regressions also include age, age squared, gender, marital status, change in household size, change in self-reported health status, level of education and time dummy variables.

Our results are consistent with Smith (2006), who finds that retirees that involuntarily left the labour market spend just above 10 percent less in food - including food out - than their non-retired counterparts. Our analysis differs in that we are not considering only food expenditure but total non-durable expenditure. First, we found that involuntary retirement is associated with a decrease in non-durable expenditure. Indeed, according to our results, those retiring involuntarily reduce their consumption by 7.5 percent. This is consistent with the life cycle model augmented by considering uncertainty about the time of retirement; earlier than expected retirement is associated with a negative shock to lifetime income and thus with a reduction in expenditure. Second, our results suggest that there is no consumption drop for those retiring voluntarily. The coefficient is -0.014 but statistically significant not different from zero.

In sum, while the majority of people do not retire unexpected and consequently do not experience a drop of consumption at retirement, there is a non-negligible fraction of workers that forced to retire earlier than planned, suffer a reduction in consumption at the time of retirement. This is consistent with the idea that involuntary retirement is associated with a reduction of expenditure due to a negative shock to wealth or lifetime resources, possibly due to a lower than expected pension income. Note that this result is in line with the permanent income hypothesis in the sense that for those that retire involuntarily, retirement is seen as the arrival of new information and the change in consumption as a response to news in the income process.

Financial wealth

Table 2.16: *Health shock and change in consumption at retirement by net financial wealth quartile*

	No Health Shock (α_j)	**Health Shock (β_j)**
1st Quartile	-0.01	-0.108
($j = 1$)	*(0.021)*	*(0.059)*
2nd Quartile	-0.025	-0.007
($j = 2$)	*(0.016)*	*(0.048)*
3rd Quartile	-0.007	-0.034
($j = 3$)	*(0.015)*	*(0.040)*
4th Quartile	-0.012	-0.004
($j = 4$)	*(0.012)*	*(0.048)*
Demographic, Health and Time Controls	Yes	
R^2	0.3554	
No. Obs	4,106	

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses.

Intrahousehold risk-sharing

Table 2.17: *Intrahousehold risk-sharing*

	Non-durables
Partner returns to work	-0.033
	(0.023)
Single male	-0.029
	(0.022)
Single female	-0.026
	(0.021)
Age	-0.021
	(0.028)
Age squared	0.000
	(0.000)
Change in household size	0.263
	(0.024)**
Good-Fair	0.018
	(0.021)
Good-Poor	-0.034
	(0.099)
Fair-Good	0.006
	(0.029)
Fair-Fair	-0.006
	(0.033)
Fair-Poor	-0.023
	(0.076)
Poor-Good	-0.015
	(0.017)
Poor-Fair	0.025
	(0.076)
Poor-Poor	0.046
	(0.039)
Graduate	0.011
	(0.017)
Wave 2	-0.001
	(0.016)
Wave 4	0.036
	(0.019)
Constant	0.653
	(0.883)
R^2	0.3545
N	587

* $p < 0.05$; ** $p < 0.01$

Notes: The dependent variable is $\triangle ln(C_{it})$. Robust standard errors are reported in parentheses.

Inflation Rate Assumptions

Inflation rates were calculated based on data of the Consumer Price Index (CPI) time series obtained from the UK Office for National Statistics (ONS). Expenditures are expressed in September 2002 prices (mid point of ELSA Wave 1 survey) and different inflation rates were calculated for each of our consumption measures. We take January 2005 prices, October 2006 prices and January 2009, as the Wave 2, Wave 3 and Wave 4 prices respectively.

Table 2.18: *Assumed Inflation Rates by Type of Good (September 2002=100)*

	Food	Alcohol & Tobacco	Clothing	Housing	Transport	Recreation	Comm.	Restaurants & Hotels
Wave 2	103.0	104.0	87.0	108.7	106.6	96.8	97.7	106.9
Wave 3	109.1	108.8	84.0	127.2	111.8	94.9	97.7	113.7
Wave 4	126.7	118.4	68.1	146.6	117.8	92.8	91.3	122.1

Source: Office for National Statistics (ONS): www.statistics.gov.uk

Chapter 3

Life-cycle expenditure and retirees' cost of living

3.1 Introduction

Economists have long been interested in measuring how the cost of living changes over time. But, how do we measure changes in the cost of living? In general, governments and statistical agencies use consumer price indexes as measures of the true cost of living. Price indexes such as the Consumer Price Index (CPI) or the Retail Price Index (RPI) in the United Kingdom measure the proportional change in the cost of buying a fixed basket of goods as prices change. It is implicitly assumed that consumers do not modify their behaviour when experiencing price changes and thus price indexes as measures of the cost of living suffer from the so called “substitution bias”. When prices change, consumers could substitute away from the goods that have become relatively more expensive and shift their consumption towards goods that have become relatively cheaper. A true cost of living index should take this into account. Then, a true economic cost of living index measures the cost of maintaining a given utility or welfare level after a change in prices.

A second aspect to consider is whether price indexes are representative of specific segments of the population. By construction, price indexes aim to represent the average consumer in the economy and not necessarily are representative of segments of the population. This is important because Social security benefits and State pension are adjusted by the change in the RPI in the UK but, is the RPI an accurate measure of the cost of living of pensioners[1]? In its construction, expenditure by high income households and pensioner households whose income is mostly draw from State Benefits are excluded from the sample.

The aim of this paper is twofold. First, we document the expenditure life-cycle profile in the United Kingdom and relate it to differences in the inflation experience across age. We estimate household specific inflation and assess whether there are differences in the inflation experience of workers and pensioners. The second objective is to account for the "substitution bias" and estimate true cost of living indexes for pensioners in order to better understand retirement income requirements. Pensioners have a mixture of annuitized - state pensions, defined benefit and defined contribution pensions - and unannuitized wealth - private savings in financial and real assets - to finance consumption during retirement. Our interest is in understanding what income path best matches consumption needs during retirement years. In that sense, we are interested in assessing whether the Retail Price Index (RPI), an average measure of inflation and usually used as the indexation metric for State Pension and annuities, is representative of the cost of living of pensioners [2].

Our main contribution is first, to extend previous analyses on household specific inflation until the year 2010, allowing us to show interesting features of inflation during the latest financial crisis. Our second contribution is to estimate theoretically consistent cost of living indexes for pensioners and workers separately in order to understand different income requirements.

Figure 3.1 shows the well-known hump-shaped life-cycle profile of non-durable consumer expenditure [3] in the United Kingdom. This profile is consistent with evidence presented by Aguiar and Hurst (2013) for the US. It illustrates increasing expenditure until between age 45 to 50 and subsequent decline during retirement. Besides changes in household demographics [4], Aguiar and Hurst (2013) attribute the decline in expenditure in the second part of the life-cycle to a decline in work related expenditure such as clothing, food away from home and transportation.

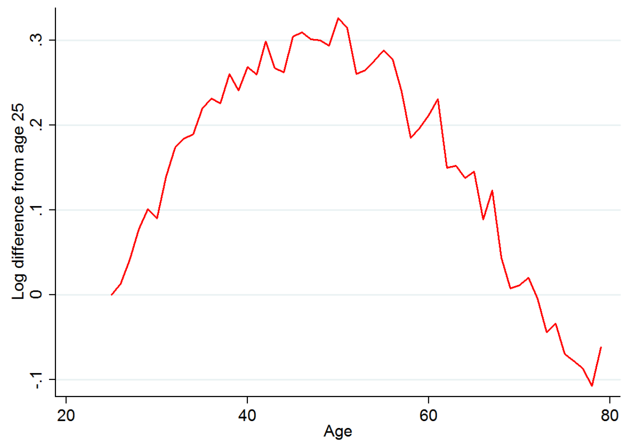
[1] The Office for National Statistics (ONS) also reports pensioners' inflation but it is aimed to represent the inflation experience of pensioners mainly dependent from the State for their income

[2] We are not going to discuss here important topics in the price index literature: formula effect, change in quality, new products, etc

[3] The graph was obtained by estimating a linear regression of log non-durable expenditure on age, cohort, period dummies and demographic characteristics. We can not identify age, period and cohort effects together due to the perfect collinearity of the three variables. We assume then that period effects sum to zero over the sample period (See Deaton (1997), among others). The corresponding age coefficients are shown in the graph and are expressed with respect to age 25.

[4] Most notably the decrease in household size.

Figure 3.1: *Hump-shaped profile of life-cycle expenditure*



Source: Own calculations based on EFS, FES and LCFS

Figure 3.2 and Figure 3.3 show the expenditure life-cycle profile by type of good in the UK. We decompose expenditure categories in those increasing and those declining over the life-cycle. The most notably increasing categories are leisure, clothing and household goods and services. After controlling for household size, people aged 60 or above spend, on average, 2 log points more per week in leisure and in clothing and 1 log point more in household goods and services than those in their 25s. On the other hand, expenditure on food out, transport, housing, fuel and light and alcohol and tobacco are declining over the life-cycle. Household spending is 0.80 log points less per week in alcohol and tobacco and 0.65 log point less in transport for those in their 60s and 70s relative to those in their 20s.

If there are changes in the consumption bundle over the life-cycle then households should experience different inflation rates as they get older. In order to mitigate the inflation risk, an optimal income indexation mechanism should then take into account the change in the expenditure composition over the life-cycle and in particular after retirement. Figure 3.4 shows the U-shaped profile of inflation over the life-cyle[5]. Inflation declines from 3.1% at age 25 to 1.7% at 60, to increase thereafter and during retirement, reaching 2.5% by age 79.

[5]The graph was obtained by estimating a linear regression of household specific inflation rate on age, cohort and period dummies. The constant was added to the corresponding age coefficients - and 95% confidence interval - in order to obtain the results shown in the graph. See Section 3.4.2 for an explanation on how to obtain household specific inflation.

Figure 3.2: *Expenditure life-cycle profile by type of good: Increasing*

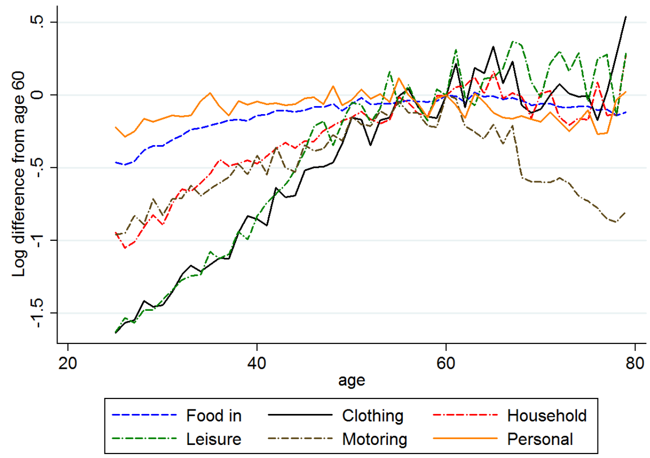


Figure 3.3: *Expenditure life-cycle profile by type of good: Declining*

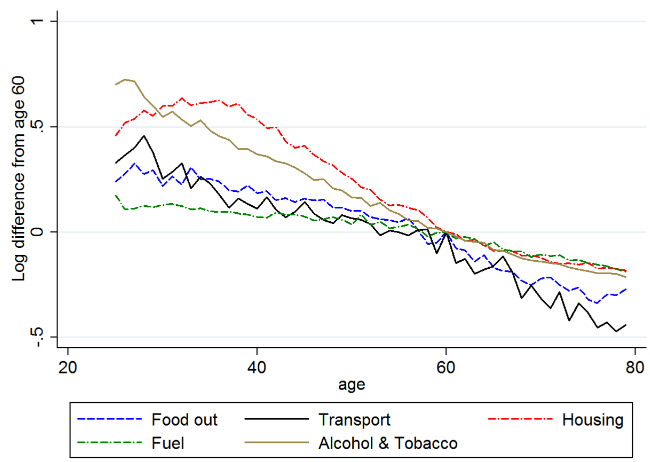
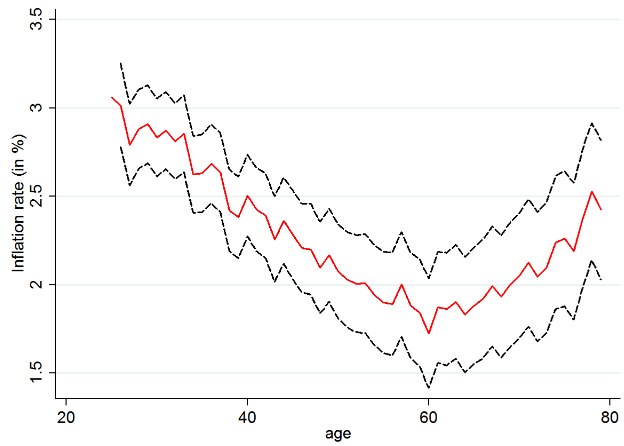


Figure 3.4: *Life-cycle profile of inflation*



The rest of this chapter is organized as follows. In the next section we summarize the related literature. A simple theoretical model about the welfare consequences of real annuities is presented in Section 3.3. In Section 3.4 we provide a description of the data used in the empirical analysis as well as present estimates of household specific prices and provide evidence of the different inflation experiences of workers and pensioners. In Section 3.5 we present the estimation of a demand system and the resulting cost of living index for both pensioners and workers. Finally, Section 3.6 concludes.

3.2 Related literature

There is a vast literature on consumer demand estimation but few applications to the estimation of the cost of living. Deaton and Muellbauer (1980) linear Almost Ideal Demand System (AIDS) is probably the most popular parametric consumer demand model. The specification of the AIDS implies linearity with respect to total expenditure and a rank 2 demand, which means that it only allows linear Engel curves. It has been shown that empirical Engel curves are non-linear for some goods - such as clothing - so the Quadratic Almost Ideal Demand System (QUAIDS) of Banks et al. (1997) that allows a quadratic term in expenditure and has rank 3 is more suitable to model non-linear Engel curves. Recently, Lewbel and Pendakur (2009) proposed the Exact Affine Stone Index (EASI) demand system that allows polynomials or splines of any order in expenditure and are not limited in terms of the shape of the Engel curves. A second interesting feature of the EASI model is that the error terms in the budget share equations can be interpreted as individual unobserved heterogeneity. In spite of the growing literature on empirical demand system models, little attention has been given to cost of living estimation. Banks et al. (1996), Banks et al. (1997) and Lewbel and Pendakur (2009) are exceptions. The former use QUAIDS to estimate a demand system with UK data and then compute the change in cost of living associated with a 17.5% increase in the price of clothing. They find that not including the "second order term" or substitution effect results in a 0.3% error in the true welfare change. Lewbel and Pendakur (2009) use the EASI demand system with Canadian data and simulate a 15% increase in the price of rent. They also find a relatively modest substitution bias.

The semi-parametric and non-parametric literature on demand estimation has also grown during the last years. Particularly of interest for this paper are Blow and Crawford (2001) and Blundell et al. (2003). They use revealed preference information and non-parametric methods to obtain bounds for the welfare effect of price changes. Similar to the parametric studies they find a small substitution bias in the UK RPI.

A strand of literature in the UK has also focused on the inflation experience of different household types: Crawford (1994), Crawford and Smith (2002), Leicester et al. (2008) and Levell and Oldfield (2011). Crawford (1994) estimates Tornqvist type price indexes for 74 commodities to study changes in the cost of living of different types of household during the period 1978 to 1992. He finds small differences in the inflation rate experienced by the different types of households, in particular, richer households experienced higher inflation than poorer during this period due to the fall in relative prices of necessities and the corresponding increase of luxuries.

Crawford and Smith (2002) study the inflation experience of different types of households during the period 1976 to 2000. Using data from the UK Family Expenditure Survey (FES) and computing household specific inflation rates, they find that the distribution of inflation varies substantially over time. They do not find a particular pattern in the dispersion of inflation across households over time but suggest that household inflation is more dispersed in periods of high inflation. They then study how representative is the average rate of inflation finding that, between 1976 and 2000, only 35 percent of the households experience inflation within 1 percentage point of the average. They also study the inflation experience of different types of households finding that, on average, inflation is higher for high income households, non-pensioners, mortgagors, employed, single adults and younger. Finally, they show the importance of allowing differential effects of inflation in studying inequality over time.

More recently, Leicester et al. (2008) study the inflation experience of older households and Levell and Oldfield (2011) the inflation experience of low-income households in the UK. Of particular interest for this study is the analysis of Leicester et al. (2008). They use data from the UK FES to compute household specific inflation between 1977 and 2008 and find that, albeit substantial differences in given years, during the whole period there is no difference in the average inflation rate of pensioners (5.8 percent) and non-pensioners (5.9 percent). They then study how inflation varies within pensioners and find that those aged 75 or above suffered more from the rapid increase in fuel and food prices than younger pensioners.

In the US, Braithwait (1980) assesses the substitution bias in the US CPI estimating alternative demand systems - linear expenditure system, generalized linear expenditure system and indirect addilog - and find no major differences across the different models. More recently, an advisory commission - the Boskin Commission (See Boskin et al. (1996) and Triplett (2006) for a critic) - was given the task to analyze the CPI in the US. They estimate that the total bias in the US CPI between 1995 and 1996 is of 1.1 percentage points per annum with the substitution bias accounting for 0.4 percentage points.

In this paper we follow Lewbel and Pendakur (2009) and estimate a parametric demand system to compute cost of living indexes for workers and pensioners. Our main contribution is first, to extend previous analyses on household specific inflation until the year 2010, allowing us to show interesting features of inflation during the latest financial crisis. Our second contribution is to estimate theoretically consistent cost of living indexes for pensioners and workers separately in order to understand different income requirements.

3.3 Conceptual framework: Annuities and consumer's welfare

In this section we present a simple theoretical model to exemplify the welfare consequences of cost of living adjustments for a consumer that buys an annuity in order to finance consumption during retirement [6] Assume the consumer lives for T+1 periods ($t = 0, 1, 2, ..., T$). She works in the initial period and receives income w_0, spends q_0 in a consumption good[7] and, in order to finance future consumption, she pays A in exchange of annuity payments

[6]The model is extremely simple but gives an idea of the importance of having access to real annuities. A particular simplifying assumption is that the agent do not save their annuity income in order to finance future consumption and thus the only way to finance each period consumption is through the annuity income.

[7]Without loss of generality, the price level at time 0, p_0, is set equal to one.

m_t in the following periods until her death. The spot price of the annuity payments is equal to ϕ_t. Let δ_t be the probability that the consumer is alive in period t. Assume further that the consumer has a time separable utility function and that the within period utility is the same in every period. Let q_t be quantities consumed at time t, β the consumer's discount factor and $(1+r)$ the intertemporal technology. Consumer's lifetime utility is thus: $U = \sum_{t=0}^{T} \beta^t \delta_t u(q_t)$.

We will start with the Arrow-Debreu world as a benchmark case and then study what happens with consumption and welfare once we introduce a real or nominal annuity. The availability of a real annuity implies that the annuity payment m_t is linked to inflation while the nominal annuity implies that the consumer gets a constant payment every period.

3.3.1 Benchmark case (Arrow-Debreu)

In the Arrow-Debreu world the consumer buys consumption at time $t = 0$ for time $t \geq 1$ in the eventuality that she is alive. In this case, the spot price of future consumption is $\phi_t = \frac{\delta_t}{(1+r)^t}$ and then actuarially fair pricing of the annuity implies that: $A = \sum_{t=1}^{T} \frac{\delta_t q_t}{(1+r)^t}$. The consumer optimization problem can then be expressed as:

$$\begin{aligned} \underset{q_t}{\text{Max}} \quad & U = \sum_{t=0}^{T} \beta^t \delta_t u(q_t) \\ \text{st} \quad & q_0 = w_0 - \sum_{t=1}^{T} \frac{\delta_t q_t}{(1+r)^t} \end{aligned}$$

Then the Lagrangian for this problem is:

$$L = \sum_{t=0}^{T} \beta^t \delta_t u(q_t) + \lambda \left[w_0 - q_0 - \sum_{t=1}^{T} \frac{\delta_t q_t}{(1+r)^t} \right]$$

And then, the FOC implies that:

$$u'(q_t) = \beta(1+r)u'(q_{t+1})$$

Assuming that $\beta = \frac{1}{(1+r)}$ implies a constant stream of consumption over time: $q_t = q_{t+1}$.

3.3.2 Access to annuities

We first are going to show that if the consumer has access to an inflation-linked annuity we can replicate the Arrow-Debreu result. Assume now that the consumer has access to a real annuity that is uprated every period according to inflation. As before, she pays A in period 0 in order to obtain an inflation-linked income stream m_t until she dies. Note that in this case, the spot price of the annuity payment is given by the probability of survival, the intertemporal technology and also the price level: $\phi_t = \frac{\delta_t}{p_t(1+r)^t}$. The consumer's maximization problem can be expressed as:

$$\begin{aligned}
\underset{q_t}{\text{Max}} \quad & U = \sum_{t=0}^{T} \beta^t \delta_t u(q_t) \\
\text{st} \quad & q_0 = w_0 - \sum_{t=1}^{T} \delta_t \frac{m_t}{p_t(1+r)^t} \\
& p_t q_t = m_t \qquad \forall t = 1, 2, .., T
\end{aligned}$$

If we think of this problem as the consumer choosing the future income stream m_t, the Lagrangian can be expressed as:

$$L = u(q_0) + \sum_{t=1}^{T} \beta^t \delta_t u\left(\frac{m_t}{p_t}\right) + \lambda \left[w_0 - q_0 - \sum_{t=1}^{T} \delta_t \left(\frac{m_t}{p_t(1+r)^t}\right)\right]$$

The FOC with respect to m_t together with he assumption that $\beta = \frac{1}{(1+r)}$ implies, as in the Arrow-Debreu world, that the consumer smooths consumption over time. Then, $u'(q_t) = u'(q_{t+1})$ which implies: $q_t = q_{t+1}$.

We showed that the access to an inflation-linked annuity allows the consumer not only to insure herself against survival risk (as in the Yaari (1965) model) but also against inflation risk. Note that, in this case, annuities act as an Arrow security with the different states of nature given by different inflation rates.

Assume that the consumer now has access to a nominal, instead of a real, annuity. The annuity payment is now constant over time and thus, in an inflationary scenario, declining in real terms. We now have that $m_t = m$, $\forall t = 1, 2, ..., T$. Note that we are including an additional constraint in the consumer maximisation problem. With a declining income stream - in real terms - and no other instrument to trade consumption between periods, the consumer can not replicate the Arrow-Debreu result and, by revealed preferences, she is worse off than in the case of real annuities.

The main issue in this analysis is how to define inflation. We are currently assuming that each consumer has access to a real annuity that is linked to her specific inflation. In that sense, we are assuming the existence of as many markets for the contingent commodity (real annuity) as different consumers (in terms of their specific inflation) are in the economy.

3.4 Descriptive analysis

3.4.1 Data

The analysis in this paper uses expenditure data from the Family Expenditure Survey (FES) for 1987 to 2000, the Expenditure and Food Survey (EFS) for 2001 to 2007 and the Living Costs and Food Survey (LCFS) for the period between 2008 and 2010. Together with other data sources, the survey is used by the Office for National Statistics (ONS) to compute the weights for the calculation of the Retail Price Index (RPI) and the Consumer Price Index (CPI). The survey is conducted annually and draws a cross sectional sample of the United Kingdom (Great Britain and Northern Ireland) population. The sample size is around 7,000 households per annum. Respondent households keep a record of their daily expenditure in a diary over a period of 2 weeks and are asked questions during a face-to-face interview about household and individual characteristics.

Expenditure is recorded at the household level and thus we are going to consider a pensioner household one in which the head of the household is retired. We define a household as being retired if the head of household considers herself as retired while we are going to define a household as being in-work if the head of the household defines herself as being an employee or self-employed. Results are qualitatively the same if we consider pensioner households those with their head above 65 years of age and in-work households those with a head aged below 65 years.

We also use RPI monthly index series from January 1987 for 75 different type of goods obtained from the ONS. Expenditure in each of the 75 goods is expressed in real terms by dividing current expenditure by its corresponding price index.

3.4.2 Household specific prices

Define inflation rate for household i at time t as:

$$\pi_{it} = \sum_{j=1}^{J} w_{it}^{j} \pi_{t}^{j} \tag{3.1}$$

Where: $w_{it}^{j} = \frac{p_{it}^{j} q_{it}^{j}}{p_{it} q_{it}}$, is share of expenditure of household i in good j at time t and π_t^j is the year-on-year inflation rate of good j at time t. Inflation rates for the different goods are only available at the national level from the ONS and thus variation in the inflation experienced by different households is due to differences in the expenditure shares. To compute the household specific inflation rate we consider 75 sections of the RPI (j=1,...,75) [8] and compute w_{it}^{j} for each household in the sample between 1987 and 2010. Household inflation depends then, on the RPI section inflation rate and on the basket of goods consumed.

It is worth a special note about the treatment of housing costs. We opt to follow the same approach as the one currently used by the ONS for the compilation of the RPI. The ONS used an implicit rent approach to capture owner-occupied housing costs until its replacement in 1975 with mortgage interest payments. Housing costs for tenants is still being represented by rents. The implicit rent approach considers landlords as agents maximising the present value of the cash flow from renting their house while the user cost approach takes households as consumers that maximise their utility by allocating their budget between different goods (Fry and Pashardes (1986)). Owner-occupied housing costs in the RPI are captured by mortgage interest payments, owner-occupiers' housing depreciation, Council Tax and estate agents' fees [9]. Housing depreciation has been included in the RPI since January 1995 with the aim to capture expenditure that owner-occupiers would need to affront in order to maintain constant the quality of their house. Due to data availability we exclude the housing depreciation component of housing costs to compute household inflation.

First, there is substantial variation in the evolution of price indexes over time. While food prices increased 2.9% per year on average between 1987 and 2010, the figure is 6.5% for Tobacco, 4.9% for housing and 4.6% for transport fares. On the other hand, clothing and footwear and leisure goods decreased by 0.4% and 0.7% respectively per year during the same period (see Table 3.1).

These changes in relative prices affect total household expenditure and the consumption

[8] See Appendix for details

[9] Section 9.5 in Office for National Statistics (2012) explains in more detail how each component of owned-occupied housing costs is modelled

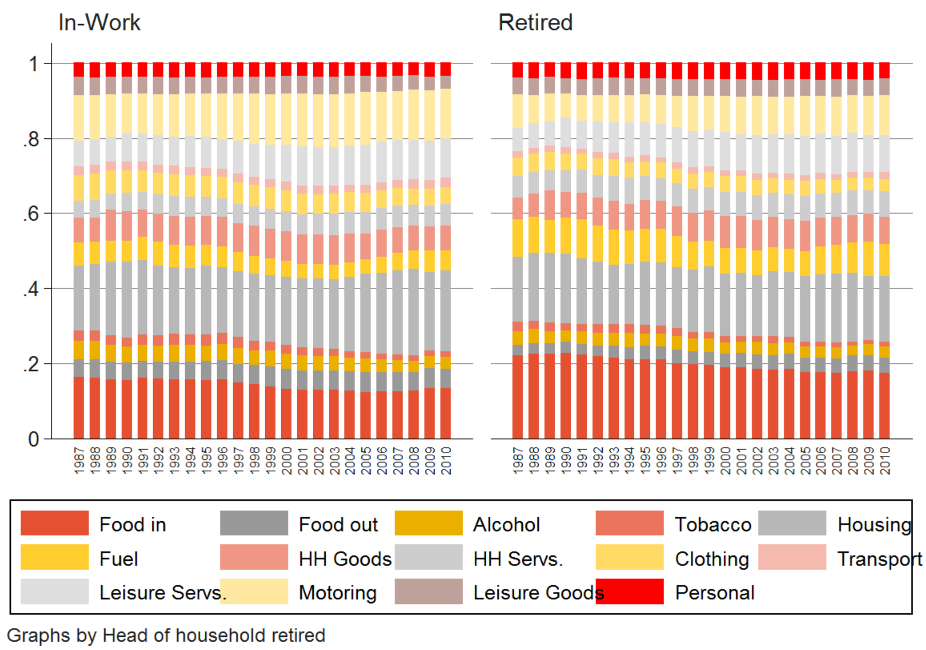
Table 3.1: *Price index by type of good (Selected years, 1987=100)*

	1987	1995	2000	2005	2010	1987-2010	Year average
Food in	100	135	142	152	193	93%	2.9%
Food out	100	164	198	233	272	172%	4.5%
Alcohol	100	162	184	204	240	140%	3.9%
Tobacco	100	179	270	328	422	322%	6.5%
Housing	100	161	208	278	304	204%	4.9%
Fuel & light	100	136	125	161	264	164%	4.3%
Household goods	100	130	137	142	166	66%	2.2%
Household services	100	139	154	181	213	113%	3.3%
Clothing	100	119	111	95	91	-9%	-0.4%
Transport	100	157	182	223	283	183%	4.6%
Motoring	100	147	175	178	212	112%	3.3%
Leisure goods	100	120	110	93	85	-15%	-0.7%
Leisure services	100	165	205	257	313	213%	5.1%
Personal goods and services	100	155	182	200	233	133%	3.7%

Source: Office for National Statistics (ONS)

bundle. Figure 3.5 shows expenditure shares over time for pensioner and in-work households. Two key messages can be extracted from the graph. First, pensioner households spend a bigger proportion of their budget in food, fuel and light, household goods and services, leisure goods and personal goods and services than households with a worker head. Second, for both worker and pensioner households, the proportion of the budget spent on food consumed at home declined over time. While pensioners spend 22% of their budget on food in 1987, they spend 17% in 2010. The same happens with workers whose food budget share declined from 16% to 13% between 1987 and 2010. Among the goods that increased their budget share for pensioners are household goods and leisure services; while housing and leisure services increased its proportion in workers budget. With prices treble between 1987 and 2010, leisure services budget share increased from 6% to 10% for both retired and in-work households.

Figure 3.5: *Share of expenditure: 1987-2010*



Source: Own calculations based on EFS, FES and LCFS

Another way to look at expenditure shares is by estimating Engel curves. We then non-parametrically estimate Working-Leser Engel curves of the following form:

$$w_{ij} = f_j(\ln x_i) + \epsilon_{ij}$$

Where i index households, j index goods, and w_{ij} is the budget share of good j for household i, and $\ln x_i$ is the log of total non-durable expenditure. Following Banks et al. (1997) we estimate Engel curves by Kernel regressions of the total non-durable expenditure share of each component on the log of non-durable spending. We estimate the Engel curves for pensioners and workers separately and to make results more comparable we consider only respondents living in households with 2 members in 2009-2010.

Results are shown in Figure 3.6 for goods in which pensioners' expenditure share is higher than workers' and in Figure 3.7 for those goods for which workers' expenditure share is higher than pensioners'. As expected, pensioners' budget share of work related goods like food out, clothing and fares and transport is lower than that of workers. On the other hand, irrespective of total expenditure, pensioners spend a higher proportion of their budget in personal goods and services, household services and leisure services. They also spend a higher proportion of their budget in home production related goods such as food at home and fuel and light.

Figure 3.6: *Engel curves (1)*

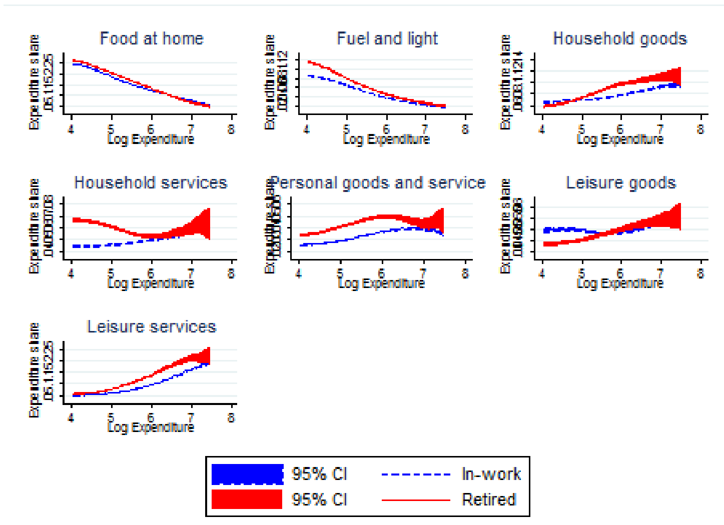
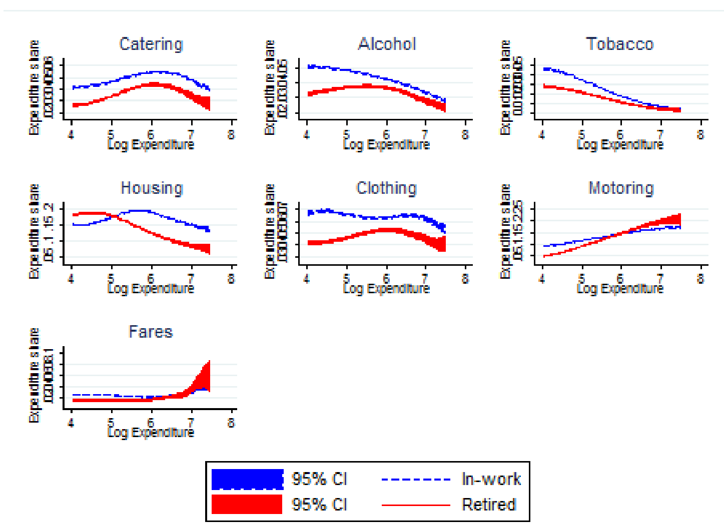
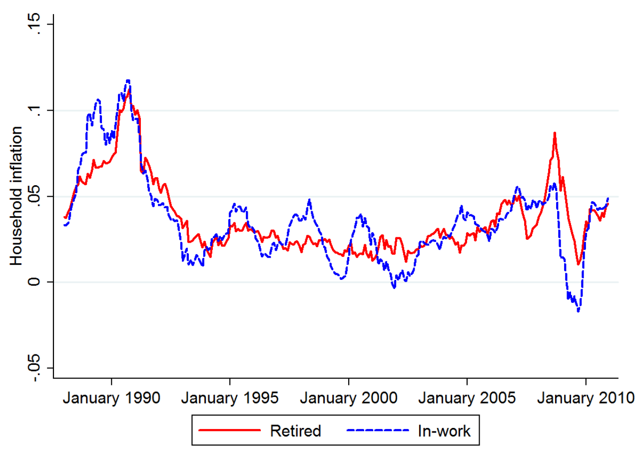


Figure 3.7: *Engel curves (2)*



These differences in the budget composition and the evolution of the RPI division price indexes result in different rates of inflation for workers and pensioners. Figure 3.8 shows average yearly household inflation between 1988 and 2010 according to the labour market status of the household head. Workers inflation is usually more volatile than pensioners', mostly due to the volatility of mortgage interest rates, a component that has less weight in pensioners' budget. On average during the whole period, pensioners inflation has been 0.1 percentage points higher than workers: 3.7% versus 3.6% respectively. Pensioners inflation is usually higher than workers' in periods of low interest rates, like the beginning of the 90s and the last financial crisis, particularly between 2009 and 2010. The year with the largest difference between the two groups is 2009 in which pensioner inflation is 3.1% and worker inflation is -0.3% [10].

Figure 3.8: *Average household inflation: 1988-2010*



Source: Own calculations based on ONS and EFS, FES and LCFS

In sum, we showed in this section that there are differences in the consumption bundle of pensioners and workers and that results in different inflation experiences. Albeit substantial differences in given years, the inflation experienced by the two groups is not significantly different over a long time period. In the next section we describe the theory of cost of living and attempt to estimate cost of living changes using parametric cost functions and expenditure data for the UK.

[10] A comparison between average household inflation and RPI is shown in the Appendix

3.5 Demands, cost of living and simulations

We start this section by summarizing the theory of cost of living. In this section, we are interested in understanding the welfare effect of a price change. Headline inflation is usually used to adjust pay and benefits. An important question is how much should income increase in order to compensate households for inflation. Households could substitute away from a given good when experiencing price increases and thus the true change in cost of living would be lower than when considering household inflation. In order to estimate cost of living indexes we need first to estimate the cost function and for that we have to specify a demand system. Over the last years, the literature has made progress in both parametric and non-parametric approaches of demand estimation. At this stage we are going to follow Lewbel and Pendakur (2009) and assume a parametric cost function. The estimation of the demand system will allow us to simulate price changes and calculate changes in the cost of living for each household.

3.5.1 Modelling the cost of living

The cost of living index compares the costs of obtaining a given level of utility under two different price sets. It represents the change in income necessary to maintain a given standard of living after a change in prices.

Assume momentarily that there is only 1 type of consumer. The consumer obtains utility from the consumption of a J-goods vector $\boldsymbol{Q} = (q_1, q_2, ..., q_J) \geq \boldsymbol{0_J}$. Thus, the consumer chooses a consumption bundle in order to maximize her utility:

$$\begin{aligned} &\underset{q_1,\dots,q_J}{\text{Max}} \quad U = F(\boldsymbol{Q}) \\ &\text{st} \qquad \boldsymbol{pQ'} = \sum_{i=1}^{K} p_i q_i \leq x \end{aligned}$$

Where $\mathbf{p} = (p_1, ..., p_J) >> \boldsymbol{0_J}$ is a J-vector of good prices, and $x > 0$ is expenditure on the J goods. This problem can be decomposed in 2 steps. First, the consumer minimizes the cost of attaining a given utility level and, then, chooses the highest utility, subject to the budget constraint.

The first step gives the cost function, which defines the minimal cost necessary to attain a given utility level, u, when the consumer faces prices $\mathbf{p}$: $C(u, \mathbf{p})$. The Konüs (1939) cost of living index (COLI) for the representative consumer gives the proportional change in cost needed to maintain the reference utility level $u^R = F(\boldsymbol{Q})$ after a price change from $\boldsymbol{p^0}$ to $\boldsymbol{p^1}$:

$$P(\boldsymbol{p^0}, \boldsymbol{p^1}; u^R) = \frac{C(u^R, \boldsymbol{p^1})}{C(u^R, \boldsymbol{p^0})}$$

If we abandon the assumption of a representative consumer, given individual heterogeneity in preferences, each consumer will have her specific COLI. Thus, for consumer $h = 1, ..., H$, we define the household specific COLI as:

$$P_h(\boldsymbol{p^0}, \boldsymbol{p^1}; u_h^R) = \frac{C_h(u_h^R, \boldsymbol{p^1})}{C_h(u_h^R, \boldsymbol{p^0})} \tag{3.2}$$

Due to data availability, we are assuming that consumers face the same prices and that individual heterogeneity is due to differences in preferences . Because individual level consumption is not available, we are not going to model explicitly intra-household consumption allocations. This means that we consider the household as a representative consumer: household members pool resources and make consumption decisions in order to maximize household utility based on the pooled budget constraint. Our objective is then to estimate equation 3.2 for workers and pensioners and compare with household specific prices and headline inflation in order to assess their bias when measuring cost of living changes. Given that the estimation of equation 3.2 gives household level COLI we need to aggregate these individual COLIs in order to obtain a group level - for workers and pensioners - COLI. We use a democratic group COLI computed as the unweighted average of the household level COLIs[11]:

$$P_g = \frac{1}{H_g} \sum_{h=1}^{H_g} P_h(\boldsymbol{p^0}, \boldsymbol{p^1}; u_h^R) \tag{3.3}$$

Where $g = \{workers, pensioners\}$ and H_g is the number of households in group g.

3.5.2 Demand System Estimation: EASI

To estimate the cost of living index we need to estimate first the cost function and for that, we need to estimate a system of demand equations. We follow Lewbel and Pendakur (2009)

[11] Crossley and Pendakur (2010) discuss the issues associated with the aggregation of COLIs across consumers and propose the common scaling social cost of living index (CS-COLI) that gives the scaling to everyone's cost in order to maintain social welfare constant after price changes.

and estimate an Exact Affine Stone Index (EASI) implicit Marshallian demand system by starting with the following parametric cost function:

$$\ln C(\mathbf{p}, u, \mathbf{z}, \epsilon) = u + \sum_{j=1}^{J} m^j(u, \mathbf{z}) \ln p^j + \frac{1}{2} \sum_{j=1}^{J} \sum_{k=1}^{J} \sum_{h=1}^{H} a^{jkt} z_h \ln p^j \ln p^k + \frac{1}{2} \sum_{j=1}^{J} \sum_{k=1}^{J} b^{jk} \ln p^j \ln p^k u + \sum_{j=1}^{J} \epsilon^j \ln p^j \tag{3.4}$$

Where: $j = 1, ..., J$ refers to commodities, $\mathbf{z}$ is a H-vector of demographic variables, $\mathbf{p}$ is a J-vector of prices, u is utility and ϵ represents unobserved individual heterogeneity. Let $m^j(u, \mathbf{z})$ be defined as:

$$m^j(u, \mathbf{z}) = \sum_{r=1}^{R} b_r^j u^r + \sum_{h=1}^{H} g_h^j z_h + \sum_{h=2}^{H} d_h^j z_h u \tag{3.5}$$

Then, by Sheppard's Lemma ($\frac{\partial \ln C(.)}{\partial \ln p^j} = w^j$), the share of expenditure in good j is:

$$w^j = \sum_{r=1}^{R} b_r^j y^r + \sum_{h=1}^{H} g_h^j z_h + \sum_{h=2}^{H} d_h^j z_h y + \sum_{k=1}^{J} \sum_{h=1}^{H} a^{jkh} z_h \ln p^k + \sum_{k=1}^{J} b^{jk} \ln p^k y + \epsilon^j \tag{3.6}$$

It can be shown from 3.6 that implicit utility ($y = u$) takes the following form:

$$y = u = \frac{\ln x - \sum_{j=1}^{J} w^j \ln p^j + \frac{1}{2} \sum_{j=1}^{J} \sum_{k=1}^{J} \sum_{h=1}^{H} a^{jkh} z_h \ln p^j \ln p^k}{1 - \frac{1}{2} \sum_{j=1}^{J} \sum_{k=1}^{J} b^{jk} \ln p^j \ln p^k} \tag{3.7}$$

Equations 3.6 and 3.7 define the EASI demand system. Note first that utility (equation 3.7) is expressed in terms of observables. Second, this flexible specification allows us to include additively separable effects in implicit utility ($y = u$), demographics ($\mathbf{z}$), prices ($\ln p^k$) and unobserved individual heterogeneity (ϵ). We also include two-way interactions between demographics ($\mathbf{z}$) and y and $\ln p^k$ and also between implicit utility ($y = u$) and $\ln p^k$. The chosen specification allows us, thus, to compute not only price and income elasticities but also cost of living indexes by demographic groups.

The estimation of the demand system is not straightforward. First, note that w^j is defined implicitly because $y = u$ is a function of w^j and thus budget shares are present in both the left and right hand sides of equation 3.6. A second issue with the estimation of the budget shares system is that the system is non-linear in y, which is in turn a function of budget shares (w^j), prices ($\mathbf{p}$) and demographics ($\mathbf{z}$). The endogenous non-linear system could be estimated either by the Generalized Method of Moments (GMM) or by Blundell and Robin (1999) iterated linear method. A third approach proposed by Lewbel and Pendakur (2009) and the one we follow in this paper, is to estimate an approximate version of equation 3.6. We then approximate y by: $\widetilde{y} = \ln x - \sum_{j=1}^{J} w^j \ln p^j$ and estimate the approximate demand system by 3 stage least squares (3SLS).

We only use households headed by someone between 25 and 79 years old in our estimations and aggregate expenditure into 33 different commodities ($J = 33$): bread, cereals and biscuits, beef, lamb, pork, bacon, poultry, other meat, fish, fats, cheese, eggs, milk and milk products, tea and coffee, soft-drinks and confectionary, vegetables, fruit, other food, catering, alcohol, tobacco, rent, mortgage interest payments, other housing, fuel and light, household goods, household services, clothing and footwear, personal goods and services, motoring expenditure, fares and other travel costs, leisure goods and leisure services. We impose symmetry of a^{jk} and b^{jk} such that $a^{jk} = a^{kj}$ and $b^{jk} = b^{kj}$ leaving a total of 4,416 parameter to estimate and 1,984 symmetry restrictions [12]. Due to the large number of parameters to estimate we do not report the estimation results here but will show in the next section budget share elasticities and cost of living changes, which are estimated directly from the demand system.

As we are interested in estimating cost of living indexes and price elasticities for different segments of the population and in particular for retirees and workers separately, we include among the household demographic characteristics in the demand system, a dummy that takes the value 1 if the household head is retired and 0 if still in-work and the household size.

3.5.3 Estimating the cost of living

The cost of living index resulting from the EASI specification can be expressed in terms of observables and parameters and thus could be recovered from the data. Define $\boldsymbol{p_t}$ as prices at time t, then $(\ln p_1^j - \ln p_0^j)$ measures the percentage change in prices between the benchmark period ($t = 0$) and period 1. From equation 3.4, the cost of living index in our empirical application is defined by the following equation:

[12] See Appendix for a test of negativity of demand

$$\ln\left[\frac{C(\boldsymbol{p_1},u,\mathbf{z},\epsilon)}{C(\boldsymbol{p_0},u,\mathbf{z},\epsilon)}\right] = \sum_{j=1}^{J} w_0^j(\ln p_1^j - \ln p_0^j) + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{J}\left(\sum_{h=1}^{H} a^{jkh}z_h + b^{jk}y\right)(\ln p_1^j - \ln p_0^j)(\ln p_1^j - \ln p_0^j) \tag{3.8}$$

We can simplify this expression by taking initial prices equal to 1, i.e $\boldsymbol{p^0} = \boldsymbol{I_J} = [1, 1,...,1]'$. The cost of living index can then be expressed as:

$$\ln\left[\frac{C(\boldsymbol{p_1},u,\mathbf{z},\epsilon)}{C(\boldsymbol{p_0},u,\mathbf{z},\epsilon)}\right] = \sum_{j=1}^{J} w_0^j \ln p_1^j + \frac{1}{2}\sum_{j=1}^{J}\sum_{k=1}^{J}\left(\sum_{h=1}^{H} a^{jkh}z_h + b^{jk}y\right)\left(\ln p_1^j\right)^2 \tag{3.9}$$

Note that the first term of the right hand side of equation 3.9 is identical to the household specific inflation rate calculated in section 3.4.2 . The second term captures the substitution effect across goods and can be either zero (implying no substitution), positive (little substitution) or negative (large substitution). The degree on which the household specific inflation under or over estimates the cost of living is thus given by the second term in equation 3.9.

Budget share price elasticities for pensioners and those in-work can be recovered from the demand estimation (see Table 3.2) using the following expression:

$$\frac{\partial w^j}{\partial \ln p^k} = \sum_{h=1}^{H} a^{jkh}z_h + b^{jk}y \tag{3.10}$$

Note that in our empirical specification budget share elasticities vary not only with real expenditure, y, but also with observed characteristics, $\mathbf{z}$. Table 3.2 shows budget share own-price elasticities for pensioners and those in-work. There are marked differences between pensioners and workers budget share own-price elasticities. Take for example the case of catering: whilst a 10% increase in the price of catering results in an increase of 3.8 percentage points in the catering expenditure share for workers, the figure is -9.5 for pensioners. This suggests that pensioners substitute away from catering more than workers. On the other hand, a 10% increase in the price of fuel and light results in a 4.5 percentage points increase in the budget share of fuel for pensioners while the figure is 2.3 for workers

[13]. Whilst a 10% increase in the price of leisure services results in a 7.2 percentage points decline in its budget share for pensioners, it results in a 6.8 percentage points increase in the budget share among workers. Another noticeable difference is in the price elasticity of rent, while workers decline their rent share after a price increase, rent budget share increases by 1.7% points among pensioners in reaction to a 10% increase in price.

Luxury goods, like catering or household goods, are more elastic to price changes than necessities. A 10% increase in the price of alcohol results in a decline of 8.0 percentage points in its budget share for pensioners and 16.0 for workers. Finally, there are goods for which price elasticities are similar between workers and pensioners, among them: eggs, fruit, household goods and household services.

Figures 3.9, 3.10, 3.11 and 3.12 show estimated budget share own-price elasticity distributions for the 33 goods. They give a similar picture as Table 3.2 in terms of the price sensitivity of workers and pensioners but also show the substantial variation within the two group of consumers. Pensioners are more price sensitive than workers for pork, other food, soft-drinks and confectionery and fruit among food categories. Workers are particularly sensitive to price changes in rent and, as well as pensioners, to changes in the price of household goods. Note in particular the case of catering, while practically all households with a working head show positive own-price elasticity, all pensioner household reduce their catering budget share as a result of price increases. The case of fuel and light is also interesting, not only due to the fast price increase over the last 5 years but also because it shows that pensioners are not able to substitute away from fuel and light as a result of price increases.

[13]Qualitatively similar results are found by Beatty et al. (2011). The authors find that poorer old households are not able to smooth consumption when experiencing income shocks captured by extreme cold temperatures. They find that households respond to a cold shock by increasing fuel expenditure and reducing food spending.

Table 3.2: *Estimated budget share own-price elasticities (Mean, in %)*

	In-work	CI 95%	Retired	CI 95%
Bread	0.068	[0.065;0.071]	0.654	[0.649;0.659]
Cereals and biscuits	1.181	[1.18;1.182]	2.178	[2.177;2.179]
Beef	0.341	[0.339;0.343]	0.273	[0.271;0.275]
Lamb	-0.104	[-0.105;-0.103]	-0.242	[-0.243;-0.241]
Pork	0.079	[0.078;0.079]	-0.088	[-0.088;-0.088]
Bacon	-0.046	[-0.046;-0.045]	0.204	[0.203;0.205]
Poultry	-0.388	[-0.39;-0.385]	-0.403	[-0.406;-0.4]
Other meat	0.829	[0.829;0.83]	0.034	[0.033;0.035]
Fish	-0.128	[-0.13;-0.126]	0.476	[0.473;0.48]
Fats	0.079	[0.079;0.08]	0.348	[0.347;0.349]
Cheese	0.093	[0.092;0.093]	0.551	[0.551;0.552]
Eggs	0.138	[0.137;0.138]	0.128	[0.127;0.128]
Milk	0.155	[0.149;0.16]	0.898	[0.89;0.905]
Tea and coffee	0.169	[0.169;0.17]	0.281	[0.28;0.282]
Soft drinks and confectionary	0.053	[0.047;0.059]	-6.394	[-6.404;-6.384]
Vegetables	1.188	[1.185;1.191]	1.746	[1.742;1.751]
Fruit	0.620	[0.62;0.621]	0.543	[0.542;0.543]
Other food	3.174	[3.16;3.188]	3.954	[3.933;3.976]
Catering	3.766	[3.756;3.776]	-9.462	[-9.477;-9.447]
Alcohol	-16.010	[-16.034;-15.986]	-8.046	[-8.07;-8.021]
Tobacco	1.553	[1.551;1.556]	2.848	[2.843;2.852]
Rent	-4.875	[-4.884;-4.865]	1.702	[1.687;1.718]
Mortgage interest payments	4.845	[4.838;4.852]	1.805	[1.793;1.817]
Other housing	1.818	[1.803;1.833]	2.054	[2.028;2.08]
Fuel and light	2.284	[2.275;2.293]	4.510	[4.494;4.525]
Household goods	-21.594	[-21.649;-21.54]	-22.990	[-23.084;-22.895]
Household services	5.802	[5.787;5.817]	5.802	[5.777;5.827]
Clothing and footwear	2.370	[2.345;2.396]	3.327	[3.299;3.354]
Personal goods and services	-6.749	[-6.762;-6.736]	-12.428	[-12.448;-12.409]
Motoring expenditure	23.955	[23.935;23.975]	14.845	[14.81;14.88]
Fares and other travel costs	-1.145	[-1.158;-1.132]	-1.819	[-1.842;-1.796]
Leisure goods	-4.221	[-4.249;-4.194]	-0.430	[-0.466;-0.395]
Leisure Services	6.764	[6.74;6.789]	-7.202	[-7.244;-7.16]

Note: The column "95% CI" shows the 95% confidence interval for the mean predicted value

Figure 3.9: *Estimated budget share own-price elasticities*

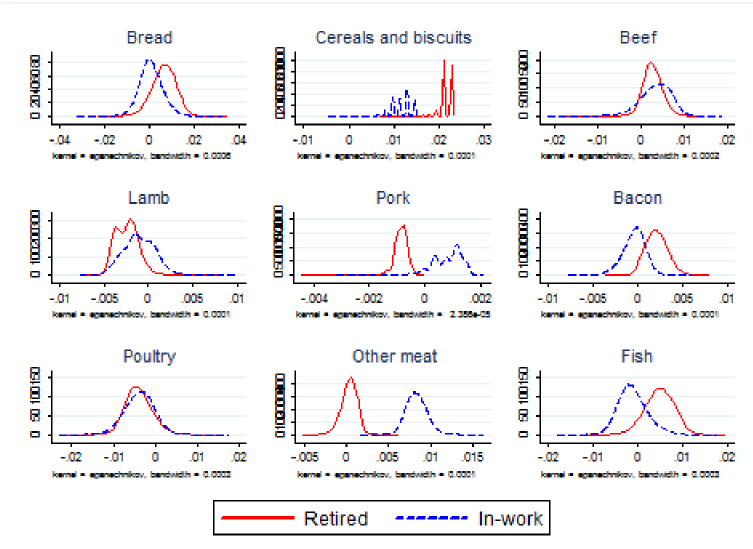


Figure 3.10: *Estimated budget share own-price elasticities*

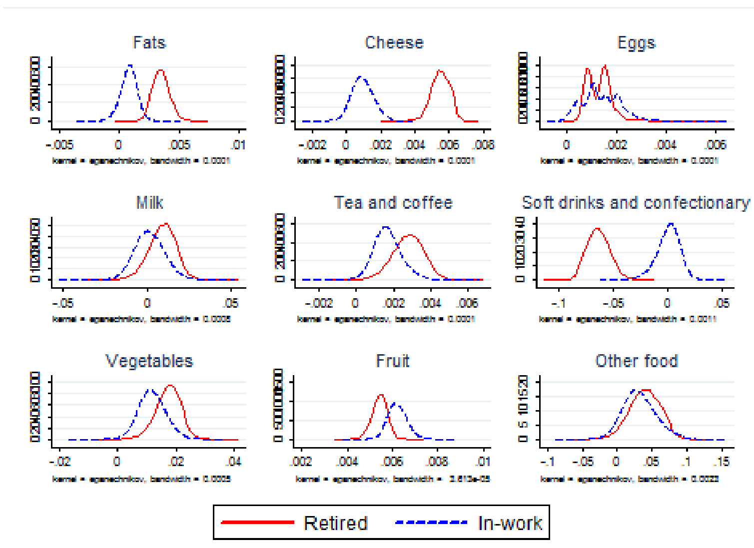


Figure 3.11: *Estimated budget share own-price elasticities*

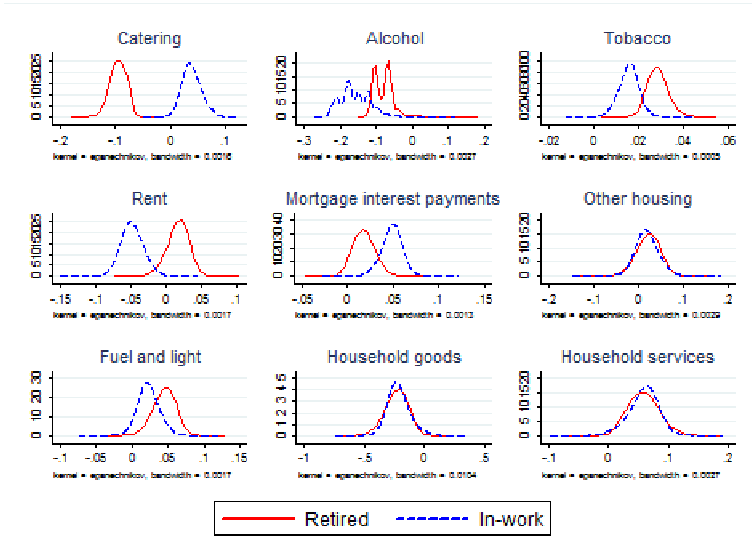


Figure 3.12: *Estimated budget share own-price elasticities*

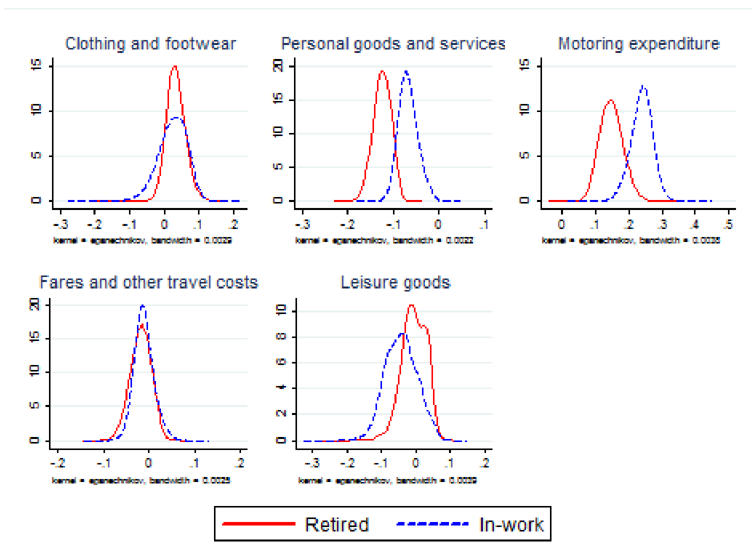


Table 3.3 shows the estimated COLI, together with its decomposition in the household specific inflation (first term of equation 3.9) and the substitution effect (second term of equation 3.9), for the whole sample, pensioners and those still in-work. First, not consider-

ing the substitution effect amounts to an error in the measure of the average cost of living of between -0.01 (or -0.30%) - estimated in 1995 - and 0.38 (or 11.0%) percentage points - in 2008. This masks some differences between workers and pensioners substitution behaviour which is closely related to differences in the own and cross price elasticities of the two group of consumers.

The differences in terms of household prices and substitution effect translate in differences in terms of cost of living between pensioners and workers. Results are summarized in Figure 3.13.

Table 3.3: *Change in Cost of living by labour market status: Retired and In-Work*

	ALL			RETIRED			IN-WORK		
	COLI	Household inflation	Substitution effect	COLI	Household inflation	Substitution effect	COLI	Household inflation	Substitution effect
1990	8.80%	8.75%	0.05%	9.06%	9.00%	0.06%	8.73%	8.68%	0.05%
1991	5.22%	5.20%	0.02%	6.11%	6.12%	-0.01%	4.97%	4.94%	0.03%
1992	2.41%	2.37%	0.04%	3.18%	3.15%	0.02%	2.15%	2.11%	0.04%
1993	2.05%	2.01%	0.04%	2.30%	2.27%	0.02%	1.97%	1.93%	0.04%
1994	2.82%	2.78%	0.03%	2.52%	2.49%	0.02%	2.91%	2.88%	0.04%
1995	3.34%	3.36%	-0.01%	3.28%	3.30%	-0.02%	3.37%	3.37%	-0.01%
1996	2.00%	1.95%	0.04%	2.37%	2.36%	0.02%	1.89%	1.83%	0.05%
1997	3.49%	3.30%	0.19%	2.14%	2.04%	0.10%	3.93%	3.71%	0.22%
1998	2.15%	2.14%	0.01%	2.17%	2.16%	0.01%	2.14%	2.14%	0.00%
1999	0.92%	0.87%	0.05%	1.30%	1.26%	0.04%	0.81%	0.76%	0.05%
2000	2.62%	2.47%	0.15%	1.77%	1.68%	0.09%	2.90%	2.73%	0.17%
2001	0.31%	0.17%	0.14%	1.70%	1.64%	0.07%	-0.09%	-0.26%	0.17%
2002	1.97%	1.95%	0.02%	2.02%	2.00%	0.02%	1.96%	1.93%	0.03%
2003	2.12%	2.10%	0.02%	2.08%	2.07%	0.01%	2.13%	2.11%	0.02%
2004	3.47%	3.28%	0.19%	2.34%	2.22%	0.12%	3.96%	3.74%	0.22%
2005	2.12%	2.10%	0.02%	2.35%	2.32%	0.04%	2.02%	2.00%	0.02%
2006	5.16%	5.00%	0.16%	5.01%	4.81%	0.20%	5.21%	5.06%	0.15%
2007	3.87%	3.74%	0.12%	2.87%	2.78%	0.09%	4.29%	4.15%	0.14%
2008	3.46%	3.08%	0.38%	6.35%	5.96%	0.39%	2.02%	1.65%	0.37%
2009	2.65%	2.28%	0.37%	3.12%	2.90%	0.22%	2.43%	1.99%	0.44%

Figure 3.13: *Change in cost of living index by labour market status: 1990-2009*

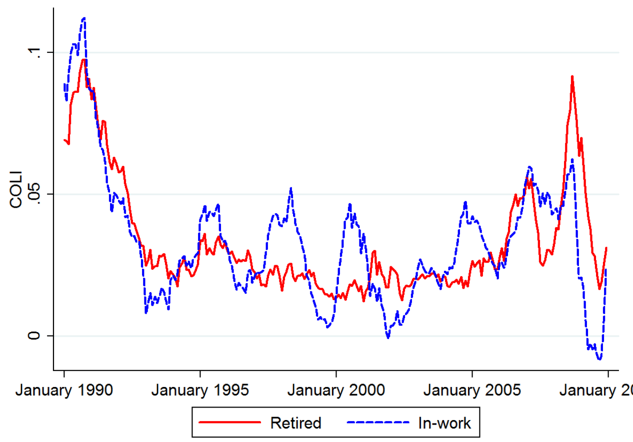
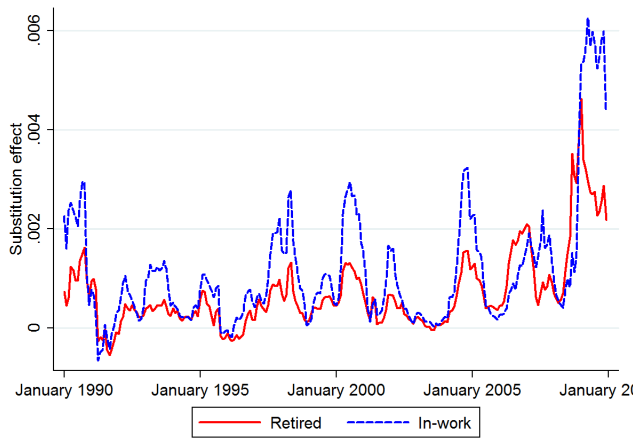


Figure 3.14 shows the substitution effect over time for workers and pensioners. Substitution effects are not large but do fluctuate over time due to changes in relative prices and variations in the inflation of the different components of the consumption basket. The relatively high substitution effect[14] of both pensioners and workers during the beginning of the 1990s is mostly due to high inflation of items for which both pensioners and workers are price sensitive, such as alcoholic drinks, personal goods and services and certain food items like poultry and soft-drinks and confectionery. Another interesting period is between the mid of the 1990s and early 2005 during which we can identify three clear periods in which workers substitute less than pensioners basically because of high inflation of mortgage interest payments an item that has less weight in the pensioners basket and with a lower own-price elasticity. During these three periods mortgage interest payment inflation fluctuated between 15% and 34%. Finally, the reason of the high peak during the last year of the sample period is the high inflation of fuel and light and most food items during 2008 and 2009. Indeed, during that period there is a combination of high inflation of fuel and light, reaching almost 40% by the end of 2008, and high inflation in food items, reaching for example 24% for beef, 21% for pork, 20% for bread and 16% for milk and milk products. Explaining the low substitution effect during this period is the fact that pensioners do not substitute away from fuel and light price increases. The lower substitution effect for workers during those years is due to deflation in mortgage interest payments.

[14]Recall that negative values of the substitution effect means that households substitute away from goods that become relatively expensive towards goods that are relatively cheaper.

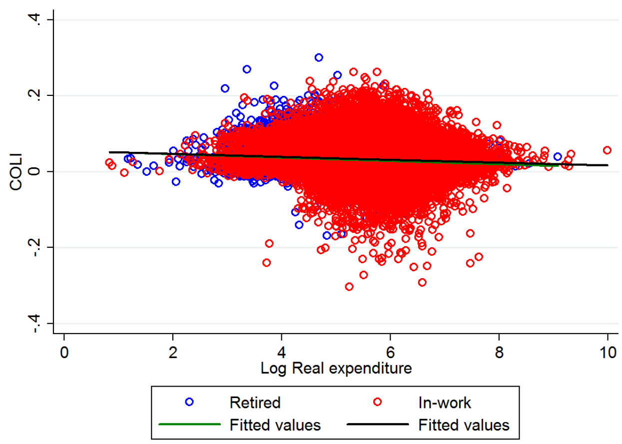
Figure 3.14: *Substitution effect by labour market status: 1990-2009*



Our results suggest that the substitution bias is, on average, not important. A potential issue with our data is the fact that as we are working with relatively aggregated expenditure data (i.e. 33 goods) we are only considering substitution between these 33 goods and not allowing for substitution within goods. In other words, we are estimating the substitution between, for instance, lamb and pork but not considering substitution between different cuts of pork or lamb. That feature of our data means that we could be underestimating the substitution bias. Comparing results with other UK studies suggest that the potential underestimation is not substantial. Blow and Crawford (2001) use revealed preference and 62 commodities to estimate the substitution bias in the RPI. They give confidence intervals for the COLI estimated non-parametrically and find that the substitution bias amounts to between 0.1 and 0.35 percentage points in 1977 and between 0.22 and 0.11 in 1993, the year when the error is the greatest in percentage terms. Moreover, there are 3 years in their data for which the rate of inflation measured by the household specific inflation is within the bounds of the estimated COLI. A second paper that estimates the bias between the COLI and different price indexes is Blundell et al. (2003). They estimate COLI non-parametrically using 22 different commodities and find that the substitution bias is in order of magnitude close to our results using a parametric model and 33 items.

Figure 3.15 and 3.17 show the change in cost of living and the substitution effect respectively by total non-durable real expenditure (in logs) for all the years in our sample: 1990-2009. First, the average masks substantial variation in the change of cost of living for both workers and pensioners, with a maximum of 34.6% and a minimum of -14.4%. Second, pooling together all the years, the change in cost of living is negatively correlated with expenditure. A simple OLS regression of COLI and log real expenditure gives a statistically significant coefficient of -0.0007727 [15]. Finally, Figure 3.16 shows the change in cost of living by total non-durable expenditure for each sample year. It is clear from this graph that Figure 3.15 masks differences in the relationship between COLI and log real expenditure by year. While expenditure is strongly negative correlated with COLI in 1992 and 2009, the relation is flat in 1997 and 2004, it is positive correlated in 2005, 2006 and 2007.

Figure 3.15: *Change in cost of living index by labour market status and expenditure*



[15] This mild negative correlation does not show in the graph due to the scale. See Figure 3.21 in the Appendix for more details

Figure 3.16: *Change in cost of living index by labour market status and expenditure: by year*

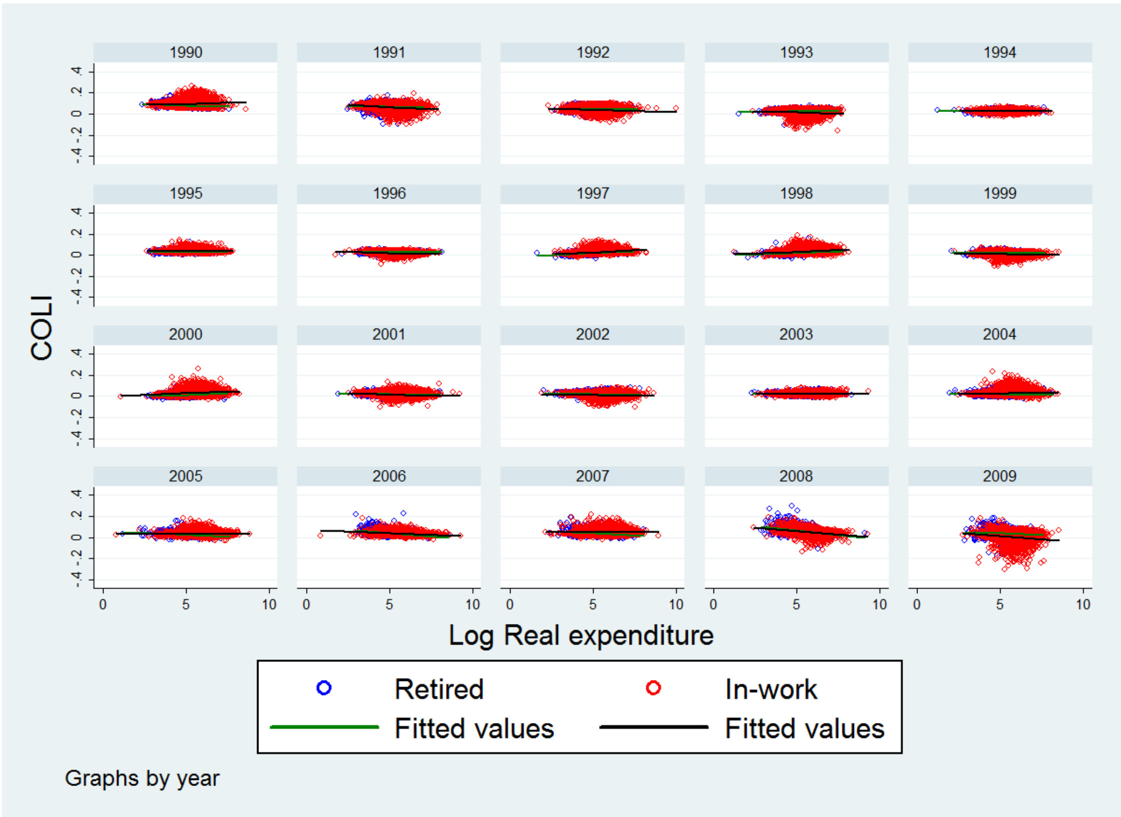


Figure 3.17 shows the positive correlation between the substitution effect and real expenditure for the whole sample. First, as for the COLI, Figure 3.17 masks differences over time. While the substitution effect is negatively correlated with expenditure in all the years until 2003, it is positively correlated from 2003 to 2009 (See Figure 3.18)[16]. A second interesting feature of the results is that the variance of the substitution effect is increasing over time and particularly from 2006. This is due to the increasing variance in the evolution of prices since 2006 and particularly in 2008 and 2009.

[16]See Figure 3.22 in the Appendix

Figure 3.17: *Substitution effect by labour market status and expenditure*

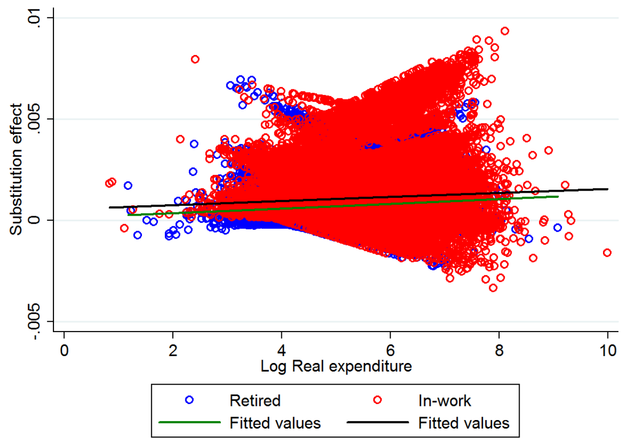
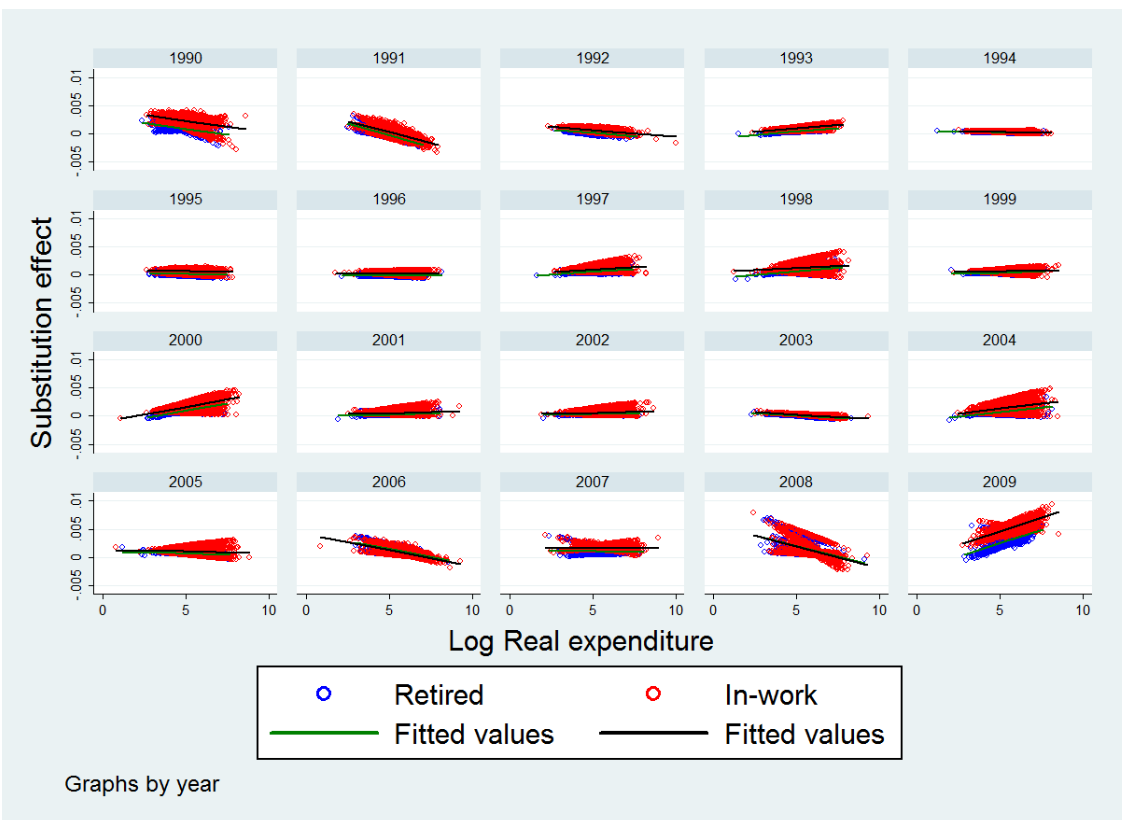
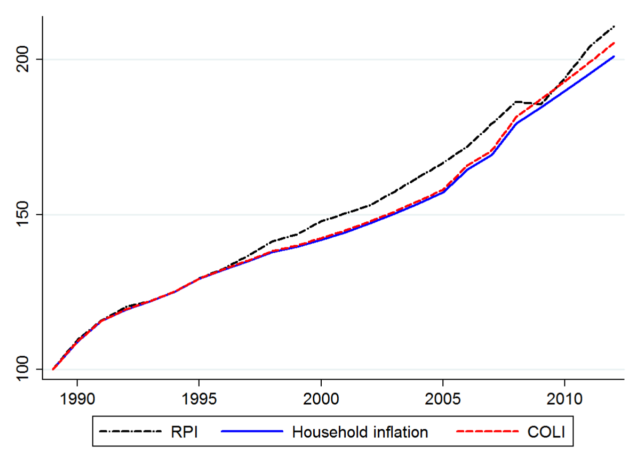


Figure 3.18: *Substitution effect by labour market status and expenditure: by year*



Assume that the representative pensioner receives 100 in pension income in 1989 that is then adjusted by different cost of living measures. What would be her income in 2009 if the adjustment is based on headline inflation (RPI), her specific household inflation or the cost of living index resulting from our demand system estimation? Figure 3.19 shows pension income under the three alternative indexation metrics [17]. At least during the period 1990-2009, adjusting pension income by the RPI results in a higher income than adjusting by the cost of living index or household inflation. The major difference between headline inflation and the other two metrics is in 2004 when the difference of adjusting pension income by the RPI or household inflation is 10.2%. The figure is 10.3% when we compare income adjusted by the RPI and the cost of living index. The difference is subsequently reduced, particularly in 2008-2009. The sharp reduction in 2008 and particularly in 2009 is due to the fact that there is deflation measured by the RPI while both the cost of living change and household inflation are 1.3% in 2009. The decline in the RPI during that year is explained by an average decline of 42% in mortgage interest payments price index, an item that has less weight in pensioners' consumption basket than in the RPI.

Figure 3.19: *Pension indexation under alternative measures: 1989-2009*



3.6 Conclusions

We document the expenditure life-cycle profile in the United Kingdom and show how differences in the consumption bundle of pensioners and workers translates into different inflation

[17] We use for the adjustment of pension income the average annual change for each of the three measures

experiences. On average during the whole period, pensioners inflation has been 0.1 percentage points higher than workers but there are substantial differences in given years. The year with the largest difference between the two groups is 2009 in which pensioner inflation is 3.1% and worker inflation is -0.3%.

In the second part of the paper we estimate cost of living indexes for pensioners and workers in order to better understand pension income requirements. We then estimate an EASI Marshallian demand system and compute the change in the cost of living and the substitution effect for both pensioners and workers for the period 1990-2009. According to our results, not considering the substitution effect amounts to an error in the measure of the average cost of living of between -0.01 (or -0.30%) - estimated in 1995 - and 0.38 (or 11.0%) percentage points - in 2008. This masks some differences between workers and pensioners substitution behaviour, which is closely related with the differences in own and cross price elasticities of the two groups of consumers. Although we do not find important differences over the long run, there are major differences in terms of cost of living between pensioners and workers in given years.

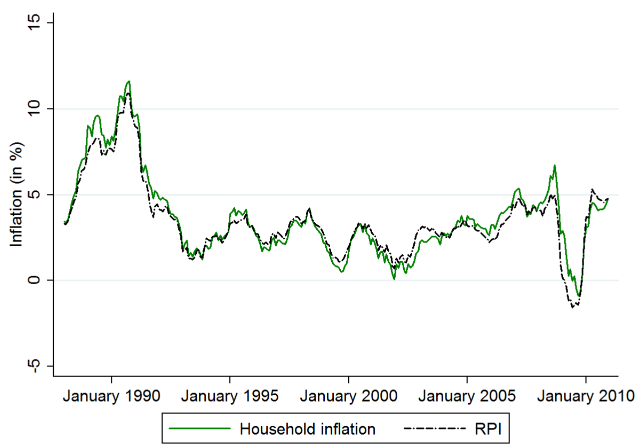
Finally, we show how pension income would evolve during the period 1990-2009 under three alternative indexation measures: headline inflation - RPI -, household specific inflation and cost of living estimated from the demand system. At least during the period 1990-2009, adjusting pension income by the RPI results in a higher income than adjusting by the cost of living index or household inflation.

3.7 Appendix

Average household inflation vs RPI

Figure 3.20 shows average household inflation and RPI inflation over time. Our household inflation measure follows the RPI quite close. The slim differences in the average household inflation and RPI over time are due to small differences in how the ONS computes the RPI and how we compute household inflation. First, due to data availability we do not consider depreciation. Second, households at the top 4% of the income distribution and pensioners that derive more than three quarter of their income from state benefits are not considered by the ONS for the calculation of the RPI. Third, the ONS use other data sources besides the expenditure survey we use to compute expenditure shares. Finally, we use what is called a democratic measure of household inflation (unweighted average) and the ONS use a plutocratic one (weighted average, more heavily influenced by households that spend the most). See Leicester et al. (2008) for more details about the differences.

Figure 3.20: *Average household inflation vs RPI: 1988-2010*



Negativity of demand

We can check for negativity of demand using the normalized Slutsky matrix. Note that Slutsky compensated own price elasticities should be negative to assure negativity of demand. Within the EASI demand system, the components of the normalized Slutsky matrix are given by:

$$S_{ij} = \frac{\partial w^i}{\partial \ln p^j} + w^i w^j - w^i I_{i=j} \tag{3.11}$$

Where $I_{i=j}$ is an indicator function equal to 1 if $i = j$ and 0 otherwise. Table 3.4 shows the average own price Slutsky terms resulting from the demand system estimation:

Table 3.4: *Own price normalized Slutsky terms*

Bread	-0.0066
Cereals and biscuits	-0.0029
Beef	-0.0036
Lamb	-0.0043
Pork	-0.0026
Bacon	-0.0037
Poultry	-0.0106
Other meat	-0.0077
Fish	-0.0064
Fats	-0.0029
Cheese	-0.0029
Eggs	-0.0009
Milk	-0.0124
Tea and coffee	-0.0035
Soft drinks and confectionary	-0.0331
Vegetables	-0.0072
Fruit	-0.0052
Other food	0.0199
Catering	-0.0417
Alcohol	-0.1743
Tobacco	-0.0012
Rent	-0.0581
Mortgage interest payments	-0.0067
Other housing	-0.0154
Fuel and light	-0.0269
Household goods	-0.2831
Household services	0.0066
Clothing and footwear	-0.0199
Personal goods and services	-0.1184
Motoring expenditure	0.1254
Fares and other travel costs	-0.0321
Leisure goods	-0.0729

Cost-of-living and substitution effect according to expenditure

Figure 3.21 shows the coefficients and confidence interval resulting from a linear regression of cost of living index and log real expenditure for each year between 1990 and 2009. Figure 3.22 shows the coefficients and confidence interval resulting from a linear regression of the substitution effect and log real expenditure for each year between 1990 and 2009.

Figure 3.21: *Coefficients and confidence interval: COLI*

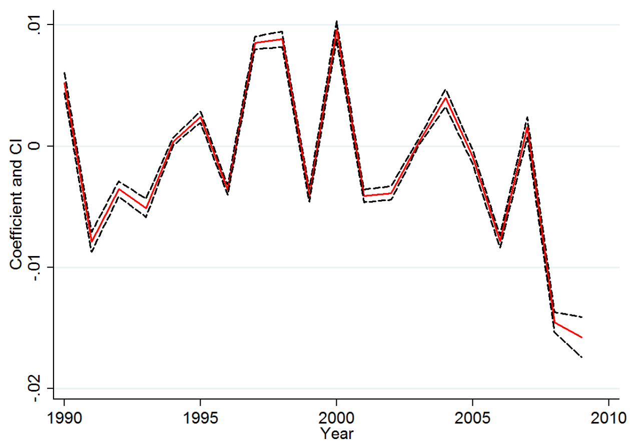
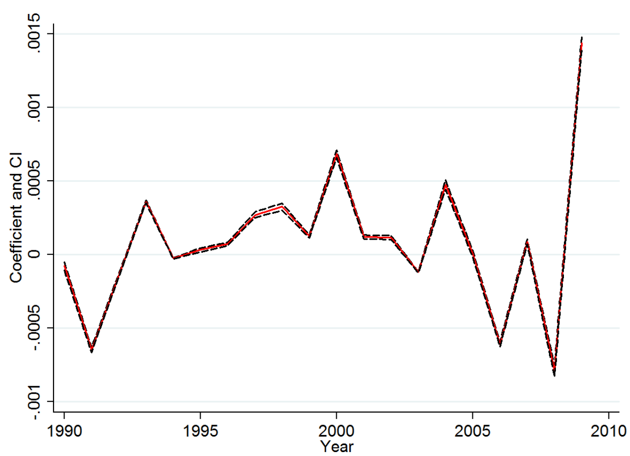


Figure 3.22: *Coefficients and confidence interval: Substitution effect*



Retail Price Index Sections

Table 3.5: *RPI Sections*

FOOD	HOUSING	MOTORING EXPENDITURE
Bread	Rent	Purchase of motor vehicles
Cereals	Mortgage interest payments	Maintenance of motor vehicles
Biscuits	Council tax and rates	Petrol and oil
Beef	Water and other charges	Vehicle tax and insurance
Lamb	Repairs and maintenance charges	FARES AND OTHER TRAVEL COSTS
Pork	Do-it-yourself materials	Rail fares
Bacon	Dwelling insurance and ground rent	Bus and coach fares
Poultry	FUEL AND LIGHT	Other travel costs
Other meat	Coal and solid fuels	LEISURE GOODS
Fish	Electricity	Audio-visual equipment
Butter	Gas	CDs and tapes
Oil and fats	Oil and other fuels	Toys, photographic and sports goods
Cheese	HOUSEHOLD GOODS	Books and newspapers
Eggs	Furniture	Gardening products
Fresh milk	Furnishings	LEISURE SERVICES
Milk products	Electrical appliances	TV licences and rentals
Tea	Other household equipment	Entertainment and other recreation
Coffee	Household consumables	
Soft-drinks	Pet care	
Sugars and preserves	HOUSEHOLD SERVICES	
Sweets and chocolate	Postage	
Potatoes	Telephones, telemessages,etc	
Other vegetables	Domestic services	
Fruit	Fees and subscriptions	
Other food	CLOTHING AND FOOTWEAR	
CATERING	Men's outwear	
Restaurants	Women's outwear	
Canteen	Children's outwear	
Takeaway	Other clothing	
ALCOHOL	Footwear	
Beer	PERSONAL GOODS AND SERVICES	
Wine and spirits	Personal articles	
TOBACCO	Chemists goods	
Cigarrettes	Personal services	
Other tobacco		

Part II

Diets and physical activity in England

Chapter 4

Gluttony or Sloth? Long-run changes in bodyweight, diet and activity

4.1 Introduction

There has been a marked increase in bodyweight, and in rates of overweight and obesity, across much of the developed world. In the UK over 25% and in the US over 30% of adults are obese and in the UK over 60% and in the US almost 70% are overweight.[1] Excess weight is a result of a caloric imbalance between calories ingested and calories expended. The literature has focused on excess calorie consumption (Cutler et al. (2003), Duffey and Popkin (2011), Swinburn et al. (2009)).

Why is it important to study nutrition and obesity from the perspective of Economics? First, obesity is currently a public health problem. It is related to cardiovascular diseases, hypertension, diabetes, joint problems and increased mortality. Second, some studies (Bhattacharya and Sood (2011)) have found that obesity is also correlated with lost workplace productivity. Finally, obesity is an externality in health insurance. The Department for Environment, Food and Rural Affairs (DEFRA) estimates that the cost of obesity and overweight in 2008 in the UK amounted to GBP 8 billion. All these factors point to the need of a better understanding of the factors behind the increase in obesity during the last 30 years.

Long-run studies of nutrition, bodyweight and physical activities are hampered by the

[1] From OECD Health Data 2011. Obesity is defined using the Body Mass Index (BMI). BMI is weight in kilos squared divided by height in meters. A BMI over 25 is overweight and over 30 is obese.

lack of micro data. We compile a unique time series of microdata on calorie and food purchases spanning over more than 30 years. Using a combination of food diary data and information on its nutritional content, we are able to track calorie purchases of English households from over 200 food categories. There are several advantages to the use of this data source: first, recording food purchases is less sensitive to underreporting due to the social desirability of healthy eating behaviours. The existence of such underreporting – between 15.7% for women and 9.5% for men relative to recommended intakes– is well-known in surveys of nutrient intakes (Bingham et al. (1995); Briefel et al. (1997); Rennie et al. (2007)). Second, most studies of long-run trends in diet and nutrition are based on food availability data which records food production and trade and computes food for human consumption as a residual. Several studies show that while initially a good proxy for average calorie consumption, food availability data overestimates trends in calorie consumption in many countries, e.g. in India (Deaton and Dreze (2010)), Japan (Dowler and Seo (1985)) and the US (Crane et al. (1992)) [2]. Third, a micro-based aggregation avoids aggregation biases in macrodata which arise from lack of information about the heterogeneity across population subgroups (Blundell et al. (1993)).

Even where microdata (over a shorter time period) is available, nutrition data is often partial. The second unique feature of our data compilation is that we measure calories from food at home purchases over the whole time series, but are also able to fill the gap of knowledge about calories from other foods and drinks, i.e. eating out and alcohol. Using a combination of observed and imputed data, we are able to fill the gap of knowledge about calories from alcohol and - even more fundamentally- from eating out. Thus, we are adding information on food and drinks groups that account for around 40% of total food spending, and -as we will show- for around 18 to 20% of calories.

In addition to this detailed household-level data on food and calorie purchases, we document jointly data on bodyweight, calorie purchases and calories expended in different activities exploiting various data sources. This allows us to extend and expand on the macroeconomic analysis by Bleich et al. (2008), and allows us to look at the joint trends in bodyweight, calorie purchases and calories expended in activity.

We show that there has been a substantial *decrease* in total calories purchased. This affects most food categories, but there are substantial shifts in diet composition. The

[2]See Appendix where we show the trends using microdata versus Food Agriculture Organization aggregate food balance sheets data and also find that levels in 1980 are similar, but trends are massively diverging with a positive FAO trend and a negative NFS one in the UK

increase in some calorie-dense categories, like fast food, snacks and drinks, is more than offset by a decrease in other categories, including sugary products like jam and honey and fats and increasing weights of fruit and vegetables, fish and cereals in diets. We also find that about 10% of the decline in calories is due to reduced calorie density of food items due to within-category substitution from higher to lower calorie density products or increased offers of healthy varieties of a food item.

This finding leads to a puzzle; if calories are declining why are people gaining weight? We provide evidence that changes in time use and the strenuousness of activities resulted in an even greater reduction in calories expended, leading to an excess of calories. Changes in the nature of work and leisure, housework and other activities, have lead to substantial reductions in the strenuousness of daily life.

We document a decline in labour force participation and strenuousness of work for men that plausibly explains the observed weight gain. For women, the increase in labour market participation has mean a shift towards less strenuous activity, away from housework. Together with these trends we observe an increase in sedentary activities over time, such as watching TV and sleeping. It is important for policy formation to understanding what factors have driven the rapid rise in obesity. These results do not say that food is not a problem, but that policies aimed to tackle the obesity problem should look at both sides - calorie ingestion and expenditure.

Our work relates to several literatures.The literature from the US suggests that the declining cost of food plays an important role. In a highly cited paper, Cutler et al. (2003) stress changes in technology that have reduced the time and financial costs of calorie consumption, and argue that the amount of calories expended in work and exercise has remained roughly constant. Counter to this Lakdawalla and Philipson (2009) and Lakdawalla et al. (2005) suggest that 60% of weight growth due to declining physical activity. Lakdawalla and Philipson (2007) suggest that job-related exercise affects weight.

Other work suggests that obesity has increased most among married women, that countries with more regulation supporting traditional agriculture and delivery systems have lower rates of obesity and that sociodemographic changes are important, including female labor force participation and urbanisation (see for instance: Ewing et al. (2003), Cutler et al. (2003), Bleich et al. (2008) and Baum and Chou (2011)).

Brunello et al. (2009) study the relationship between obesity and family background and find that maternal education and weight are related to obesity among young Europeans. Finkelstein and Zuckerman (2008) argue that the rise in obesity in the US is due to the combination of declining food costs, particularly of processed high-calorie foods, and an increasing use of technology that makes the economy more productive but the population more sedentary. The authors state that this results in an imbalance between calories consumed and calories burned that explains the increase in bodyweight in the US over the last 30 years. Similarly, Philipson and Posner (2003) state that obesity is the result of choices that the individual makes and emphasize the impact of the economic environment on these choices. They then argue that the increase in obesity could be explained by the lower cost of food intake and the increasing cost of physical activity due to technological change. Using data from the first three waves of the US National Health and Nutrition Examination Surveys, Rashad (2006) estimates a model of the determinants of adult obesity and finds that caloric intake, physical activity and smoking are determinants of obesity. They find that older people, blacks, Hispanic females and married males are more likely to have a higher BMI. On the other hand, BMI is negatively correlated with education and, only for women, income. The author also states that the increase in the availability of restaurants and the decline in food prices are also important contributors to the increase in obesity. By estimating a cross-country demand system, Seale et al. (2003) analyze how low, middle and high-income countries food consumption respond to changes in income and food prices. They find that both income and price elasticities for food items are larger in poorer countries. Finally, Chou et al. (2004) and Baum and Chou (2011) suggest that increasing relative price of smoking accounts for 4% of weight increase.

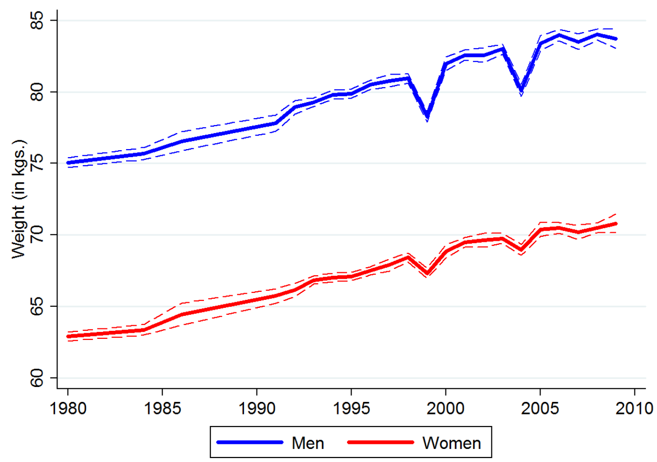
The structure of the rest of the paper is as follows. The next section shows the increase in bodyweight over time. Section 4.3 presents the data on calories and shows that there has been a substantial decline in calories purchased. Section 4.4 discusses the determinants of bodyweight. Section 4.5 presents data on energy expenditure by activity and shows that there have been substantial declines in energy expenditure. A final section concludes. An accompanying appendix to this chapter provides details on the data, presents robustness checks and describes our calories imputation procedure.

4.2 Weight gain

We use several surveys to measure weight for the years 1980 to 2009. We use the Health Survey for England (HSE) to measure weight for the years 1992 to 2009 and we use additional sources for weight for the years previous to 1992: i) the Health and Lifestyle Survey (HALS) to obtain weight data in 1984-85 and in 1991-92, ii) the Dietary and Nutritional

Survey of British Adults (DNSBA) for weight in 1986-1987, and iii) the National Heights and Weights survey for weight in 1980. Due to missing information we intrapolate between missing years (1981-1983 and 1987-1991) [3]. Figure 4.1 shows the substantial rise in average weight over time amongst both men and women [4]. Men's average weight increased by 8.6 kilograms, from 75.1 in 1980 to 83.7 in 2009. On average, women gained 7.9 kilograms during that period, from 62.9 in 1980 to 70.8 in 2009. This corresponds to an average increase of around 12 and 13% respectively for men and women.

Figure 4.1: *Changes in bodyweight, men and women*



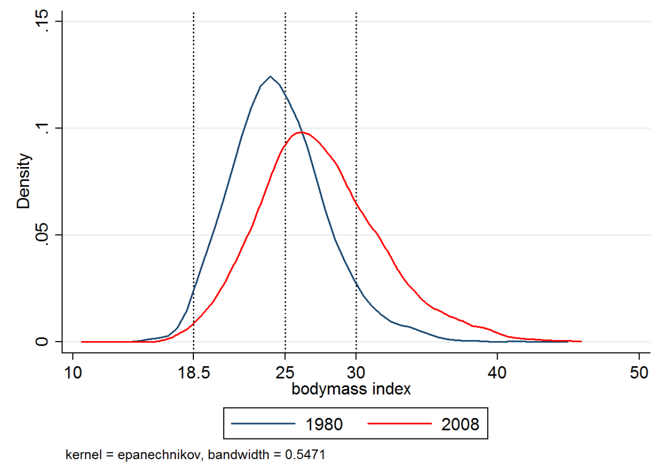
A comparison of the weight distributions in 1980 and 2008 illustrates the increase in average BMI as well as an increasing variance. For both genders, BMI distribution becomes less right skewed, as the percentage of men (women) of normal weight decreases by 41% (31%), as the population is gaining weight. Figure 4.2 quantifies the shifts between BMI categories: in 2008, 42% of men and 30% of women are overweight, an increase by 23 and 31% from 1980. The shift in BMI leads to an even more drastic increase in the percentage of the population that is obese: it increases from 6.5% to more than triple its size (23%) for men during this time period, and almost tripling from 8.2 to 23.3% for women.

[3] A detailed description of the data sources used in this section is presented in Section B.1.2 in the Appendix.

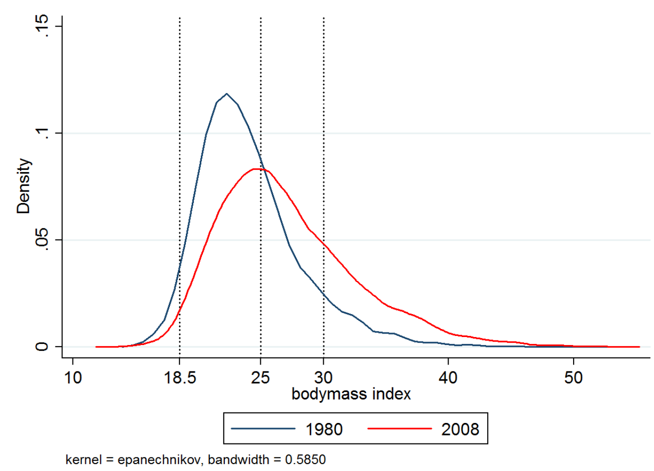
[4] We show weight in the graph but a similar trend is found looking at BMI. Average height has not changed much during the period under study

Figure 4.2: *Changes in the distribution of BMI, men and women*

(a) Men



(b) Women



Male bodyweight is increasing throughout our sample period for all age groups. Large weight gains are observed for men in all age brackets but in particular for the 30-59 age group. Men in that age group gained an average of 320 grams a year or a total of 9.3 kilograms between 1980 and 2009. Young men's weight increased 230 grams per year or 9% during that period. Finally, old-age men's average weight increased 290 grams per year reaching 83 kilograms in 2009; an 11% increase relative to 1980 (See Figure 4.3).

Figure 4.4 shows similar trends for women. As for men, we also observe a substantial weight increase for women but female weight gain is negatively correlated with age. While younger women gained 8.3 kilograms on average between 1980 and 2009, the figure is 8.1 and 5.8 for women aged 26-54 and women aged 55+ respectively. That represents an average increase of 286, 280 and 199 grams per year during the sample period.

Figure 4.3: *Weight by age: Men (in kgs.)*

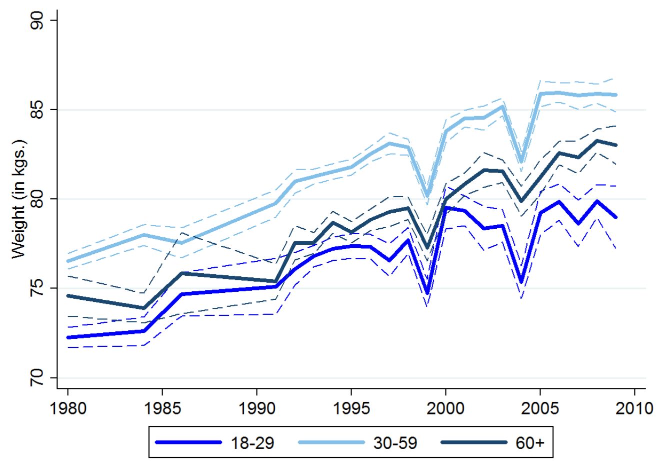
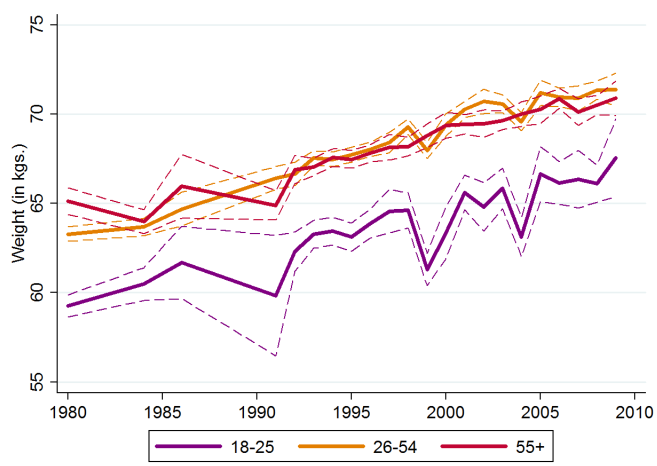


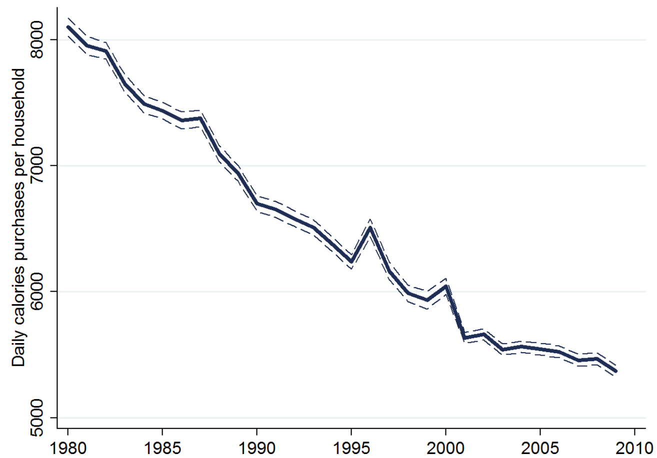
Figure 4.4: *Weight by age: Women (in kgs.)*



4.3 Gluttony?

Calories purchased have declined substantially over the past thirty years. Figure 4.5 shows for a representative sample of English households between 1980 and 2009 that mean daily calories per household have fallen by 30% over the last 30 years.

Figure 4.5: *Calories purchased per household per day, all foods and drinks*



Note: NFS/EFS/LCFS and own estimations (see Appendix A)

One of the problems that has confounded research in this area has been the lack of high quality data on calories purchased over a long time period. We observe food purchases and caloric content for English households in the National Food Survey (NFS) for 1980 to 2000 and in the Expenditure and Food Survey (EFS) and Living Costs and Food Survey (LCFS) for 2001 to 2009. The NFS/EFS/LCFS include information on expenditure, quantities and nutrient conversion factors on a large number of food groups back to 1980.[5] See a detailed description of the data used in the paper in the Appendix B.

Data on food purchases are reported at the household level. Over the time period between 1980 and 2009, average household size falls from 2.99 in 1974 to 2.36 by 2009, while the average number of children declines from 0.93 to 0.47. Comparing trends over time at the household-level could thus be misleading. Since individual calories and expenditures

[5] In fact the data go back to 1974, and on paper back to the 1940s. However, further work is needed to make the early years of data comparable to the later years.

are unobserved, we use the modified OECD equivalence scale [6] to account for household size in food spending.

For calorie purchases, there are only few studies looking at the mapping between individual and household-level calories (Chesher (1997) and De Agostini (2007) for the UK and Bonnet et al. (2013) for France). Since total calorie purchases of the household are the sum of its household members' purchases, $x_h = \sum_{i=1}^{N} x_{ih}$, individual calorie purchases can be expressed as a fraction w of household-level calorie purchases: $x_{ih} = x_h \cdot w_{ih}$. Since this fraction w is unobserved, many studies convert household-level calories into calories of an adult equivalent. It is defined as the sum of caloric needs of all individuals in the household divided by 2550, the Estimated Average Requirement (EAR) for energy of a man aged 19 to 50. However, estimated Average Requirements (EAR) for energy by age and sex differ strongly (see Table B.2 in the Appendix Section B.1.1). Using the equivalent adult representation suppresses this gender- and age-specific heterogeneity and thus presents a coarse proxy for individual calories.[7]

We avoid the additional assumptions required for an individual mapping of calorie purchases and follow a different approach: Table 4.1 shows the marked population shift across household types with an increasing number of single households (among young *and* older single households) and the parallel decrease in the prevalence of families and other households by around a 17 percentage points. Within (multi-person) household types, household size remains largely constant with declines in household size of at most 7.3% over 30 years (see Table 4.1). Similar conclusions can be inferred when looking at the proportion of household members that are female and average age. Since demographic change is concentrated in changes *across* and not *within* household types, we continue reporting calories at the household level, but differentiate diet and nutrition trends by household type to avoid overstating the calorie decline.

Table 4.2 shows that averaging across all households leads to an overestimation of the total decline in calories over the sample period as expected. For each household type, however, we find a sizeable decline in calories from all foods and drinks: they decline by

[6]This is a commonly used equivalence scale, especially in cross-country inequality analyses, which assigns a weight of 1 to the first adult in the household, a weight of 0.5 for each further adult and a weight of 0.3 to each child. Atkinson et al. (2002).

[7]An alternative method would be to compute individual weights based on an "optimal sharing" rule which assumes that food is allocated across household members according to the age- and gender-specific estimated Average Requirements outlined in Table B.2. The assumption underlying this method allocates calories according to a nutritionist definition of "need" but rules out alternative sharing rules, e.g. rules based on intra-household bargaining mechanisms. See Appendix Section B.1.1 for more details on this.

Table 4.1: *Changes in household composition, 1980 - 2009*

	1980	1990	2000	2009	1980-2009 (percentage change)
		Proportion of households by type			
single pensioner	14.54	14.98	17.70	20.47	5.93
single	3.42	6.43	8.67	7.45	4.03
lone parent	2.68	3.68	5.96	5.60	2.92
couple, no kids	30.26	33.06	32.28	34.48	4.22
family	31.50	25.69	22.78	19.61	-11.89
other	17.60	16.16	12.61	12.39	-5.21
		Average household size by type			
lone parent	2.78	2.73	2.78	2.74	-1.4%
family	3.98	3.94	3.94	3.81	-4.3%
other	4.09	3.87	3.79	3.79	-7.3%
		% of household members that are female			
single pensioner	75.3	70.8	66.0	62.0	-13.30
single	45.7	40.3	42.3	44.4	-1.30
lone parent	64.6	68.4	66.4	64.8	0.20
couple, no kids	51.4	50.7	50.5	50.5	-0.90
family	49.2	48.3	49.3	50.8	1.60
other	48.6	48.6	49.6	49.2	0.60
		Average age			
single pensioner	69.7	69.9	69.5	67.7	-2.87%
single	31.5	31.9	34.4	37.4	18.73%
lone parent	36.6	32.5	35.5	36.4	-0.55%
couple, no kids	54.9	53.4	55.7	57.7	5.10%
family	37.1	37.4	39.2	39.5	6.47%
other	51.8	50.7	52.4	52.0	0.39%

Notes: We consider six different household types: single (single household, less than 50 years old), single pensioner households (aged 50 or more), lone parents (one adult with kids), couple (two adults without kids), family (two adults with kids) and other.

21 to 26% in larger households and households with children and by 14 to 17% in one and two-person households.

Which diet changes lead to this calorie decline? We consider all sources of calories and differentiate three main groups: (i) food purchased for consumption at home, (ii) calories purchased for consumption out, including takeaways, soft drinks, confectionary and snacks, even if brought into the home (henceforth labeled "Eating out"), and (iii) alcohol, including both consumed at home and out.

Table 4.2: *Average trend and household heterogeneity in calorie purchases from all foods and drinks, 1980-2009*

Daily calories per household							
	all households	single	lone parent	couple	family	pensioner	other
1980	7674	2811	6795	6061	9931	3044	11311
1990	6254	2486	5485	5400	8439	2781	9423
2000	5559	2494	5699	5077	7871	2709	8658
2005	5430	2424	5405	5209	7895	2605	9055
2009	5259	2398	5346	5034	7553	2597	8333
Percentage change 1980-2009							
1980-2009	-31.47%	-14.71%	-21.33%	-16.93%	-23.94%	-14.70%	-26.32%

The comprehensive recording of diets in our data is noteworthy, as information about calories consumed (or purchased) from food that is eaten out or from alcohol is even more sparse than data on the nutrition composition of food consumed at home. Many studies are restricted to nutrients from food at home (Chesher (1997), De Agostini (2007)), the category which accounts for the majority of calories. If the margin between consuming food at home and eating out changes over time, a net decrease in calories from food at home may be overcompensated by increases in calories from other sources. For this reason, comprehensive data on calorie purchases is crucial for the study of long-run trends in diets and nutrition.

The lack of data often hampers the analysis of diet changes as the consumption margin between food eaten out and at home has changed over time. We fill this important gap by combining observed and imputed data of calories from Eating out and Alcohol.

4.3.1 Imputation

Eating out and alcohol are the two partially missing nutrient sources: information on quantity and nutrition conversion factors on alcohol, soft drinks and confectionary at home is only available from 1992 and on food, alcohol, soft drinks and confectionary out is only available from 2001 in the NFS.

However, there is rich additional information on the evolution of spending on eating out that we can take into account: The Living Conditions and Food Survey and its predecessors - the Family Expenditure Survey and the Expenditure and Food Survey (henceforth: EFS) contains detailed information on food spending on these items over the time period of interest - 1980 to 2009. Both EFS and NFS are nationally representative samples drawn from the same population (in the same manner). We further observe general price trends in these goods via ONS price series. Food consumed out of the home comprises food eaten during restaurant and fast food visits, from takeaways, and soft drinks and confectionery. The category alcohol contains alcohol consumed at home and out of the home. Thus, we employ a multi-step imputation method which is based on the dynamics in socio-demographics and household composition, changes in spending patterns, and price dynamics to obtain a measure of calories from these two categories. In the first step, we use multiple imputation [8] by chained equations (MICE) [9] and -to deal with the frequency of zero expenditures in both categories - predictive mean matching (PMM) to impute real expenditure on food out and alcohol for the whole time period. In the second step, we estimate two variants: a) in a conservative estimate, we assume that calories per (real) pound spent on the categories eating out and alcohol differ across household types due to differences in diets, but are constant over time; b) we allow them additionally to vary across time by using the observed nutrient composition of alcohol and food eaten out for the period 2001 to 2009 to backwards impute average calories per pound spent. Again, we use observed spending trends, prices and demographics in the imputation process. We apply a Generalised Linear Model (GLM) estimator with a log-link function to incorporate abstinence or purchase infrequency. The product of the partially observed and partially imputed objects in the first and second step, real expenditures and calories purchased per pound spent, are calorie purchases for the two missing categories.

A detailed description of the procedure and results can be found in Appendix A. We

[8]See Rubin (1987), Rubin (1996), Schafer (1997) and Schafer (1999), among others

[9]See Royston and White (2011).

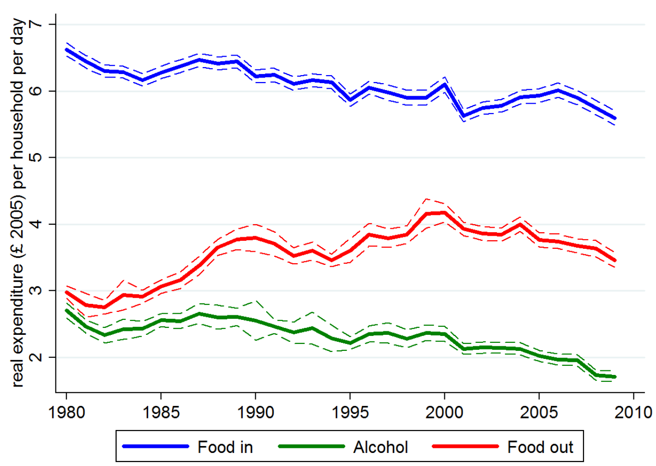
show that our imputation method fits the data well. Additionally, we perform robustness checks based on simpler assumptions about the time pattern of average calories per pound spent, i.e. household-specific, but time-constant spending on food out and alcohol over time, and show that imputed calories are sensitive to spending trends and changes in household demographics, but not very sensitive to variations of the imputation model for average calories per pound spent, i.e. the second step of our imputation. In Section B.2 of Appendix A we discuss the different data sources used in previous studies and compare our results, using household budget surveys, with studies using household intake surveys and aggregate food balance sheets. We also show alternative data sources on alcohol expenditure and duty collected by HMRC that are consistent with our imputed measures.

4.3.2 General trends in calories

Based on the observed and imputed information on food spending and nutrition, we can now trace the sources of the decline in calories over the last 30 years and reconcile it with observed food spending patterns.

We compute daily real expenditures on food and its components for each household using ONS prices series and express expenditures in December 2005 prices.

Figure 4.6: *Real food spending per household per day (December 2005 prices)*



Source: EFS

Overall, real food spending of households increases very moderately until the mid 2000s and declines thereafter, leading to an overall reduction by 12.4% over the sample period. If we account for household size by using the square root of household size as equivalence scale, we see that the reduction in overall food spending per person is with 2.5% much smaller. The first two panels in Table 4.3 also show that both - per person and per household- real expenditures on food at home and alcohol decrease over time, while real expenditure on eating out increases. We also see that expenditure on alcohol and eating out varies much more over time than expenditure on food at home. As the third panel of the Table shows, the expenditure share of food at home is thus remarkably stable over time. However, we find large shifts in the composition of food spending between the other two categories: while the expenditure share of alcohol declines by more than a quarter, that of eating out increases by more than a third.

If there were a 1 : 1 link between calories and expenditures, we would expect calories to remain relatively stable over time. However, the food categories differ in terms of both their calorie density and their calorie content per GBP expenditure: while food at home accounts for only about 60% of food spending, it accounts for around 80% of total calories purchased. As the bottom panel of Table 4.3 shows, the expenditure share of food at home varies even less over time than its calories share - it only declines by 2.95 percentage points over 30 years. In other words: while food at home represents just between 55 and 60% of total expenditure, it accounts for almost 80% of calories purchased throughout the sample period. Calories from Eating out and Alcohol thus account for roughly one fifth of calories purchased in 2009, with calorie shares of 17 and 3% in 2009 respectively.

Calories from eating out increased by 14% over the sample period, from 775 daily calories per household in 1980 to 885 in 2009. What is more interesting is the pattern over time (see Figure 4.7). We estimate an increase of 34% between 1980 to 1990, a subsequently stagnation at around 1,000 calories per day between 1990 and 2000, and a sharp decline since 2001. The increase in calories from Eating out together with a decline in calories from food consumed at home and a small decline in calories from alcohol results in a large increase in the share of calories from Eating out. While Eating out accounted for less than 10% of total calories in 1980, the figure is 17% in 2009.

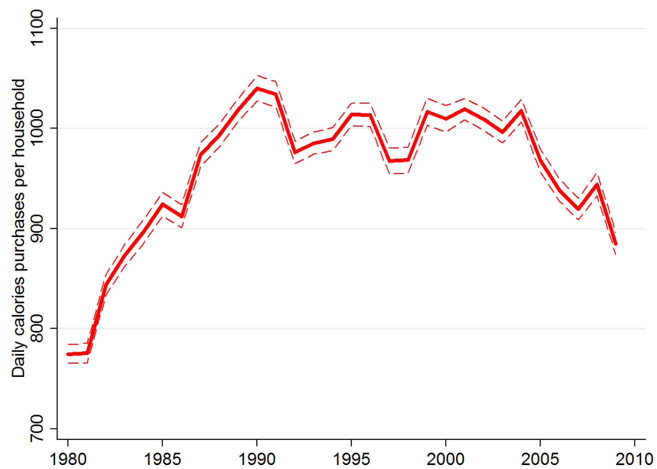
Calories from alcohol decrease over the sample period by 35% on average across households (see Figure 4.8 and Table 4.3). Here, we see a similar trend in real expenditures and calories. However, this trend is not the same across all household types: we see a sizeable decline in calories from alcohol for all household types with two exceptions: pensioners and lone parents.

Table 4.3: *Real expenditures and calories from different food groups, 1980-2009*

	1980	1990	2000	2009	1980-2009 (percentage change)
Average real expenditure (in GBP per day, *Dec.* 2005 = 100)					
Food at home	6.63	6.22	6.10	5.60	-15.51%
Eating out	2.98	3.79	4.17	3.46	16.19%
Alcohol	2.70	2.56	2.35	1.71	-36.70%
All food and drinks	12.31	12.57	12.62	10.79	-12.39%
Average real expenditure per person (in GBP per day, equivalised (modified OECD), *Dec.* 2005 = 100)					
Food at home	3.39	3.31	3.41	3.18	-6.25%
Eating out	1.49	1.98	2.27	1.91	28.39%
Alcohol	1.38	1.35	1.31	0.98	-28.56%
All food and drinks	6.26	6.63	6.99	6.08	-2.84%
Average real expenditure shares (in % of total food spending)					
Food at home	61.36	56.25	53.95	58.41	-2.95
Eating out	21.24	27.32	30.68	28.67	7.43
Alcohol	17.40	16.43	15.37	12.92	-4.48
Average daily calorie purchases					
Food at home	6920	5341	4778	4244	-38.68%
Eating out	775	1040	1010	885	14.25%
Alcohol	267	243	208	175	-34.57%
All food and drinks	7962	6624	5996	5304	-33.39%
Average calorie shares (in % of total calories from food and drinks)					
Food at home	86.91	80.62	79.68	80.01	-6.90
Eating out	9.73	15.70	16.84	16.69	6.96
Alcohol	3.35	3.68	3.48	3.39	0.04

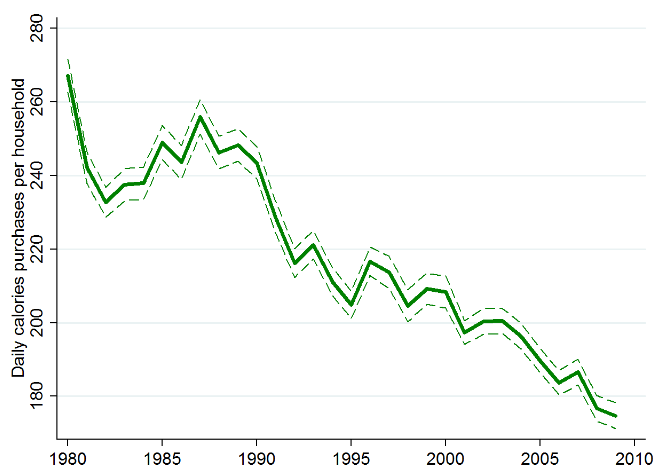
Notes: We arrive to similar results if alcohol is mapped into a per adult person equivalent, assuming that children under the age of 18 do not consume alcohol. When referring to shares (calories and expenditure), the change between 1980 and 2009 is expressed as percentage points.

Figure 4.7: *Daily Calories from Eating out per household*



Note: Own estimations (See Appendix A)

Figure 4.8: *Daily Calories from alcohol per household*



Note: Own estimations (See Appendix A)

4.3.3 Calorie purchases across households

Do all household types reduce their calorie purchases in a similar way? As Panel C of Table 4.4 shows, the overall reduction in calories from all foods and drinks per household ranges from 16 to 29% with smaller reductions in one- or 2-person households and larger ones in multi-person households whose size declines (marginally) over time. We find the largest declines in calories from food at home among lone parent households, families and other households, and the smallest adjustment among young single households who also have the lowest calorie share from food at home. Calories from eating out increase for all household types over the sample period, albeit at very different rates: 70% for pensioners, 55% for couples and just 1% for young singles.

Given the overall decline in calories, shifts in diets are best identified by looking at the evolution over time of the share of calories from different foods in total calories. We see in panel D of Table 4.4 that the calorie share from food at home lies around 85% for all household types with two outliers: it is at 77% lower for single household who eat out more, and -potentially also due to mobility limitations- with 92% highest among pensioner households. The fraction of calories purchased in the form of food at home is relatively stable for all households and declines maximally by 12 percentage points over the course of 30 years. Young singles reduce their calories from all foods and drinks, but shift their diets towards eating out (+3.5 percentage points) but away from alcohol (-2.9 percentage points).

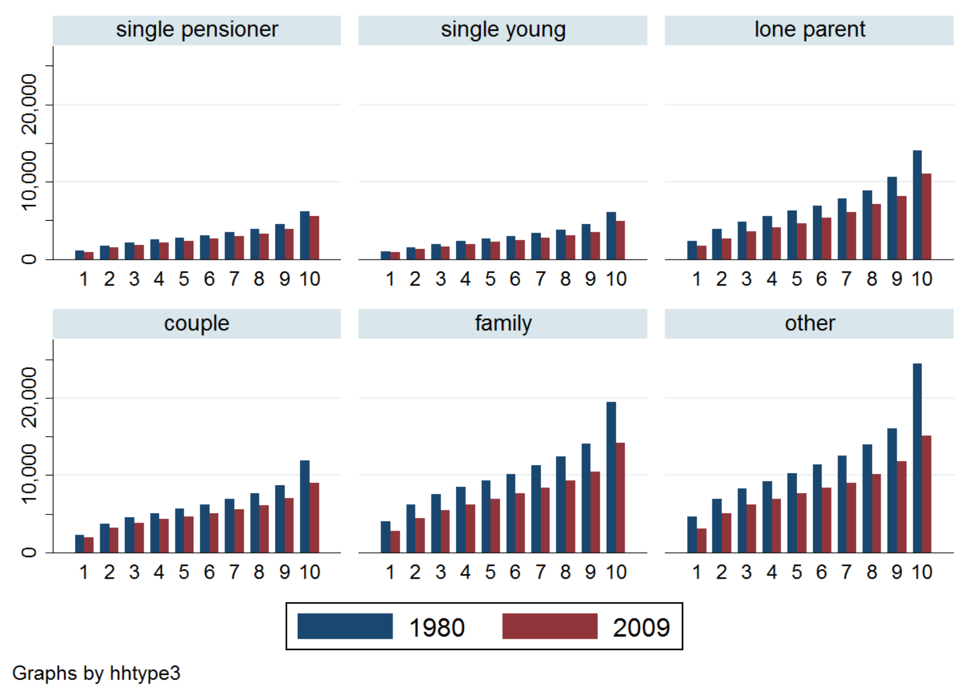
The other household types shift their calorie sources towards eating out. While the calorie share of food at home declines only slightly, some households - notably young single households, families and other households- reduce the weight of alcohol in their calorie purchases. Lone parents and particularly single pensioners also display a shift towards calories from alcohol. The share of calories from alcohol increases by 0.68 and 1.25 percentage points respectively for single pensioner and lone parent households. However, overall the percentage of calories in overall diets coming from alcohol is small, so that the effect of these drastic shifts on overall calorie purchases is very much muted. For all households in 2009, calories from food at home account for at least 75% of their total calories purchased.

We might be interested not only in the mean, but in how diet varies at other points of the distribution. In particular, as our concern is about obesity and weight gain, we might be interested in households that purchase a large amount of calories relative to other households of the same type. In Figure 4.9 we show the amount of calories purchased in

1980 and 2009 within each household type by decile. The deciles are defined based on total calories purchased in each year; so on the far left the bar marked "1" are the 10 percent of households that purchase the smallest amount of calories, and on the far right the bar marked "10" are the households that record purchasing the largest amount of calories.

We see a decline in calories purchased at all parts of the distribution.

Figure 4.9: *Calorie purchases by household type and calorie deciles: 1980 vs 2009*



Note: The horizontal axis indicates the decile in terms of calories purchased. The far left the bar marked "1" are the 10 percent of households that purchase the smallest amount of calories, and on the far right the bar marked "10" are the households that record purchasing the largest amount of calories.

Thus, we next take a closer look at food at home which accounts for the majority of daily calories and is also the category that drives most of the calorie decline between 1980 and 2009.

Table 4.4: *Real expenditures and calorie purchases by household type, 1980-2009*

	All food & drinks		Food at home		Eating out		Alcohol	
	1980	1980-2009	1980	1980-2009	1980	1980-2009	1980	1980-2009
Panel A	Daily real expenditure by food category (Dec2005=100), equivalised (modified OECD)							
single young	8.15	-26.7%	2.60	-2.1%	2.42	-16.6%	3.13	-54.5%
lone parent	5.39	4.5%	3.64	-15.1%	1.31	50.4%	0.44	25.1%
couple	6.73	10.8%	3.71	4.3%	1.39	60.3%	1.63	-17.0%
family	7.25	-1.7%	3.98	-6.6%	1.87	35.3%	1.40	-37.1%
single pensioner	4.06	28.6%	2.82	10.9%	0.69	88.9%	0.55	43.9%
other	8.14	-8.6%	3.97	-9.4%	2.10	21.7%	2.07	-37.6%
Panel B	Expenditure share (in % of overall food spending)							
single young			31.91	10.70	29.66	4.08	38.43	-14.58
lone parent			67.55	-12.71	24.27	10.64	8.18	1.61
couple			55.18	-3.26	20.63	9.21	24.19	-6.07
family			54.95	-2.76	25.75	9.66	19.30	-6.95
single pensioner			69.49	-9.57	16.90	7.91	13.61	1.61
other			48.77	-0.44	25.75	8.53	25.48	-8.09
Panel C	Daily Calorie purchases							
single young	2990	-18.3%	2313	-18.9%	435	1.1%	242	-47.5%
lone parent	7075	-23.7%	6181	-34.1%	823	49.7%	71	28.1%
couple	6248	-19.0%	5564	-25.0%	441	55.4%	243	-14.9%
family	10276	-26.4%	8915	-33.5%	1064	35.9%	297	-36.9%
pensioner	3129	-15.7%	2888	-22.2%	178	69.8%	63	36.2%
other	11760	-29.1%	10019	-34.9%	1283	19.5%	459	-39.3%
Panel D	Calorie share (in % of total calories)							
single young			77.36	-0.56	14.55	3.45	8.09	-2.89
lone parent			87.35	-11.87	11.64	11.19	1.01	0.68
couple			89.06	-6.66	7.06	6.47	3.89	0.19
family			86.76	-8.35	10.36	8.76	2.89	-0.41
single pensioner			92.29	-7.02	5.69	5.77	2.03	1.25
other			85.19	-6.93	10.91	7.49	3.90	-0.56

Note: We arrive to similar results if alcohol is mapped into a per adult person equivalent, assuming that children under the age of 18 do not consume alcohol.

4.3.4 Trends in food at home

Household calories from food consumed at home declined by 39% between 1980 and 2009. Accounting for household type, we find declines in one-person households of 19 to 22%, in couple households by one quarter and by about a third in larger households over the sample period (see Table 4.5).

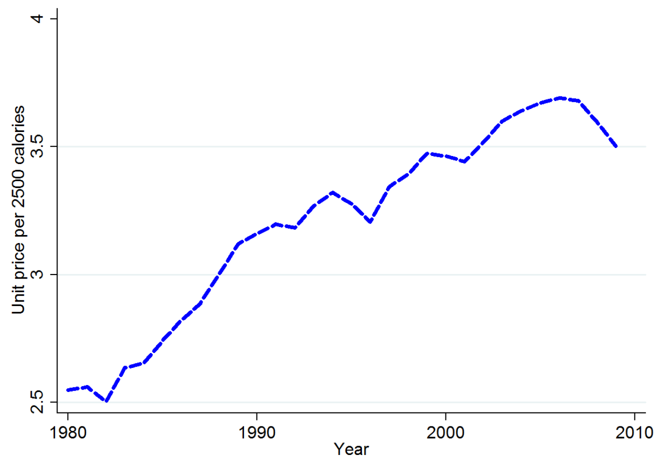
Table 4.5: *Average trend and household heterogeneity in calorie purchases from food at home, 1980-2009*

Daily calories per household							
	all households	single	lone parent	couple	family	pensioner	other
1980	6920	2313	6181	5564	8915	2888	10019
1990	5341	1936	4614	4725	7105	2587	7825
2000	4778	2184	4739	4460	6546	2528	7163
2009	4244	1876	4075	4173	5933	2248	6522
Percentage change 1980-2009							
1980-2009	-38.68	-18.90	-34.06	-25.01	-33.45	-22.15	-34.90

Parallel to these declines, the “unit price” [10] of 2500 calories - the Estimated Average Requirement for a male adult - has increased: while household paid GBP 2.5 in 1980 for 2,500 calories, the figure is 3.5 in 2009 (See Figure 4.10). These two opposing trends suggest changes in food choices towards a less calorie dense diet, or equivalently more expensive calories, over time.

[10] We compute the “unit price” of calories as the ratio of real food expenditure (in December 2005 prices) and the amount of calories from food at home

Figure 4.10: *"Unit price" of 2,500 calories (in year 2005 prices)*



Since calorie purchases in almost all food categories are reduced, we next look at changes in calorie composition. While English households consume less calories in almost all subcategories of food at home, the main change in diet composition is an increase in the share of calories from fruit and vegetables, cereals and other foods, and a decrease in the calorie-dense fats (e.g. butter, margarine etc.) and sugary products. Table 4.6 shows how the average diet of English households translates into calorie purchases, and demonstrates how diet changes have led to the decrease in calories. Between 1980 and 2009, we see large reductions in calorie purchases of milk and meat products (around 40%), eggs and fats (around 58-59%) and sugary products like jam or honey (79%) and in beverages (60%). Moreover, calories from cereals declined by almost 30% between 1980 and 2009 and by 41% from meat. Calorie purchases from milk have also declined substantially mostly due to the switch from full fat to skimmed milk. There are only two categories in which purchases (of food and calories) have increased: average calorie purchases from other foods which include soups, sauces and other foods increased by 82%, and calories from fish increased by 18%.

Table 4.6: *Average household calories per day by type of food, 1980-2009*

Food type	1980	1985	1990	1995	2000	2005	2009	1980-2009
Milk	746	641	524	498	492	433	432	-42%
Cheese	172	166	160	146	139	140	144	-16%
Meat	1048	910	778	642	646	629	614	-41%
Fish	56	62	69	58	57	67	67	18%
Eggs	101	92	57	47	44	41	42	-58%
Fats	1010	874	714	573	486	425	415	-59%
Sugars & Preserves	686	518	360	281	214	154	147	-79%
Fruit & Vegetables	767	731	729	739	734	649	627	-18%
Bread, Cakes & Cereals	2220	2000	1840	1778	1835	1599	1579	-29%
Beverages	33	32	32	24	26	14	13	-60%
Soups, Sauces & Other	104	117	127	136	143	176	190	82%
Food at home	6920	6163	5341	4959	4778	4328	4244	-38.68%
Eating out	775	924	1040	1014	1010	968	885	14.25%
Alcohol (in and out)	267	249	243	205	208	190	175	-34.57%

Notes: National Food Survey (NFS), 1974-2000, Expenditure and Food Survey (EFS), 2001-2008 and Living Costs and Food Survey 2009.

Table 4.7 shows the sources of calories shares of a broadly defined set of food types in overall calories from food at home for selected years. We observe a clear decline in the proportion of calories from high caloric food categories like sugars and fats. While sugars accounted for 9.9% and fats for just above 14% of calories from food at home in 1980, they only account for 3.4% and 9.4% respectively in 2009. English diets have switched to fish, and most notably bread and cereals and fruit and vegetables. Even though we observe a decline in the average calories purchases of fruit and vegetables, its weight in the diet has increased by 4.5 percentage points, from 11.4% in 1980 to 15.9% in 2009.

Table 4.7: *Share of calories from food at home by type of food, 1980-2009 (in %)*

Food type	1980	1985	1990	1995	2000	2005	2009	1980-2009
Milk	10.7	10.3	9.6	9.9	10.0	9.6	9.8	-0.9
Cheese	2.5	2.7	2.9	2.9	2.8	3.1	3.3	0.7
Meat	15.0	14.7	14.3	13.7	14.1	14.9	14.7	-0.3
Fish	1.0	1.3	1.5	1.4	1.3	1.7	1.7	0.7
Eggs	1.4	1.5	1.0	0.9	0.9	0.9	1.0	-0.4
Fats	14.4	14.1	13.1	11.4	9.8	9.4	9.4	-5.0
Sugars & Preserves	9.9	8.5	6.7	5.6	4.4	3.5	3.4	-6.5
Fruit and Vegetables	11.4	12.3	14.1	15.5	15.8	16.3	15.9	4.5
Bread, Cakes & Cereals	31.7	32.3	33.8	35.5	37.4	36.3	36.4	4.7
Beverages	0.5	0.5	0.6	0.5	0.5	0.3	0.3	-0.2
Soups, Sauces & Other	1.5	1.9	2.3	2.7	2.9	3.9	4.3	2.8

Notes: National Food Survey (NFS), 1980-2000, Expenditure and Food Survey (EFS), 2001-2008 and Living Costs and Food Survey 2009.

In addition to the diet change observable in broad food categories, the caloric content of food items may have changed within a food category over time. Firstly, changes in food production technology may have reduced the calorie density of each food category. In addition, the composition of some of our 250 food categories may have changed over time due to product innovations and substitution within these detailed categories. Both of these factors may have reduced the calorie density of the detailed food categories. While we cannot distinguish between these two factors in our data, changes in the nutrition conversion factors, which measure the average nutrient content of each of the 250 food items, over time pick up the joint effect. We consider two counterfactuals: overall calorie purchases if the nutrition conversion factors (NCF), i.e. the calorie density of food items, had remained constant at 1974 levels, and compare this to the actual change in calorie purchases using the actual NCF in the NFS (which change quarterly). The results suggest that changes in the calorie density within the detailed food items account for about 10% of the decrease in calorie purchases over time.

In summary, we observe a strong reduction in calorie purchases over time. Calorie purchases from all foods and drinks fall throughout the period of observation, by 36% for households overall and by around 27 to 29% for single households. This pronounced trend is driven by a number of factors: a) sizeable reductions in calorie purchases from almost all food categories (except for other goods and fish), b) a shift towards a less calorie dense diet, with less calories from fat and sugary products and to a lesser degree from meat, and more calorie purchases from goods like fruit and vegetables, cereals, fish and cheese, and other goods, and c) an overall reduction in the calorie density of food categories by 10% which is likely due to both, shifts towards less calorie dense products within category and product innovation leading to healthier, less calorie dense varieties of a food item.

4.4 Determinants of bodyweight

Weight gain results from an imbalance in calories ingested and calories expended in physical activity. The first law of thermodynamics states that the change in energy within a system is given by the difference between the energy added to the system and the energy expended by the system. Let $i = 1...N$ index individuals and $t = 1...T$ time. An individual's end of period weight W_{it} is determined by the initial weight, W_{it-1}, and the difference between the calories intake and calories burnt. We further decompose calories burnt into: calories burnt at work, calories burnt outside work and the Basal Metabolic Rate (BMR) in order to obtain the following identity:

$$W_{it} = W_{it-1} + c_{it}F_{it} - h_{it}H_{it}W_{it} - e_{it}L_{it}W_{it} - BMR_{it} \tag{4.1}$$

Where c is calories per unit of food, F is units of food purchased in the year, h are calories expended per hour worked, H is number of hours worked over the year, e is calories expended outside of work, and $L = T - H$ is time engaged in these activities. BMR is the Basal Metabolic Rate or the number of calories needed to keep the body alive. Equation 4.1 describes a physical identity, not a model of behaviour. In the reminder of the paper we document the joint dynamics of these factors.

The largest share of calories burned are through an individual's basic metabolic rate (BMR). It can be seen as the lower bound of calories expended in a day, i.e. when resting, at a given weight. BMR depends on gender, weight and age (Henry (2005)). We use the age and gender-specific approximation given in Table 4.8 to compute BMR into MJ per day and then transform into calories per day.

Table 4.8: *Basal metabolic rate by age and gender*

Age	Female	Male
25-30	$0.0615W + 2.08$	$0.0640W + 2.84$
31-60	$0.0364W + 3.47$	$0.0485W + 3.67$
61 plus	$0.0439W + 2.49$	$0.0565W + 2.04$

Source: Henry (2005).

Equation 4.1 represents the relationship between energy intake and expenditure and bodyweight. In addition to BMR, we consider activity at work, housework and leisure activities. We consider activity at work, defined by hH in equation (4.1), housework and leisure as measurable activities. The residual comprises of sleep and other more or less active activities.

Energy expended in these activities depends on the time spent [11] on them and how strenuous they are. We then combine the information on time spent in work, housework and leisure activities with measures of their strenuousness. Strenuousness is measured through metabolic equivalents of tasks (METs) which are defined as the ratio of the metabolic rate while doing a specific activity over the metabolic rate while resting. A MET is defined as 1 kilo-calorie per kilogram of bodyweight per hour. We use the Compendium of Physical Activities compiled by Ainsworth et al. (2000) and the METs values for occupations in the 2002 Census Occupational Classification System compiled by Tudor-Locke, Ainsworth, Washington, and Troiano (Tudor-Locke et al.) to determine the strenuousness of occupations and non-market activities. Since these contain separate METs for specific housework activities like, cooking, cleaning and doing laundry, we use British Time Use Surveys from several years [12] to compute a weighted average MET for housework based on the time shares spent in specific housework activities. We do the same for leisure, and also separate out the least and most active leisure activities, i.e. TV watching and exercising to characterise shifts in leisure time use over the years. Since BMR already incorporates some of the energy loss during the time spent in activities H and L, h and e are defined as additional calories expended due to an activity being more strenuous than resting, i.e. $MET - 1$.

[11] Gimenez-Nadal and Sevilla (2012) use the same data as us and show trends in time use for 7 developed countries. They classify time use into 4 categories: paid work, unpaid work, child care and leisure. The categories they use are not comparable to the ones we are using in this paper.

[12] 1974-75, 1983-1984, 1987, 1995, 2000-2001 and 2005. See Data Appendix for more details on the time use data.

Table 4.9 summarises time and energy intensity of the main activities individuals in England engage in. About one third of men's and women's time is spent in leisure activities, another third on sleep and the remaining third in market and non-market work and travel from one activity to the next. The table also shows the change in time use and strenuousness of the different activities between 1983 and 2005. Men increase the number of hours spent sleeping, traveling and doing housework while they spend less time at work or in leisure. Different is the story for women. Women have increased their labour force participation and with that the average hours they spend at work between 1983 and 2005. As men, they have also increased the time spent sleeping and traveling and reduced the time in leisure. A particular important feature for women is the shift from home production to work. While women increased the number of hours at work by almost 24% they reduce the time spent in home production by 17%. This shift in time use has important consequences in calories burnt. The second panel of Table 4.9 shows the average strenuousness of the different activities measured as average METs. First, the strenuousness of work has decreased over time for both men and women. For a given weight, an hour of work in 2005 results in 17% less calories burnt for men and 4% less calories burnt for women than in 1983.

These changes in calories burnt might seem small to explain the increase in bodyweight observed during the last three decades but Hall et al. (2011) make the point that we only need a small energy imbalance over a long period of time in order to explain the average increase in bodyweight. They develop a mathematical model of human metabolism and conclude that a persistent caloric imbalance of just 30 Kilo Joules - or 7.2 kilo calories - per day would explain the weight growth in the US over the past 30 years.

Table 4.9: *Time use trends and strenuousness by sex (1983-2005)*

	% of day spent on activity			
	Males		**Females**	
	1983	**% change 1983-2005**	**1983**	**% change 1983-2005**
work	15.4	-7.6	7.1	23.6
housework	7.5	5.3	15.9	-17.3
sleep	29.5	14.2	30.6	13.3
travel	4.3	20.5	4.1	16.7
leisure	43.3	-9.9	42.3	-8.7
of which:				
sports and exercise	1.4	18.0	0.7	64.9
tv	10.0	27.4	8.1	30.4
	Strenuousness (in mean METS)			
work	2.8	-17.6	2.3	-3.9
housework [b]	2.5	-3.1	2.4	-0.3
sleep	1.0	0.0	1.0	0.0
travel[a]	2.3	0.0	2.3	0.0
leisure[b]	1.6	5.3	1.6	5.8
of which:				
sports and exercise	3.7	-0.8	3.4	-0.4
tv	1.5	0.0	1.5	0.0

Source: Multinational Time Use Study, Versions World 5.5.3, 5.80 and 6.0 (released October 2012). Created by Jonathan Gershuny and Kimberly Fisher, with Evrim Altintas, Alyssa Borkosky, Anita Bortnik, Donna Dosman, Cara Fedick, Tyler Frederick, Anne H. Gauthier, Sally Jones, Jiweon Jun, Aaron Lai, Qianhan Lin, Tingting Lu, Fiona Lui, Leslie MacRae, Berenice Monna, JosÃ© Ignacio GimÃ©nez Nadal, Monica Pauls, Cori Pawlak, Andrew Shipley, Cecilia Tinonin, Nuno Torres, Charlemaigne Victorino, and Oiching Yeung. Centre for Time Use Research, University of Oxford, United Kingdom.
Other sources: Ainsworth et al. (2000) and own calculations
Note: [a] unweighted average of travel in different modes due to lack of travel mode information; [b] mean MET, weighted by time composition of activities of different strenuousness. All METs are based on single activity METs reported in Ainsworth et al. (2000)

4.5 Sloth?

Energy burned in calories of age group a of gender s in period t in physical activity pa is defined as:

$$EE(pa)_{a,t,s} = T(pa)_{a,t,s} \cdot S(pa)_{a,t,s} \cdot W_{a,t,s} \tag{4.2}$$

Where, T is time spent doing activity pa, S the activity's strenousness and W the individual's weight. We compile energy expended in different activities using information from several sources detailed in the Appendix Section B.1.3. We compute gender-age specific means of time use $T(pa)_{a,t,s}$ for each sample year for three physical activities pa: i) work, ii) housework, and iii) leisure, and gender-age-time-specific averages of bodyweight. We consider three age groups for men and women. We divide men into the following age groups: 18 to 30, 31 to 59 and 60 and above. For women, we consider the following age brackets: 18 to 25, 26 to 54 and 55 and above [13].

We use data from the Labour Force Survey (LFS) to obtain measures of work activity - employment and work hours. Conducted by the Office for National Statistics, the LFS is the largest household survey in the UK and provides official figures for employment and unemployment. It samples between 40,000 and 60,000 households and moved from annual to quarterly frequency in 1992.

We follow Blundell et al. (2011) and use actual hours of work as our measure of the intensive margin of labour supply. The extensive margin is determined using age and sex-specific labour force participation rates. Strenuousness of work is driven by the strenuousness of different occupations. Thus, we compute a gender and age-specific measure of the occupation mix.

We calculate the strenuousness of work, $S(work)$, as the weighted average of occupation-specific time-invariant METs where the weights vary over time due to gender and age-specific changes in the occupation mix over time.[14] Changes in the nature of work are reflected through changes in strenuousness and labour supply. Strenuousness of housework is computed based on Ainsworth et al. (2000) and detailed information on the time

[13] The age classifications for men and women are based on the labour force participation over the life-cycle. Women increase their labour force participation up to age 25, remains relatively flat between age 26 and 54 and start to retire at age 55. For men, we observe an increase in labour force participation from age 18 up to age 30, a flat profile between age 31 and 59 and a decline due to retirement by age 60.

[14] Changes in the strenuousness of work within an occupation are not captured here due to lack of information on the time variation in occupation-specific METs.

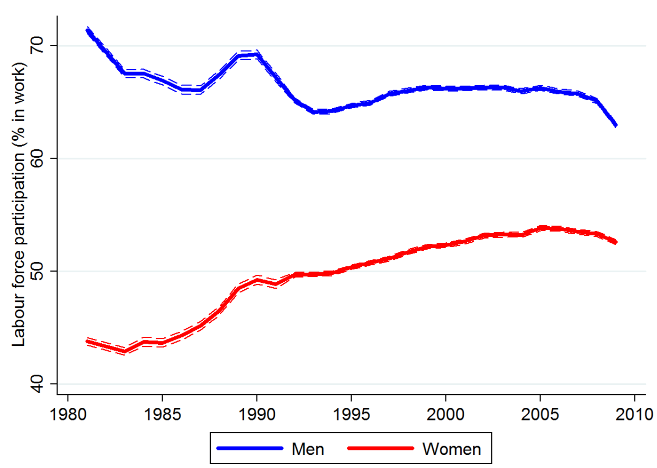
shares of specific housework tasks like cooking, cleaning and doing laundry from the 2005 cross-sectional British Time Use Survey. These time shares are matched with METs for these specific household chores to calculate a weighted measure of average strenuousness of housework by gender. Finally, strenuousness of leisure time is a weighted average of gender-age specific leisure activities (e.g. doing sports and exercise, watching TV, etc) and activity-specific METs. Since we observe changes in the time devoted of these activities, strenuousness of leisure varies over time.

Our measures of the strenuousness of the three activities is combined with time spent on these activities and bodyweight to compute calories burned according to equation 4.2. We then translate all energy into kilograms dividing EE_{iat} by 7,716; which is the number of calories that translates into one kilogram of bodyweight.

4.5.1 Work

There have been large changes in patterns of work, in labour force participation, hours of work and the strenuousness of work. Men's labour force participation remained largely constant between the mid 80s and 2008, while the period between 1980 and 2009 saw a large expansion of female labour force participation. Most of this expansion happened during the 1980s, with an increase from around 44 to 49% of women working between 1980 and 1990 and a further 3 percentage points increase between 1990 and 2009; by 2009 almost 53% of women are working (see Figure 4.11).

Figure 4.11: *Male and female employment (1980-2009)*



This aggregate patterns masks differences across age groups. While the employment rate of men aged 18 to 30 remained relatively constant at above 75% during the whole period and that of men aged 31 to 59 remained also at a relatively constant rate of 85%, the employment rate of older men exhibit a U-shape, declining from 25% in 1980 to 17% by the mid-1990s to increase thereafter and reach 23% by 2009. The younger age group was the one most affected by the latest financial crisis whit a decline of 4 percentage points in their employment rate during 2008-2009 (See Figure 4.12). Different is the case of women. We already saw the dramatic increase in female employment rate between 1980 and 2009 but that is mostly for women aged 26 and above. While the employment rate of younger women remained constant at between 60 and 65% during the sample period, there has been a sharp increase in the proportion of women employed in the mid and older age groups. The proportion of women aged 26 to 54 in employment increased 10 percentage points in a decade, from 58% in 1980 to 68% in 1990, to subsequently gradually increase and reach 75% by 2009. We also observe an increase in the employment rate of older women, with 23% employed by 2009, an increase of 8 percentage points relative to 1980 (See Figure 4.13).

Figure 4.12: *Male employment by age (1980-2009)*

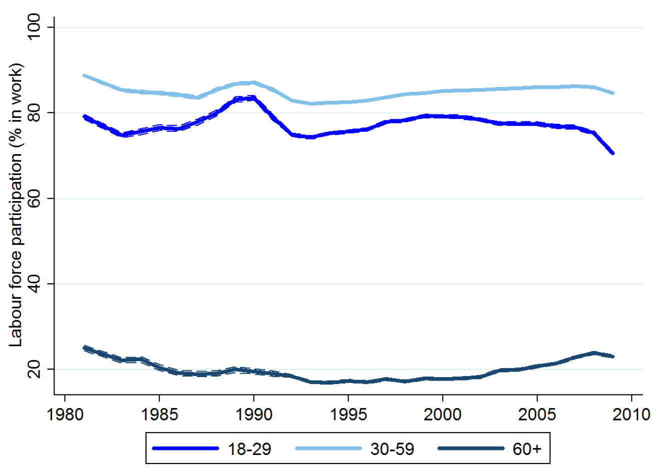
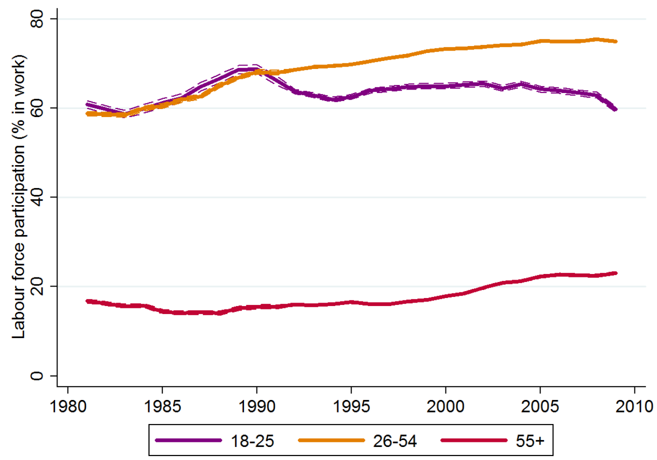
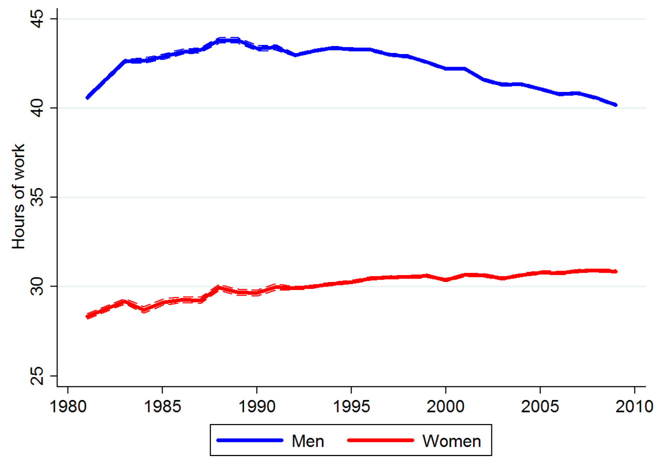


Figure 4.13: *Female employment by age (1980-2009)*



Another component of equation 4.1 is T, the time spent in each activity. Figure 4.14 shows weekly average hours of work for both men and women conditional on being in employment. First, women work roughly 10 hours less per week than men. Secondly, women did not only increase their labour supply at the intensive but also at the extensive margin: the number of hours worked for women who do work increased over the whole sample period, overall by 9%. Men, on the contrary worked an increasing number of hours during the 1980s - an increase by 7% - but subsequently reduced their number of hours. At roughly 40 hours per week in 2009, men are back to their 1980s level of work hours.

Figure 4.14: *Male and Female hours of work per week (conditional on working, 1980-2009)*



As for employment, we observe some differences in the number of hours of work across age groups (see Figure 4.15 and Figure 4.16). While hours of work decline over time for all male workers, there has been a substantial increase in the number of hours of work among female workers aged 26-54 and 55 or more and a decline for women aged 18 to 25. Younger and mid age male workers exhibit an inverse U-shape profile in work hours over time. Male workers aged 31 to 59 worked 42 hours per week at the beginning of the 80s, about 45 hours during the 90s and gradually reduced the number of hours worked during the 2000s to reach again 42 hours per week by 2009. A similar pattern, albeit with less hours worked per week and a more pronounced decline during the 2000s, is observed for male workers aged 18 to 30. Finally, old age male workers also declined the number of hours worked between the mid-1980s and beginning of the 2000s to slightly increase thereafter and reach 35 hours per week in 2009.

With the exception of younger women that on average reduce their weekly working hours between 1980 and 2009, female workers increase the number of hours of work during that period. Female workers aged 26 to 54 increased the number of hours from 27 by the beginning of the 1980s to 32 in 2009. They now work more hours than younger female workers. Another interesting fact is the increase in old-age work among females since the early 1990s; female workers aged 55 are more now work 2 hours more per week than in 1980. In spite of the increase in the number of hours of work over time, women of all age groups work less hours per week than men.

Figure 4.15: *Male hours of work per week by age (conditional on working, 1980-2009)*

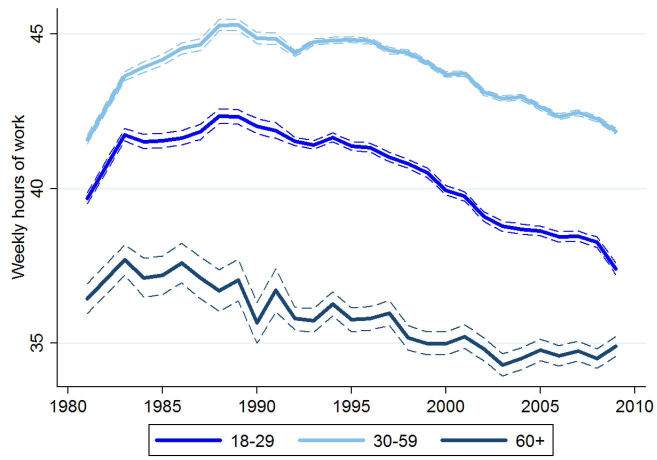
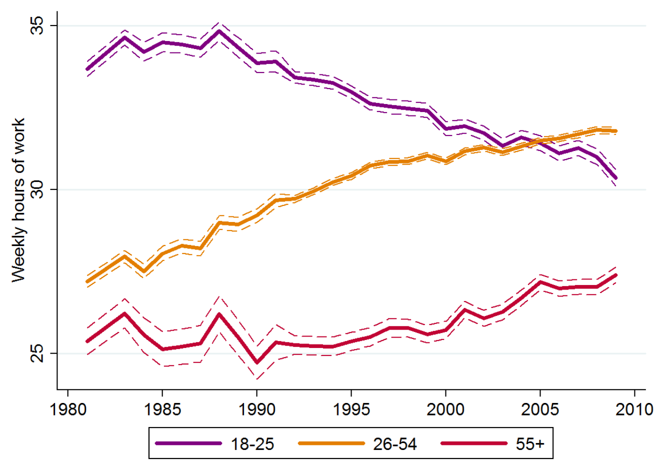


Figure 4.16: *Female hours of work per week by age (conditional on working, 1980-2009)*



A less well-documented trend in labour supply is the nature of work which has also changed markedly. Due to skill-biased technological change and the shift from manufacturing to a dominantly service-oriented economy, work has become less strenuous in England. While this is a general trend in developed countries (see Bleich et al. (2008)), it has been particularly pronounced in Britain. Our measure of strenuousness relies on individual data from the NFS/EFS/LCFS between 1980 and 2009 which allows us to measure the change in strenuousness in 12 occupations rather than across three production sectors based on a large representative survey of working age individuals. We use occupation-specific METs from the Compendium of Physical Activities and weight them according to their employment shares to generate work METs. Table 4.10 shows the drastic changes in occupational employment shares between 1980 and 2009 with almost a third (31.6%) of workers switching from more to less manual jobs.

Table 4.10: *Percent of workers (in %)*

		1980	2009	1980-2009
non-manual	Managers, professionals	38.1	57.6	19.5
	Junior non-manual	11.4	12.5	1.1
	Personal service	4.7	2.2	-2.6
	Foremen	3.4	6.9	3.5
manual	Skilled - manual	27.2	9.1	-18.1
	Semi-skilled - manual	9.2	6.4	-2.7
	Unskilled - manual	3.8	3.4	-0.4
	Agricultural	2.3	1.9	-0.4

Table 4.11 shows the change in the occupation mix between 1980 and 2009 for men and women separately. There is a dramatic change in the occupation mix among men: 77% of men workers are in non-manual occupations in 2009, an increase of 21 percentage points relative to 1980. On the other hand, we do not observe a substantial change in the occupation composition among women. Already 80% of women were in non-manual occupations in 1980 and the proportion increased to 86% by 2009. The major changes among women are within non-manual occupations with an increase of managers and professionals and a decline in the proportion of junior non-manual occupations.

These changes in the occupation composition of the workforce results in changes in the average strenuousness of work. Figure 4.17 shows the resulting decline in the strenuousness of work due to the increase in sedentary and less active jobs for both men and women. While the average male worker burnt 1.8 calories per hour per kilogram of weight in 1980 [15] he only burns 1.3 calories in 2009. For an 80 kilogram men that works 8 hours per day

[15] Remember that we measure METs in excess of BMR.

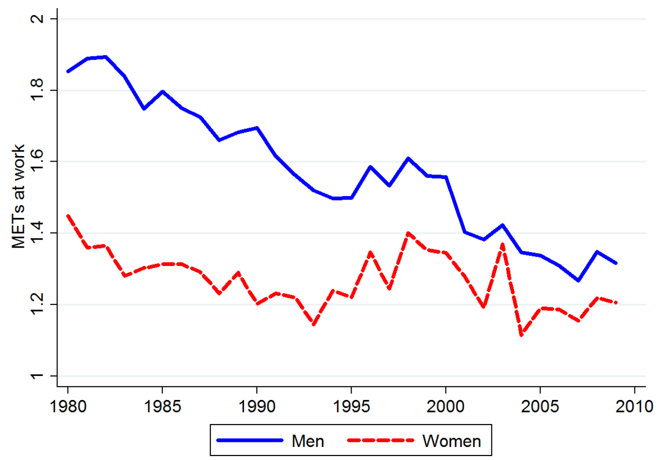
Table 4.11: *Percent of workers by sex (in %)*

		Males			Females		
		1980	2009	1980-2009	1980	2009	1980-2009
non-manual	Managers, professionals	38.8	60.9	22.1	30.7	52.4	21.7
	Junior non-manual	9.4	7.4	-2.0	37.6	22.6	-15.0
	Personal service	4.1	0.7	-3.5	11.2	6.3	-4.9
	Foremen	3.6	7.8	4.2	0.9	5.1	4.2
manual	Skilled - manual	29.1	12.5	-16.6	4.6	1.4	-3.2
	Semi-skilled - manual	9.5	5.1	-4.4	9.2	7.8	-1.4
	Unskilled - manual	3.7	3.4	-0.3	4.9	3.2	-1.7
	Agricultural	1.7	2.2	0.5	0.9	1.1	0.3

that implies burning 320 calories less per day of work. The pattern is completely different for women. As we already discussed, 80% of the female workforce was already occupied in non-manual jobs by 1980 and thus the average work MET for women has not changed much between 1980 and 2009 [16]. The change in the strenuousness of work among women is not as dramatic as for men, but a decline of just 0.2 in the average work MET for women results in 104 less calories burnt at work for a 65 kilogram women that works 8 hours per day. If a caloric imbalance of that amount is maintained over a long period of time it results in substantial weight growth.

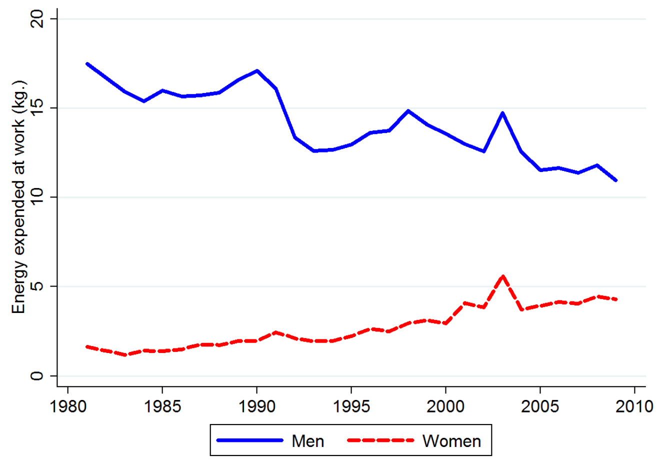
[16] A caveat about how we compute METs at work and the occupation composition by gender is worth noting. We obtain the occupation composition, and thus the strenuousness of work, from the NFS/EFS/LCFS. Only the occupation of the head of household is available and thus our measure of the strenuousness of work is based on the head of household occupation. That is not an issue for men but there might be sample selection issues for women. On average during our sample period, about 25% of the head of household are women. Of those, about 54% are single, 16% are lone parents, another 16% live with a husband or partner and 12% live in family or other types of households.

Figure 4.17: *Average METs at work (by gender, 1980-2009)*



We showed in this section the dynamics of the different components of physical activity at work for men and women and for different age groups. We now tie them up in order to compute annual kilograms burnt in physical activity at work for the average male and the average female. As a result of constant labour force participation, a small decrease in hours worked and a large decrease in the strenuousness of work, the annual energy that men spend while at work has declined from 17.5 kilograms in 1980 to about 11 in 2009, a decrease of 37% (See Figure 4.19). For women, on the contrary, the large expansion in labour force participation coupled with a large increase in the number of hours worked has overcompensated the small decrease in work strenuousness. As Figure 4.20 shows, women now expend on average almost 5 kilograms of energy at work per year compared to just 1.6 in 1980, an increase of 160%.

Figure 4.18: *Energy expended at work (in Kgs. per year)*



How does energy expended at work vary across ages? Figure 4.19 shows the trend over time for men and Figure 4.20 shows the same for women. First, due to the combination of low employment rates and low number of work hours, old-age men and women do not expend many calories at work. During the whole period, the average men aged 60 or more only spend between 1.3 and 1.7 kilograms per year and the average 55+ women only spend between 0.1 and 0.9 kilograms per year. Due to a relatively constant employment rate and hours of work and a dramatic decline in the strenuousness of work, men aged 18-29 spend 7.3 kilograms less per year in 2009 than in 1980. A similar pattern is found for men aged 30 to 59, who spent 28.6 kilograms per year at work in 1980 and spend 21.7 in 2009. The sharp increase in the employment rate of women aged 26 to 54 coupled with a dramatic increase in hours of work results in a large increase in energy expended at work. Women aged 26 to 54 expend in 2009 9.1 kilograms per year, an increase of 69% compared to 1980. Despite having a relatively constant employment rate and reducing the number of hours of work between 1980 and 2009, due to an increase in the average strenuousness of work, younger women burn 2.5 more kilograms at work in 2009 than in 1980.

Figure 4.19: *Energy expended at work by age: Men (in Kgs. per year)*

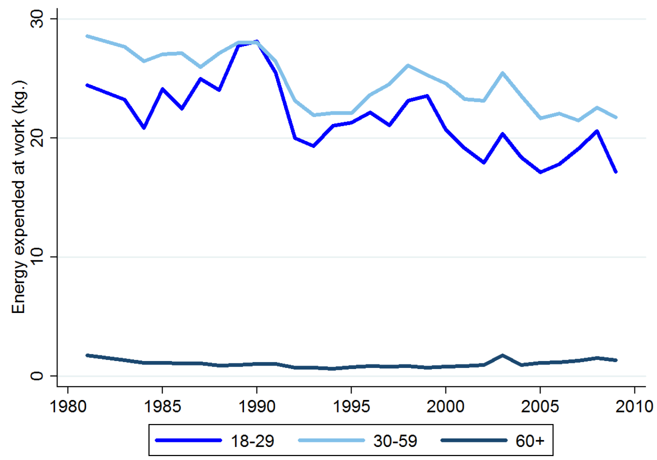
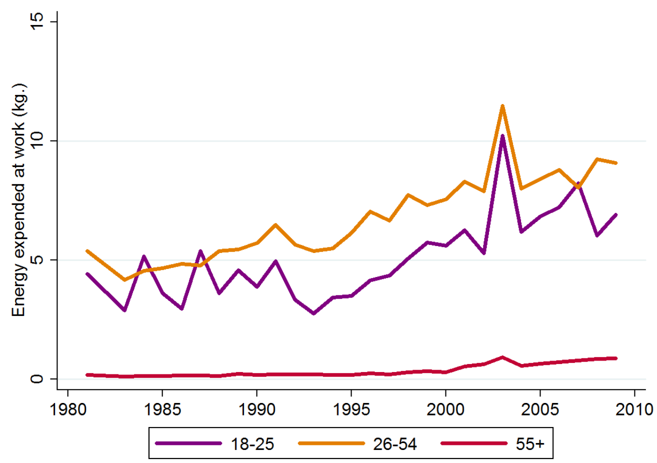


Figure 4.20: *Energy expended at work by age: Women (in Kgs. per year)*



To summarize, in this section we showed large changes in the patterns of work, in labour force participation, hours of work and the strenuousness of work. The combination of constant employment, a small decline in the number of hours worked and a large drop in the strenuousness of work result in a substantial decline in energy spend at work for men. For women, on the other hand, a large increase in employment and hours of work together with a small decline in the strenuousness of work result in an increase in energy burnt at work. In the next section we summarize time spend in other activities, most notably housework and leisure.

4.5.2 Other activities

We already saw how time and strenuousness of work changed over time. In this section we are going to focus on the remainder activities individuals in England engage in. We not only show time use changes in housework and leisure, that combined account for 50% of the time for men and 58% for women in 1983, but also on traveling and sleep. In this section we use data from the Multinational Time Use Study from the Centre for Time Use Research at the University of Oxford.

Housework

Housework comprises of activities such as cooking, washing up, cleaning, car and home maintenance, shopping and gardening. Table 4.12 shows average hours per day spend in home production and the corresponding strenuousness measured in METs in excess of BMR for men and women and the different age groups over time. First, due to the expansion of household appliances, housework has become less strenuous over time. Between 1991 and 2008, the percentage of households owning a dishwasher increased from 15 to 44% while the proportion using a microwave expanded from 56 to 92%. Average housework MET declined between 7 and 2% among men and 0.6% on average among women. Women spend on average 3.2 hours per day in 2005 in home production which is manual work and thus strenuous. Young women below age 25 spend 2 hours less per day in home production relative to women aged 26+. Housework time increases substantially at prime child-bearing age and over and remains relatively constant thereafter. With the exception of younger women, we document a considerable decrease in housework activity over time: women aged 26-54 decrease their housework time by 28% and those aged 55+ by 14% between 1983 and 2005.

Table 4.12: *Housework: time and strenousness over time (by sex and age)*

	Hours per day			MET^a		
	1983	2005	1983-2005 (in %)	1983	2005	1983-2005 (in %)
Men						
18-30	1.0	1.1	6.7	1.47	1.37	-6.9
31-59	1.7	1.7	-3.3	1.55	1.43	-7.3
60+	2.8	2.6	-6.3	1.50	1.47	-2.0
All	1.8	1.9	5.3	1.52	1.44	-5.1
Women						
18-25	2.2	2.2	1.1	1.39	1.33	-4.5
26-54	4.2	3.0	-28.2	1.38	1.37	-1.0
55+	4.1	3.5	-14.3	1.39	1.40	0.3
All	3.8	3.2	-17.3	1.39	1.38	-0.6

Source: Multinational Time Use Study, Versions World 5.5.3, 5.80 and 6.0 (released October 2012). Centre for Time Use Research, University of Oxford, United Kingdom

[a]: Measured in excess of BMR

In sum, due to the shift between housework and work, we observe a decline in the time spend on housework among women, particularly among mid-age and older women, and a small increase among men. These changes imply an increase of 0.6 kilograms in energy burnt in home production for men and a decline of 1.6 kilograms for women between 1983 and 2005. These changes affect the mid and older women age groups the most with reductions of 3.8 and 1.2 kilograms respectively per year.

Leisure

We consider the following activities among leisure: childcare, personal care, conversation, homework and study, religious activities, passive sport participation, civic and voluntary activities, excursions, going to the cinema or theater, dances or parties, social clubs, listen to radio, watch TV, listen to music, read books, papers and magazines, sew, relax, visit friends at their homes, and entertain friends at home, active sport participation and walking. Table 4.13 shows average time - in hours per day - spend on leisure for men and women by age brackets and over time. We do not only show time for overall leisure but also the time spend watching TV and doing sports and exercise. For both men and women and for all age groups we observe a decline in leisure time over the years, with reductions as high as 18% for men aged 18-30 and 14% for women aged 26-54. As expected, for both men and women the older age brackets are the ones spending more time on leisure, with an average of 12.3 hours per day for men and 11.4 for women in 1983.

While time spent watching TV represented between 20 and 25% of leisure time in 1983, it represents between 24 and 36% in 2005. The increase in time spent watching TV between 1983 and 2005 is particularly pronounced among older age groups with 31% increase for men and 47% for women. But we do not only observe an increase in sedentary leisure activities; between 1983 and 2005 there has been a dramatic increase in time doing exercise and sports, particularly for the younger age groups of both men and women. Indeed, young men and women increased the time spent doing exercise by 94% and 198% respectively. With the exception of mid aged men we observe an increase for all the age groups. In spite of this dramatic increase, time doing exercise and sports only accounts for 24 minutes per day for men and 17 minutes for women in 2005.

Table 4.13: *Leisure: hours per day over time (by sex and age)*

	Leisure		TV		Exercise	
	1983	1983-2005 (in %)	1983	1983-2005 (in %)	1983	1983-2005 (in %)
Men						
18-30	10.8	-17.7	2.2	6.9	0.30	94.4
31-59	9.2	-10.6	2.2	19.3	0.34	-4.9
60+	12.3	-8.8	3.1	31.0	0.36	18.2
All	10.4	-9.9	2.4	27.4	0.34	18.0
Women						
18-25	9.7	-8.7	1.9	16.2	0.11	198.4
26-54	9.7	-13.9	2.1	-5.5	0.20	57.9
55+	11.4	-8.2	2.2	47.1	0.15	57.1
All	10.1	-8.7	2.0	30.4	0.17	64.9

Source: Multinational Time Use Study, Versions World 5.5.3, 5.80 and 6.0 (released October 2012). Centre for Time Use Research, University of Oxford, United Kingdom

Other time

What do individuals do in the remaining time? Work, housework and leisure time combined account for about 66% of daily activities, with sleep accounting for about 30% (See Table 4.9). Sleeping time has increased for both men and women between 1983 and 2005 resulting in a larger proportion of daily time spend in sedentary activities. The remaining 5-6% of time for which we do not have a good measure is devoted to traveling. We have evidence that traveling time has increased during the sample period but we do not have information of how many calories individuals spend traveling.

We have provided evidence in this section that together with a decline in calorie purchases we observe shifts in time use that point to an increase in time spend on sedentary activities. The next section provides a summary of the dynamics of weight in England during the last 30 years and summarises our findings related to diets and physical activity.

4.5.3 Summary

We estimate a decline in calorie purchases of between 39 and 22% over the last three decades. At the same time we showed that, due to technological change and the shift from manufacturing to services that resulted in a decline in the strenuousness of work, there was a sharp fall in calories burnt at work among men. We also showed dramatic increases in the time spend on sedentary activities such as sleeping and watching TV. Albeit the differences in the strenuousness of housework and work are small, the shift from work to home production among women is likely to result in a reduction on calories burnt. A common pattern between men and women is the shift from leisure to sleeping time, with the proportion of leisure time declining by 4.3 percentage points for men and 3.7 for women between 1983 and 2005 and sleeping time increasing 4.2 and 4.1 respectively for men and women. We also showed increases in time devoted to sports and exercise, but the average is still very low. All these changes in time use point to an increase in sedentary activities.

Due to data limitations we do not attempt to decompose here weight gains into calories intake and calories burnt; our objective is to show evidence that it is possible to observe a decline in calories consumed together with an increase in bodyweight. These results do not mean that food is not a problem but suggest that physical activity is also part of the explanation. Indeed, the evidence presented here point to the idea that a small and persistent caloric imbalance over a long period of time is sufficient to explain the weight gain experienced in the UK over the last three decades.

4.6 Conclusions

There has been a marked increase in bodyweight and in rates of overweight and obesity accross much of the developed world. Over 25% of adults are obese and 63% are overweight in the UK. Obesity results from an imbalance of calories ingested relative to calories expended. So far the literature has focused on excess calorie consumption but we show that there has been a substantial *decrease* in total calories purchased in England, despite an increase in some high calorie categories like fast food, snacks and drinks. We also show that concurrently with the decline in calorie purchases, time use and the strenuousness of daily activities has changed in important ways.

We compile a unique time series of microdata on calorie and food purchases spanning over more than 30 years. Using a combination of food diary data and information on its nutritional content, we are able to track calorie purchases from over 200 food categories. The second unique feature of our data compilation is that we measure calories from food at home over the whole time series but are also able to fill the gap of knowledge about calories from other food and drinks, most notably food consumed out and alcohol. Using a combination of observed and imputed data we add information of food and drinks that account for 40% of total food spending and we estimate represent between 18 to 20% of calories.

Our results suggest that household calories from food consumed at home declined by 39% between 1980 and 2009. Accounting for household type, we find declines in one-person households of 19 to 22%, in couple households by one quarter and by about a third in larger households over the sample period. Which diet changes lead to this calorie decline? We consider all sources of calories and differentiate three main groups: (i) food purchased for consumption at home, (ii) calories purchased for consumption out, including takeaways, soft drinks, confectionary and snacks, and (iii) alcohol. We find that calories from food at home represent about 80% of calorie purchases, calories from eating out a further 17% and calories from alcohol the remaining 3%. We estimate a decrease of calories from alcohol and an increase of calories from eating out. Our results point to an increase in calories from eating out of 34% between 1980 and 1990, a subsequently stagnation at around 1,000 calories per household per day between 1990 and 2000 and a sharp decline since 2001. The overall decline in calories is due to the reduction in calories from food consumed at home. We provide evidence that diets have become less calorie dense over time, with an increase in the proportion of calories from fruit and vegetables, cereals and other foods, and a decrease in the calorie-dense fats and sugary products.

Together with this changes in diets we observe dramatic changes in the time use and the strenuousness of daily activities. We compute gender-age specific means of time use and strenuousness for each sample year for three physical activities: i) work, ii) housework, and iii) leisure, and show also evidence of changes in time use for sleeping and traveling. We show that there has been large change sin patterns of work, in labour force participation, hours of work and the strenuousness of work that result in changes in energy spend at work. Due to the combination of constant employment, a small decline in the number of hours worked and a large drop in the strenuousness of work energy spend at work declined substantially for men. For women, on the other hand, a large increase in employment and hours of work together with a small decline in the strenuousness of work result in an increase in energy burnt at work. We then provide evidence of changes in time use that point to an increase in time devoted to sedentary activities. Indeed, a common pattern between men and women is the shift from leisure to sleeping time and a dramatic increase in time watching TV. We also showed increases in time devoted to sports and exercise, but the average is still very low.

Our aim is not to suggest that food is not a problem but to point out that physical activity, defined broadly as energy burnt in all daily activities, is also part of the explanation of the increase in bodyweight in England over the last 30 years. A topic that is not discussed in this chapter and that is gaining prominence in the medical literature is the increase in the consumption of sugars, not only from soft-drinks but also from fruit juices and smoothies. Indeed, we only report the evolution of calorie purchases here but our methods can be applied to study other macronutrients.

Appendix A

Imputing nutrient purchases

A.1 Objective

We want to measure total nutritional purchases over time in the UK. The National Food Survey (NFS), and its successors, the Expenditure and Food Survey (EFS) and the Living Costs and Food Survey (LCFS) record nutrient quantities purchased for consumption at home over the period 1980-2009. Two nutrient sources are partially missing for some time period in the data (as in practically any data source of nutrient purchases): those purchased for consumption outside the home and for alcohol (at home and consumed outside the home). Both are available for 2001-2009, but not for 1980-2000.

These consist of the following broad categories[1]:

[1]While we can disaggregate these into more detailed categories easily, particularly food consumed at home, the imputation can only be done for these broad categories as we need to construct categories that are consistent across both data sources. See Table B.1 in the appendix for a detailed list of items

Table A.1: *Sources of nutrients*

Source of nutrients	Definition of category	Availability
food consumed at home	milk products, cheese, meat, fish, eggs, oil and fats, sugar and preserves, (e.g. jams etc.), fruit and vegetables, cereals, cakes, buns and pastries, other (incl. ready meals)	all periods
food consumed outside the home	any food eaten at restaurants, cafes, bars, bistrots, fast food outlets, takeaways, snacks and confectionery (in and out), soft drinks (in and out)	2001-2009
alcohol	any beer, cider, wine, spirits, alcopops (consumed in and outside the home)	2001-2009

The simplest imputation strategy would be to impute backward based on the 2001 to 2009 information on nutrient purchases. Table A.2 shows the information set that is available in the NFS:

Table A.2: *Food spending and nutrition information in the National Food Survey*

		NFS 1980 - 2000	*NFS* 2001-2009
Nutrient purchases	x_{it}	**O**	**X**
Nutrients (in grams)	η_{it}	O	X
Food expenditures (in GBP)	y_{it}	O	X
Food quantities (in grams)	q_{it}	O	X
Household demographics	D_{it}	X	X
		ONS RPI time series	
Food Prices	p_t	X	X

O: missing data; X: available data

Backward imputation would hence rely heavily on cross-sectional variation in household demographics (and their changes over time) and time series variation in overall food prices (using ONS price series). Hence, using this approach would imply strong assumptions on the source of time variation (namely that time variation stems from price changes and changes in household composition alone).

However, there is rich additional information on the evolution of spending on eating out and alcohol that we can take into account using external data sources. The Living Conditions and Food Survey and its predecessors - the Family Expenditure Survey and the Expenditure and Food Survey (henceforth: EFS) contains detailed information on food spending y_{it} over the time period of interest - 1980 to 2009. Both EFS and NFS are samples that are drawn from the same population (in the same manner). In fact, after 2000, both surveys were merged into the EFS/LCFS to reduce duplication of data collection.

The data contained in the EFS is summarized in Table A.3:

Table A.3: *Data availability in the EFS*

		EFS (and predecessors) 1980 - 2000	merged EFS-NFS data 2001-2009
Nutrient purchases	x_{it}	**O**	**O**
Nutrients (in grams)	η_{it}	O	X
Food quantities (in grams)	q_{it}	O	X
Food Expenditures	y_{it}	X	X
Real expenditure[a]	$\tilde{q}_{it}$	X	X
Household demographics	D_{it}	X	X

O: missing data; X: available data; [a] : real expenditure can be computed using the same ONS time series of prices as above

Both datatsets contain a similar set of household characteristics. In the imputation, we use the following list of household demographics:

Table A.4: *Household demographics*

hht_i	household type dummies
	(single male, single female, lone parent, couple, family and other)
$work_i$	dummy variable that takes the value 1 if the head of household is working
age_i	dummy variables that take the value 1 if the head of household age group is equal to:
	less than 35, 35-50, 51-64, 65+
A_i	number of adults in the household
K_i	number of kids in the household
E_i	number of income earners in the household
interactions:	
	total expenditures and household type dummies
	total expenditures and work status
	total expenditures and age of head (group dummies)
	age group of head and household type
	household type and number of kids in different age groups

In the following, we present a multi-step imputation method to obtain a measure of nutrient quantities for the two categories, nutrients purchased from food consumed out of the home and those from alcohol. Food consumed out of the home comprises food eaten during restaurant and fast food visits, from takeaways, and soft drinks and confectionery. The category alcohol contains alcohol consumed at home and out of the home.[2]

We want to measure the amount of nutrient (x) a household purchases in food for consumption outside the home over time. This is equal to the purchased quantity q_{it} (measured in food units like grams) times a nutrient conversion factor η_{it} (nutrients per food quantity),

$$x_{it} = q_{it}\eta_{it} \tag{A.1}$$

where

- i index household,

[2]For simplicity of exposition, we lay out the method for eating out, and then proceed analogously for nutrient purchases from alcohol.

- $t = 1980, ..., 2009$, index time,
- q_{it}: quantity, in grams, purchased by household i at time t
- η_{it}: nutrient conversion factor or nutrients per gram

Since none of our data sources contains pre-2001 data on quantities q_{it} in grams, but our external data source contains data on "quantities" $\tilde{q}_{it}$ measured in monetary terms as real expenditures in December 2005 prices, we first transform quantities in equation A.1 from grams, to December 2005 prices:

$$x_{it} = q_{it}\frac{y_{it}}{q_{it}p_t}\eta_{it}\frac{p_t}{\frac{y_{it}}{q_{it}}} = \frac{y_{it}}{p_t}\frac{\eta_{it}p_t}{up_{it}} = \tilde{q}_{it}\tilde{\eta}_{it} \tag{A.2}$$

Where $up_{it} = \frac{y_{it}}{q_{it}}$ is the unit price (or value) of a food group, e.g. the amount paid per unit (in grams). This requires an analogous transformation of the nutrient conversion factors η_{it}, from a per-gram base to a per-real-December 2005 GBP base, $\tilde{\eta}_{it}$ [3].

In the following, we use multiple imputation to obtain a measure of real expenditures $\tilde{q}_{it}$ using information on food spending from the EFS, a different sample from the population with the same observed household demographics than the NFS. To obtain the second object in equation A.2, calories (or other nutrients) per pound spent (in December 2005 prices), $\tilde{\eta}_{it}$, in the second step, we we use a nutrient-per-GBP model to obtain predictions for the period 1980-2000 based on the post-2000 information in the NFS. Finally, we combine both to obtain a measure of nutrient purchases x_{it} for the period 1980-2000.

A.2 Predicting real expenditure $\tilde{q}_{it}$

In the first step of our imputation strategy, we follow a multiple imputation procedure to obtain $\tilde{q}_{it}$. Note that we observe nominal expenditures y_{it}, and a time series of (good-, not household-specific) prices p_t and thus can obtain $\tilde{q}_{it}$ in equation A.2 by either imputing directly $\widehat{\left(\frac{y_{it}}{p_t}\right)}$ or imputing first current expenditure and then dividing by prices to obtain a quantity index: $\frac{\hat{y}_{it}}{p_t}$. The choice of which path to follow is based on the fit of the imputed values relative to the observed ones. We follow the procedure described below for both measures and decided to directly impute real expenditures $\tilde{q}_{it}$; the rest of the paper is thus based on that imputation.

[3]Prices here are not household-specific but rather the general Retail Price Index (RPI) price series.

A.2.1 Data and methods

We use EFS data on expenditure and ONS data on prices to construct a quantity index, $\left(\frac{y_{it}}{p_t}\right)$, for 1980-2009. This is measured in real December 2005 GBP. We then use multiple imputation [4] by chained equations (MICE) [5] and due to the large number of households with zero expenditure in food out and alcohol, we use the predictive mean matching (PMM) to impute the missing values. Multiple imputation is an statistical method to deal with missing values in household surveys. Instead of imputing a single value for each missing observation, by using multiple imputation we replace each missing value by a list of simulated values. This results in a series of complete datasets each of one is analyzed and combined by simple formulas in order to obtain estimates and standard errors that capture the missing data uncertainty.

We are going to use MICE, a flexible approach for the imputation of multiple variables that allows the specification of different models for each variable. In our case we have missing values of $\tilde{q_{it}}$ for alcohol and eating out, takeaways and soft-drinks and confectionary in the period 1980-2000 as well as completed variables for several demographic variables. The MICE algorithm in our case starts by regressing a transformation of real expenditure on alcohol on demographics D_{it}, real expenditure on food at home and real expenditure on food out. The missing values for $\tilde{q_{it}}$ are replaced by simulated values from the posterior predictive distribution of $\tilde{q_{it}}$ to obtain $\hat{\tilde{q_{it}}}$. In order to draw values from the observed values, PMM uses the closest neighbour based on the predictive value of a linear model. After obtaining imputed values for real expenditure on alcohol, we regress real expenditure on food out on demographics, real expenditure on food at home and real expenditure on alcohol.

As the quantity index has a skewed distribution we follow Royston and White (2011) and use a shifted log transformation. A real number γ is estimated and subtracted from the original variable to obtain a zero skewness transformed variable. The transformation is:

$$k_{it} = ln(\pm \left(\frac{y_{it}}{p_t}\right) - \gamma) \tag{A.3}$$

Where γ and the sign are chosen so that the skewness of k_{it} is zero.

We then estimate the following linear regression model:

[4] See Rubin (1987, 1996), Schafer (1997, 1999), among others
[5] See Royston and White (2011)

$$k_{it} = \alpha + \beta D_{it} + \lambda_1 D_{it}\omega_m + \lambda_2 D_{it}\mu_t + \omega_m + \mu_t + \delta k'_{it} + \epsilon_{it} \tag{A.4}$$

where:

- D_{it} are household demographics (and interactions with time)
- ω_m are month dummies
- μ_t are year dummies
- k'_{it} is a vector of zero skewness log transformed real expenditure, $k'_{it} = ln(+/-\frac{y_{it}}{p_t} - b)$, where b and the sign of $\frac{y_{it}}{p_t}$ are chosen such that k'_{it} has zero skewness. For alcohol, k'_{it} includes real expenditure on food at home and eating out. For eating out, k'_{it} includes real expenditure on food at home and alcohol.

To obtain the simulated values from the posterior predictive distribution we use PMM, a procedure in which imputed values are draws from the observed values of the imputed variable. In our case, imputed values for k_{it} on each expenditure group in the NFS for t=1980,...,2000 are going to be sampled from the observed values in the EFS. In order to draw values from the observed values, PMM uses the closest neighbour based on the predictive value of a linear model. This procedure has to be repeated as many times as the number of imputations we want. At the moment we are working with 3 imputations. There is no consent in the literature about the number of imputations to use but in general, the number of imputation should increase with the proportion of missing data.

We then use the NFS data on demographics and the estimated coefficients to impute the quantity index for 1980-2009 following the procedure described above using the following estimated model:

$$\hat{k}_{it} = \hat{\alpha} + \hat{\beta} D_{it} + \hat{\lambda}_1 D_{it}\omega_m + \hat{\lambda}_2 D_{it}\mu_t + \omega_m + \mu_t + \hat{\delta} k'_{it} \tag{A.5}$$

Thus, we obtain $j = 3$ imputed values $\hat{k}_{ijt}$ for each missing value k_{it}, with $\bar{k}_{it} = \frac{1}{3}\sum_{j=1}^{3}\hat{k}_{ijt}$.

We transform $\hat{k}_{ijt}$ to get the predicted real expenditures, $\hat{q}_{ijt} = \widehat{\left(\frac{y_{ijt}}{p_t}\right)}$.

The overall estimate of a household's real food expenditure is simply the average of the 3 imputations. To compute the overall variance, we need to first calculate the within-imputation variance $\bar{\sigma}_{WI} = \frac{1}{3}\sum_{j=1}^{3}\sigma_j$, and secondly the between-imputation variance $\bar{\sigma}_{BE} = \frac{1}{3}\sum_{j=1}^{3}\hat{k}_{ijt} - \bar{k}_{it}$. The total variance of $\bar{k}_{it}$ is then obtained as $\sigma_{total} = \sigma_{WI} + \frac{4}{3}\sigma_{BE}$.

A.2.2 Results

In order to assess the validity of our imputation procedure we are going to compare not only the imputed mean with the observed mean over time but also how the imputed values' distribution at different points in time compares with the observed values. The imputation procedure does very well in capturing the distribution of the observed values, density functions of imputed values are similar to those of observed values for all of our categories (see Figure A.1 and Figure A.2).

Figure A.1: *Distributions: imputed vs observed (Alcohol - selected years)*

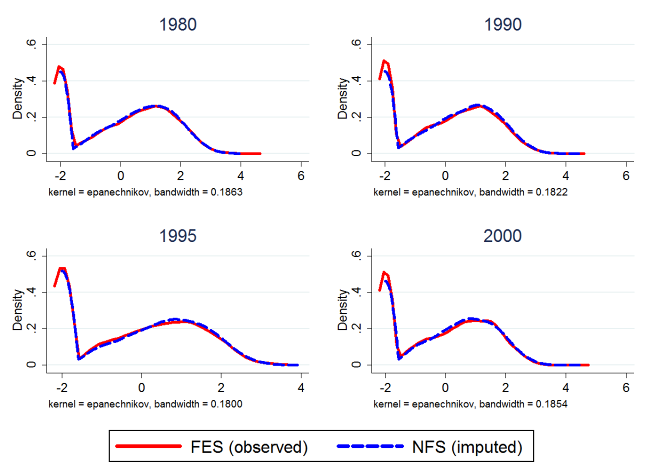
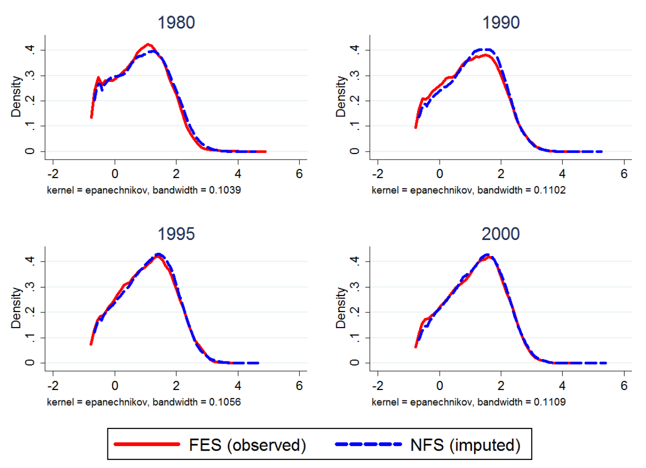


Figure A.2: *Distributions: imputed vs observed (Eating out, soft-drinks, confectionary and takeaways - selected years)*



We are also interested in assessing how our imputation procedure does in estimating the mean over time. For both alcohol and eating out our imputation procedure does a very good job in capturing the mean trend over time. Figure A.3 shows alcohol average real expenditure over time in the EFS - observed values - and the imputed values in the NFS. It also shows the 95% confidence interval computed using the formula for the standard deviation depicted in the previous section. Figure A.4 shows the same variables for eating out. It can be seen in the figures how our imputed values follow the observed ones very closely. Moreover, the observed values generally lie within the 95% confidence interval.

Figure A.3: *Alcohol: mean real expenditure over time*

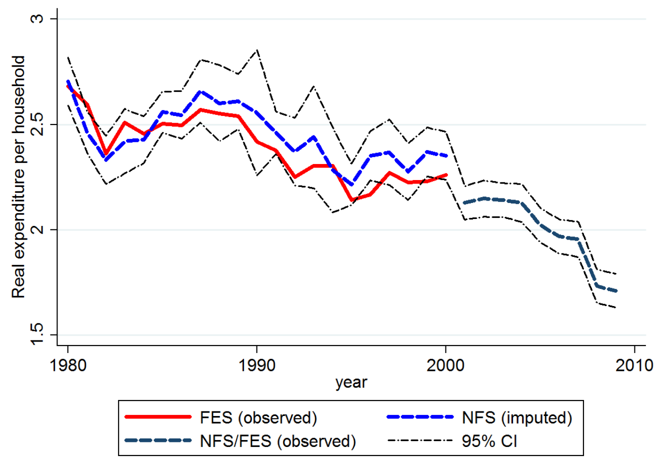
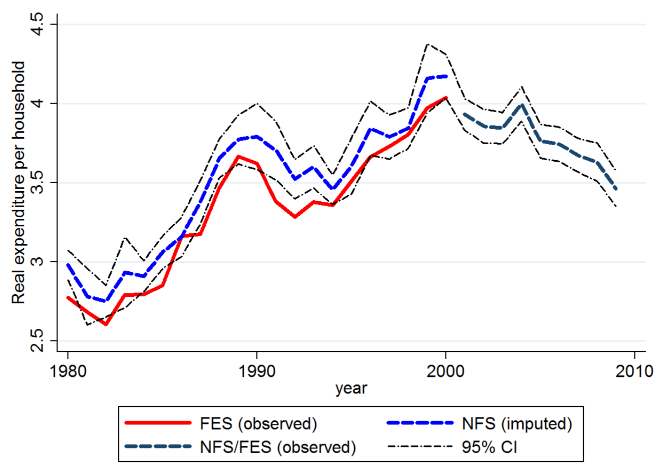


Figure A.4: *Eating out, soft-drinks, confectionary and takeaways: mean real expenditure over time*



Finally, we are also interested in assess how our imputation method performs for different demographic variables. As we are interested in calories and spending for different household types we show in Figure A.5 and Figure A.6 similar graphs by household type.

Figure A.5: *Alcohol: mean real expenditure over time by household type*

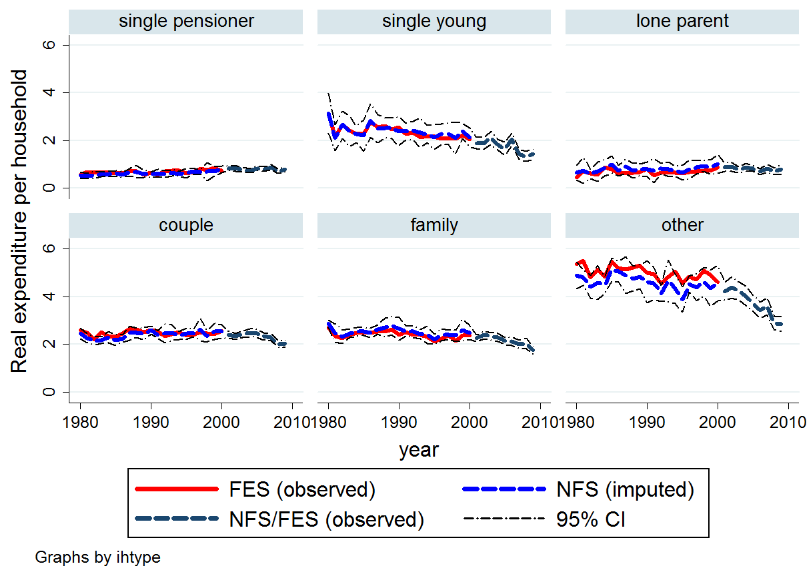
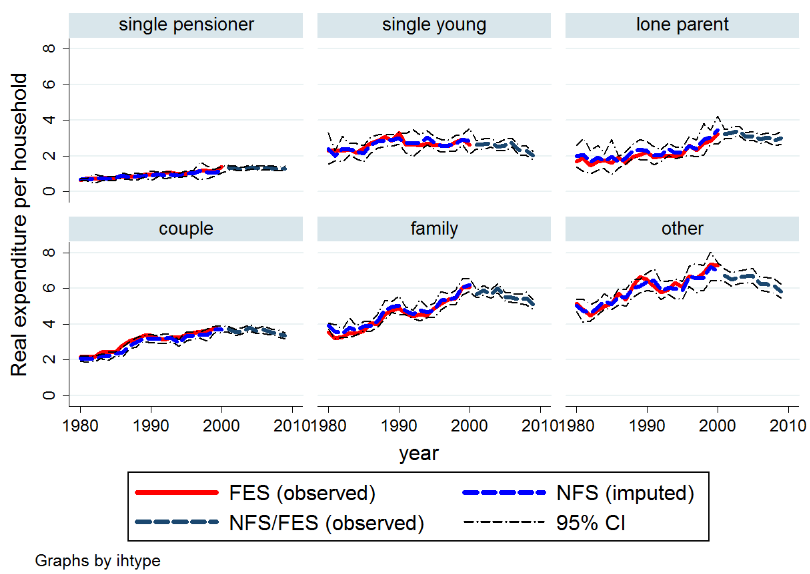


Figure A.6: *Eating out, soft-drinks, confectionary and takeaways: mean real expenditure over time by household type*



A.3 Predicting nutrient values $\tilde{\eta}_{it}$

We now want to backwards impute the second term in equation A.2, $\tilde{\eta}_{it}$. Hence, we need to construct a measure of $\tilde{\eta}_{it}$, the nutrient content per pound spent on food consumed outside the home, based on the information available in the NFS between 2001 and 2009, and then estimate its determinants for the backwards imputation. According to equation A.2, nutrients per pound spent can be computed as: $\tilde{\eta}_{it} = \frac{\eta_{it} p_t}{\frac{y_{it}}{q_{it}}}$. All of its components are observed in our 2001-2009 data.

A.3.1 Data and methods

Note: this is correct - we do compute unit values at the aggregate level as the ratio of expenditures and quantities. And this is not the same as the (unweighted) sum of the s-level unit values, but it is the same as the weighted sum of the disaggregated unit values up_{ist}:

$$up_{it} = \frac{y_{it}}{q_{it}} = \frac{\sum_s y_{ist}}{\sum_s q_{ist}} = \sum_s \frac{y_{ist}}{q_{it}} = \sum_s \frac{q_{ist}}{q_{it}} \frac{y_{ist}}{q_{ist}} = \sum_s \frac{q_{ist}}{q_{it}} up_{ist} = \sum_s w_{ist} up_{ist} \neq \sum_s up_{ist} \tag{A.6}$$

Since individual food items s are aggregated into two groups - eating out, takeaways, soft drinks and confectionery as well as alcohol -, the nutrient conversion factor η_{it} is a weighted average of the original nutrient conversion factors for each good s, δ_{st}:

$$\eta_{it} = \sum_s w_{ist} \delta_{st} \tag{A.7}$$

Where each weight, $w_{ist} = \frac{q_{ist}}{q_{it}}$, is the percentage of the overall quantity consumed (in an aggregate category) that household i consumes of sub-item s. Note that δ_{st} does not vary across households, as it is the nutrient amount contained in 1 kilogram of detailed food group s, while η varies by household due to the household-specific consumption of goods contained in an aggregate food group.

In sum, we construct nutrients per pound spent (in 2005 prices) between 2001 and 2009 as:

$$\tilde{\eta}_{it} = \eta_{it} \frac{p_t}{up_{it}} = \sum_s w_{ist} \delta_{st} \frac{p_t}{up_{it}} = \sum_s \frac{q_{ist}}{q_{it}} \delta_{st} \frac{p_t}{up_{it}} \tag{A.8}$$

During the observation period 2001-2009, $\delta_{st} \sim \delta_s$, i.e. the sub-item level nutrient conversion factors do not vary in our data. Furthermore, for food at home, we find only limited time variation in the nutrient conversion factors at the disaggregated level over the long time period between 1980 and 2009. The variation in $\tilde{\eta}_{it}$ thus originates from cross-sectional and time series variation in prices and, even more, in the the weights w which reflect the composition of food demand in the aggregate categories.

We model $\tilde{\eta}_{it}$ as a function of detailed household characteristics, prices and expenditure patterns to capture food demand and diet changes which drive changes in $\tilde{\eta}_{it}$:

$$\tilde{\eta}_{it} = \alpha + \beta D_{it} + \boldsymbol{\gamma p_t} + \zeta y_{mit} + \zeta y_{it} + y_{it} D_{it} + \epsilon_{it} \tag{A.9}$$

where
$\boldsymbol{p_t}$ is a vector of prices (food in, eating out and alcohol),
D_{it} denote household characteristics,
y_{mit} is (real) total food expenditures (and expenditures squared), and
y_{it} is (real) expenditure on the food group (eating out or alcohol)

In our estimation, especially in the category alcohol, we need to account for the frequency of zeros in our data which may be due to abstinence or purchase infrequency. A frequently used method to account for zeros is the estimation of a Tobit model. However, censored regression techniques are not designed for applications in which values beyond the censoring threshold (in our case: below zero)are infeasible. Instead, we estimate our model using the Generalised Linear Model (GLM) estimator which maximizes the log-likelihood:

$$Q(\theta) = \sum_{i=1}^{N} [a(m(x_i, \beta)) + b(y_i) + c(m(x_i, \beta))] \tag{A.10}$$

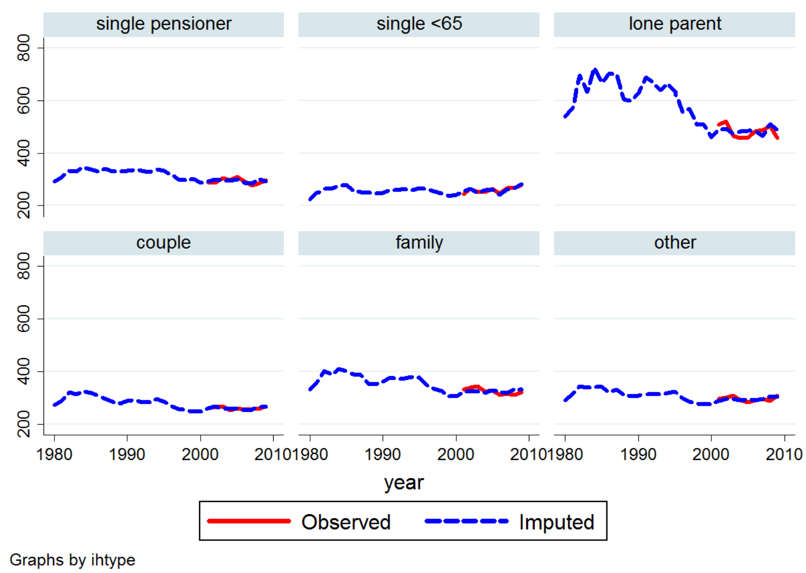
Where $m = E(y|x)$ is the conditional mean of y, $a(.)$ and $c(.)$ correspond to different members of the linear exponential family and $b(.)$ is a normalizing constant. We use a log link function, assuming that $a(m(x_i, \beta)) = \ln(E(y|x)) = x\beta$, using the Newton Raphson maximum likelihood method and assuming a Gaussian distribution of $\tilde{\eta}_{igt}$.

In the following, we plot fitted versus observed calories per GBP (in 2005 prices) to demonstrate the quality of our imputation. We start with eating out and followup with alcohol.

Figures A.7 and A.8 show that the prediction is very good in terms of fitting the level as well as predicting the right trends over time.This holds not only in terms of predicting the average but also when broken down by household type. All household types experience largely flat profiles in calories per pound spent on eating out throughout time, with the marked exception of the period between the mid 1990s and 2000, in which calories per pound spent on eating out fall distinctively (for the average from 360 calories to 300 calories per pound spent). This is mainly due to an increase in the price for eating out during these years. This decline is most marked for lone parents for whom calories per pound spent decline from about 800 to 500. This group also experiences a large increase in spending on eating out as shown in Figure A.6.

Figure A.7: *Mean trend in calories per GBP spent (in 2005 prices): imputed vs observed (Eating out, take aways, soft drinks and confectionery)*

Figure A.8: *Mean trend in calories per 2005 GBP spent, by household type: imputed vs observed (Eating out, take aways, soft drinks and confectionery)*



Figures A.9 and A.10 show equivalent results for alcohol. As for eating out, the predictions of our model closely match the trends over time. We also fit the level quite well; we underpredict it by around only 5 calories per household per pound spent. It can be seen in Figure A.9 that calories per pound spent on alcohol items increases strongly over the last decade, by around 20% between 2001 and 2009. This reflects a shift from alcohol consumed out to alcohol consumed at home and from beer to wine and spirits, both patterns associated with cheaper calories. The good fit holds not only in terms of predicting the average but also for most household types.

Figure A.9: *Mean trend in calories per GBP spent (in 2005 prices): imputed vs observed (Alcohol)*

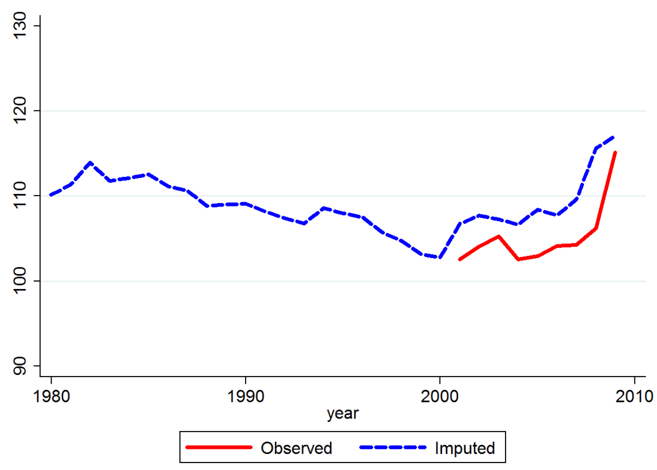
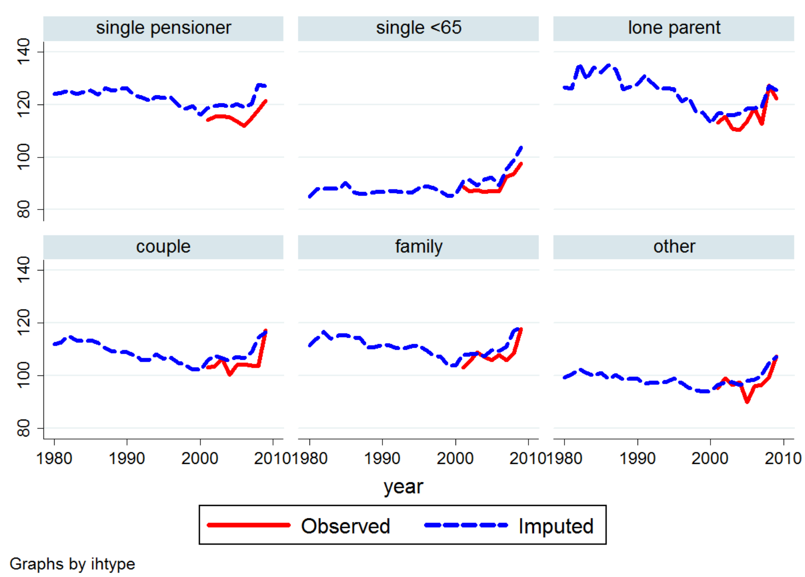


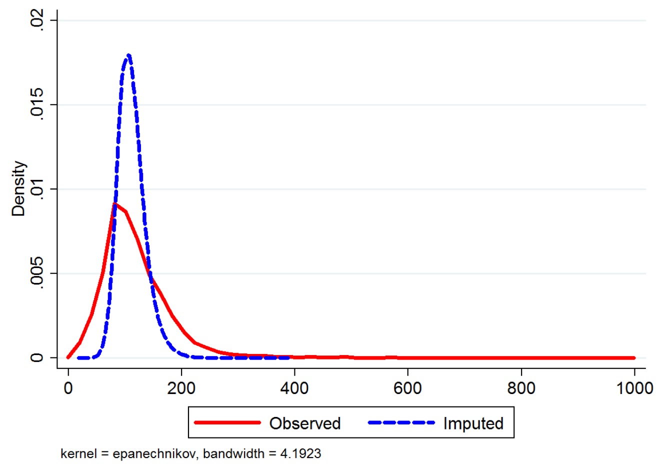
Figure A.10: *Mean trend in calories per GBP spent (in 2005 prices), by household type: imputed vs observed (Alcohol)*



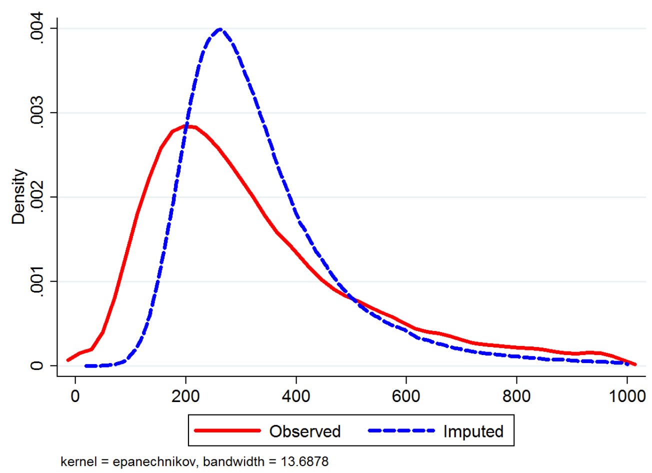
The remaining two figures in this section show that while our imputed values (necessarily) have a lower variance than the observed data since we cannot capture unobserved heterogeneity across households in our imputation method. In spite of that, we capture skewness and mean quite well.

Figure A.11: *Distribution of calories per GBP spent (in 2005 prices): imputed vs observed*

Alcohol



Eating out, take aways, soft drinks and confectionery



In the next section we predict $\hat{\tilde{\eta}}_{it}$ based on household demographics D_{it}, time series for prices (of eating out and alcohol), and real expenditures (or quantities), y_{mit} and y_{it}, which are all observed throughout the sample period.

A.4 Predicting calories $\tilde{x}_{it}$

Finally, we compute imputed calories (or other nutrients) x_{it} using equation A.2:

$$\hat{x}_{it} = \hat{\tilde{q}}_{it}\hat{\tilde{\eta}}_{it} \tag{A.11}$$

Alternatively, we also impute calorie purchases from alcohol and eating out based on the assumption of constant nutrient conversion factors over time, i.e. instead of using our imputation model from equation A.9, we assume that calories per pound spent on these goods has not changed over time and fix their value at the average across households and across all years between 2001 and 2009 as a robustness check and in order to check how sensible our imputation strategy is to assumptions made in our model about calories per GBP spent. Figure A.12 shows average calories from eating out over time from our two imputation methods and the observed values during the period 2001-2009. Our imputation underpredict calories from eating out by between 50 to 100 calories per household per day. A similar picture is shown in Figure A.13 for alcohol. At least at the mean, assuming constant nutrients per pound spent improves the prediction for both eating out and alcohol. For both eating out and alcohol, we obtain similar trends over time whether we use our imputation method or if we assume constant calories per GBP.

Figure A.12: *Mean trend in calories: imputed vs observed (Eating out, takeaways, soft drinks and confectionery)*

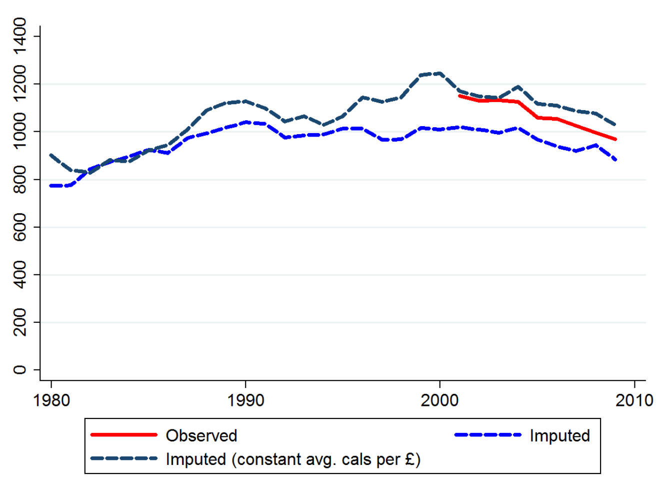


Figure A.13: *Mean trend in calories: imputed vs observed (Alcohol)*

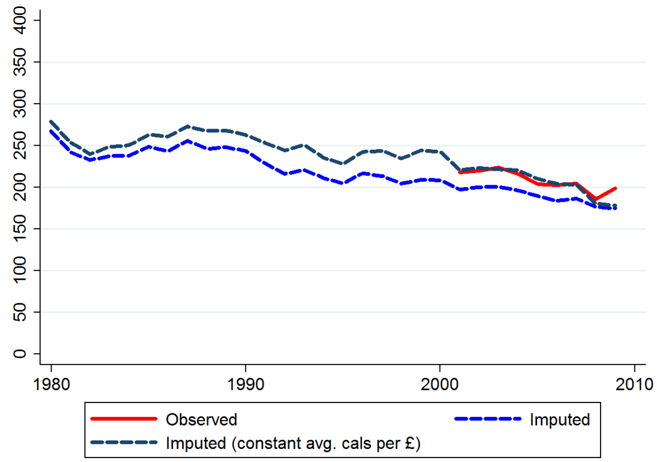


Figure A.14 shows estimated total calories (including food at home) for the period 1980 to 2009 using the two proposed imputations methods and the observed value for the period 2001-2009. In order to show the importance of calories from food at home in total calories, we also include in the graph average household calories from food in. Either imputation method gives similar results: a sharp drop in total calorie purchases over time. We estimate a substantial decline in total calories from food and drinks until 2000 and a moderately decline thereafter. During the last 30 years, we estimate a reduction in total calories per household of about 30%, slightly less pronounced than the decline in calories from food at home.

Figure A.14: *Mean trend in calories from all foods: imputed vs observed*

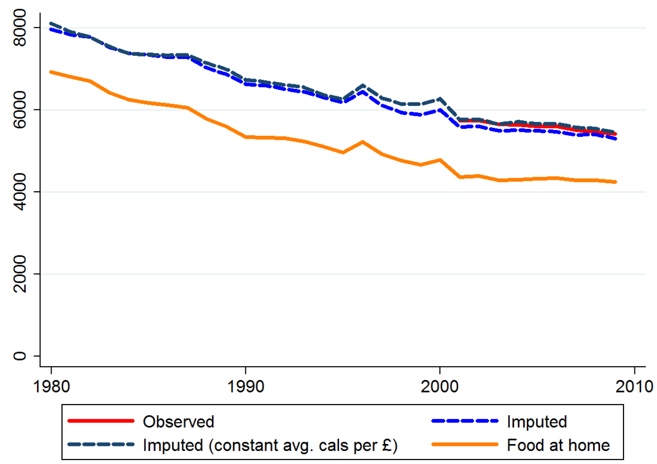


Figure A.15, Figure A.16 and Figure A.17 show similar pictures by household type. We observe differences in the evolution of calories from food in and overall food across household types, with smaller reductions in total calorie purchases among singles and 2-person households. We also observe large increases in calories from eating out for families, lone parents and other household types. Calories from alcohol remain relatively flat for lone parents and couples, increase slightly for single pensioners and decline for single youngs, families and other household types.

Figure A.15: *Mean trend in calories, by household type: imputed vs observed (Eating out, takeaways, soft drinks and confectionery)*

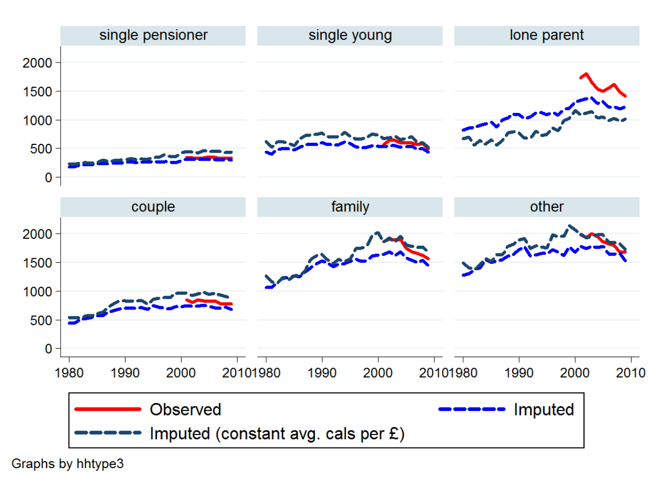


Figure A.16: *Mean trend in calories, by household type: imputed vs observed (Alcohol)*

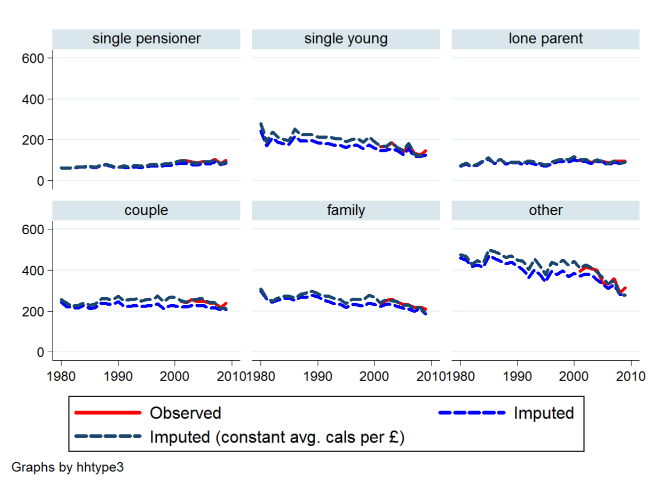
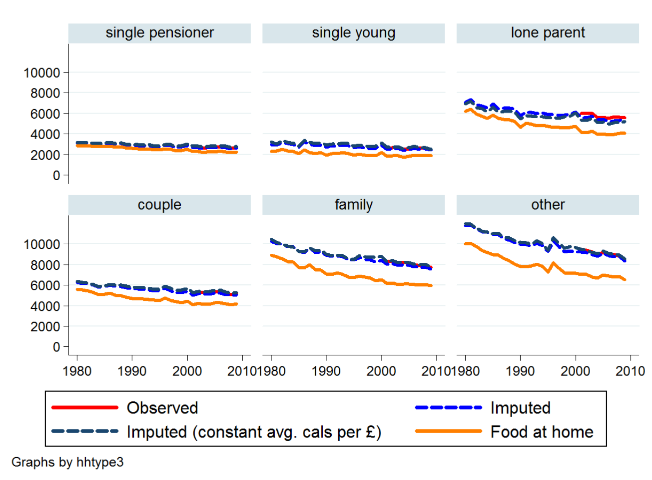


Figure A.17: *Mean trend in calories from all foods, by household type: imputed vs observed*



Finally, Figure A.18 and Figure A.19 show the empirical distribution of both observed and imputed values of calories from eating out and calories from alcohol. As can be inferred from the graphs, for both categories we predict the distribution of calories quite well.

Figure A.18: *Distribution of calories: imputed vs observed (Eating out, takeaways, soft drinks and confectionery)*

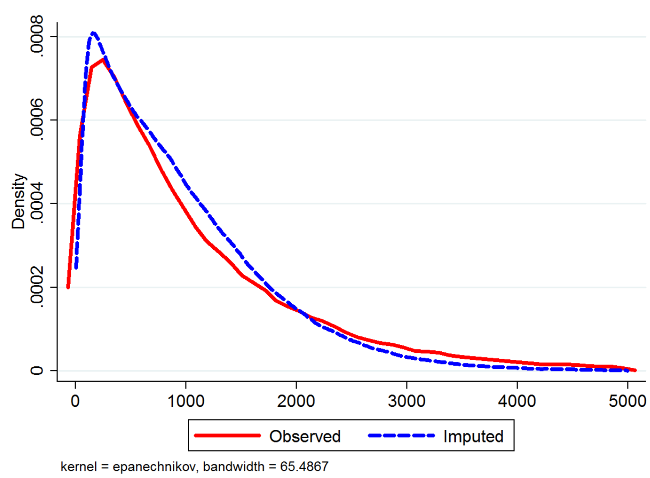
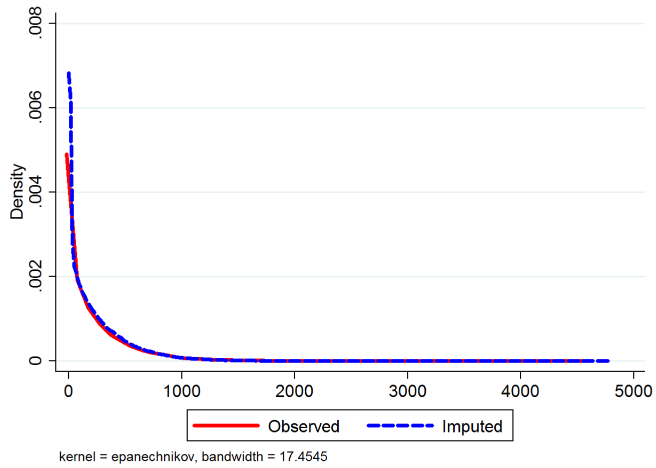


Figure A.19: *Distribution of calories: imputed vs observed (Alcohol)*



Appendix B

Data appendix

B.1 Data sources

B.1.1 Expenditure and calories

Data we use

National Food Survey (NFS) for 1980 to 2000

The National Food Survey (NFS) was originally set up in 1940 by the then Ministry of Food to monitor the adequacy of the diet of urban households during wartime, but it was extended in 1950 to become representative of British households. It is a repeated cross-section that samples about 8,000 households per year. The information is collected continuously during the year. The person who does most of the food shopping is in charge of keeping records of all the food purchased and brought home during seven days. For each item, the diary keeper has to record in the diary: a short description, quantity purchased and the cost. Free food is recorded only at the time of use. Depending on the year there are between 180 and 240 food items. Together with food purchases, demographic characteristics of the household members are obtained through a face-to-face interview.

Expenditure and Food Survey (EFS) and Living Costs and Food Survey (LCFS) for 2001 to 2010

The last wave of the NFS was conducted in 2000. From April 2001, the NFS has been merged with the Family Expenditure Survey to form the new Expenditure and Food Survey (EFS).

Later in 2008 and due to small changes in the questionnaire, the EFS was re-named as the Living Costs and Food Survey (LCFS). The EFS/LCFS collects household expenditure not only on food and beverages but also on other durable and non-durable goods. All household members aged 16 or more keep a personal diary of daily expenditure for 14 days. Simplified diaries are kept by members of the household aged between 7 and 15. Contrary to the NFS, the EFS/LCFS collects not only information on all the food and beverages brought home but also on food and drinks that do not enter the house such as restaurant meals and school meals. For household purchases the quantities are collected in the diaries and also through receipts. This is not possible for eating out, take-aways and some instances of free food. For these items the Department for Environment, Food and Rural Affairs (DEFRA) use estimated portion sizes to calculate weight/volume and in turn nutrient intakes. Where possible, whole meals eaten out are split into food components. There are in total around 500 food items reported in the EFS/LCFS of which 240 are of food brought home. Another difference with the NFS is with respect to free food. While free food is recorded in the diary in the NFS, it is obtained through an interview in the EFS/LCFS and most categories are estimated by assigning standard portion sizes. Expenditure on regular items, such as utilities, mortgages payments or rents, as well as infrequent expenditures are obtained through a face-to-face interview. Demographic characteristics of household members are also obtained through a face-to-face interview.

Consistency: NFS, EFS and LCFS

We made two changes to the original expenditure data in order to make the categories in the different surveys consistent over time.

Grouping: Although the surveys are similar in its structure, there are few changes in the available items over time. In general, there is a higher level of aggregation in the expenditure items available in the NFS than in the EFS/LCFS. Not considering alcohol, confectionery and soft drinks and eating out categories, there are roughly between 180 and 200 items between 1974 and 1984, 215 since 1985 and 240 since 2001. In order to make the items consistent over time we have to grouped some of them. A detailed list of items is available from the authors upon request.

Adjustment factors: According to DEFRA, for some types of food, expenditure estimates from the NFS (1980-2000) are substantially lower than those from the EFS (from

2001). In order to make the data comparable DEFRA suggest to apply an adjustment factor. Take the example of Yoghurt (code 1301). The adjustment factor proposed by DEFRA is 1.14732982499301. Then, if average purchased quantities of yoghurt per person per day in the NFS is 28.9 ml, DEFRA suggests to adjust that value as 28.9 times Adjustment factor=33.1 ml. We follow this procedure for all the items. A detailed explanation of the estimation of the NFS adjustment factors can be found in DEFRA (2011).

Table B.1: *Summary list of items*

Food at home	
Milk	Full fat milk, skimmed milk, semi-skimmed milk, other milk, dairy deserts, yoghurt, infant milk, dried milk, condensed or evaporated milk, fromage frais, milk drinks, non-diary milk substitutes, cream
Cheese	Hard cheese (cheddar, edam, etc), soft cheese, cottage cheese, processed cheese
Meat	Beef, veal, mutton, lamb, pork, ox liver, lambs liver, pigs liver, other liver, offal other than liver, bacon, ham, chicken, turkey, other poultry, corned beef, other cooked meat, canned meat, sausages, meat pies, sausage rolls, pasties, puddings, burgers, other convenience foods and ready meals, pate, delicatessen type sausages, meat pastes and spreads, other meat products
Fish	White fish, herrings and other blue fish, salmon, shellfish, tinned salmon, other tinned or bottled fish, ready meals and other fish products
Eggs	Eggs
Fats	Butter, soft margarine, other margarine, lard, cooking fat, vegetable cooking oils, olive oil, vegetable and salad oils, reduced fat spreads, suet and dripping, imitation cream, all other fat
Sugar and preserves	Sugar, jams and fruit curds, marmalade, honey
Fruit & veg.	Potatoes, cabbages, brussels sprouts, cauliflower, lettuce and leafy salads, peas, beans, carrots, turnips and swede, onions, leeks, shallots, cucumbers, mushrooms, tomatoes, stewpack, stirfry pack, other vegetables, chips, ready meals and other vegetables products Oranges and other citrus fruits, apples, pears, stone fruit, grapes, bananas, melon, other fresh fruit, tinned peaches, pears and pineapples, other tinned or bottled fruit, dried fruit, nuts and nut products
Bread, cakes & cereals	White bread, brown bread, wholemeal bread, rolls, malt bread, fruit loaves, vienna and french bread, other bread, sandwiches Flour Buns, scones, teacakes, cakes, pastries Crispbread, sweet biscuits, cream crackers, other unsweetened biscuits Oatmeal and oat products, breakfast cereals, canned milk puddings, puddings, rice, infant cereals, cereal snacks, other cereals, pizza, pasta,
Beverages	Tea, coffee beans and ground coffee, instant coffee, coffee essences, cocoa and chocolate drinks, malt drinks
Soups, sauces & other	Baby foods, soup, meals on wheels, pickles and sauces, spreads and dressings, stock cubes and meat and yeast extract, jelly squares or crystals, ice-cream, salt, artificial sweeteners, vinegar, spices and dried herbs, bisto, gravy granules, stuffing mix, soya and novel protein foods
Alcohol	
Alcoholic drinks (in and out)	Wine, beers, ciders and perry, champagne, sparkling wine, spirits, fortified wines, liqueurs and cocktails, alcopops, bitter
Eating out: Soft-drinks, confectionery, takeaways and food out	
Soft drinks (in and out)	Soft-drinks, vegetable and fruit juices, mineral water, milk as a drink, milkshake and flavoured milk
Confectionery (in and out)	Chocolate bars, chewing gum, mints, boiled sweets, fudges, toffees, caramels, other sweets
Takeaways	Chicken, meat pies and pasties, meat based ready meals, burger and bun, kebabs, sausages and saveloys, miscellaneous meats, fish, fish products and based meals, chips, vegetable products, sandwiches, breads, pastries, rice, pasta and noodles, pizza, crisps, savoury snacks, pop, tea and coffee, other takeaway food, sauces and mayonnaise, ice-cream and ice-cream products, confectionery
Food out	Indian, Chinese or Thai, meat and meat products, fish and fish products, cheese and egg dishes, pizza, fresh and processed potatoes, vegetables, salads, rice, pasta, noodles, soups, breakfast cereals, fresh and processed fruit, yoghurt and fromage frais, bread, sandwiches, other food products, beverages

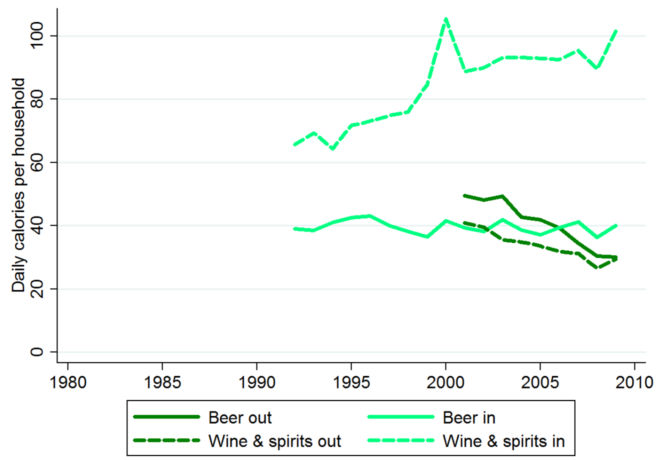
Alcohol

We show in the main paper a decline in calorie purchases from alcohol over the period 1980-2009. In this section we show observed calorie purchases for beer and wine & spirits during the period 1992-2009. We also show expenditure data from the Family Expenditure Survey (FES) to give more details on the expenditure changes during the period 1980 to 2009.

While data on calories from alcohol consumed at home are available from 1992, data for alcohol consumed out are available from 2001. Figure B.1 shows daily calorie purchases per household for beer and wine & spirits depending on whether consumption is at home or out. The overall decline in calories from alcohol is due to the decline in consumption out: beer consumed on premises declined 39% and wine & spirits declined 29% between 2001 and 2009. On the other hand, while calories from beer consumed at home remained relatively flat beetween 1992 and 2009, calories from wine & spirits consumed at home increased by 55%. While alcohol consumed out represented 41% of total calories from alcohol, of which 23% were from beer and 19% from wine &spirits, by 2009 the figure is just 30%. Calories from wine & spirits consumed at home are now 51% of total calories from alcohol.

The composition of calories from alcohol has changed: households are substituting from beer to wine and from consuming alcohol out of the home to drinking at home. While the former cannot be explained by prices (and potentially reflects changes in the availability of wine and/or preference shifts), the latter coincides with strong increases in the price of alcohol consumed outside the home over time, while the price of alcohol for home consumption has remained comparatively flat since 1990. While this has led to a very small increase in calories per pound spent due to the lower price of alcohol bought for home consumption, quantities of (liquid containing alcohol, not of alcohol itself) consumed have decreased. For example, if the choice between a standard sized glass of wine and a pint of lager is made in favor of the wine, consumed calories fall from 200 per pint of beer to 160 per 0.2l wine glass.

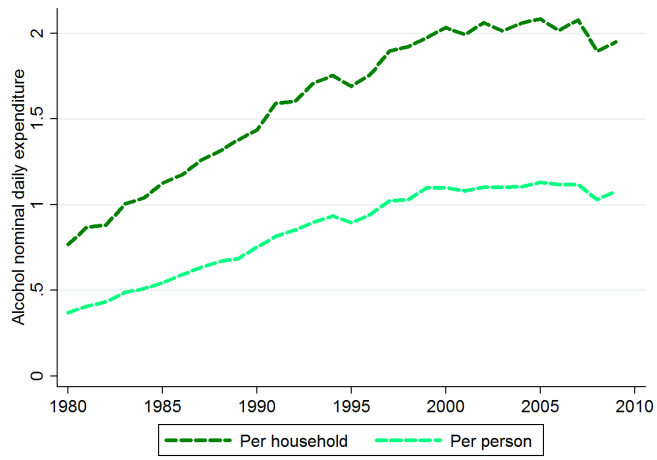
Figure B.1: *Daily calories from alcohol: by type (per household)*



Source: National Food Survey-Expenditure and Food Survey-Living Cost and Food Survey

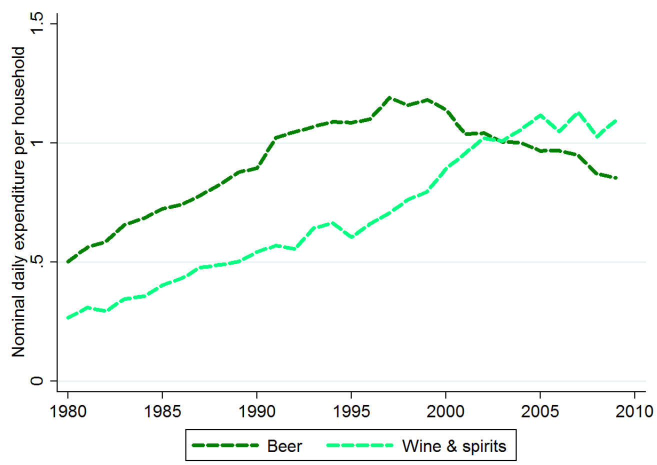
This pattern is also present when looking at expenditure. While alcohol nominal expenditure has steadily grown until 2000, both average alcohol nominal expenditure per household and per person has remained constant during the last decade (see Figure B.2). This is explained by two features: the decline of expenditure on beer and the increase of expenditure on wine and spirits (see Figure B.3) and the decline of expenditure on alcohol consumed out and the increase of expenditure on alcohol consumed at home (see Figure B.4). We observe then a shift from beer to wine and spirits and from consumption out to consumption at home. Finally, Figure B.5 shows that the decline of expenditure on alcohol consumed out is explained by a sharp decline in expenditure on beer that is not offset by the increase in wine and spirits consumed out.

Figure B.2: *Total alcohol nominal daily expenditure (per household and per person)*



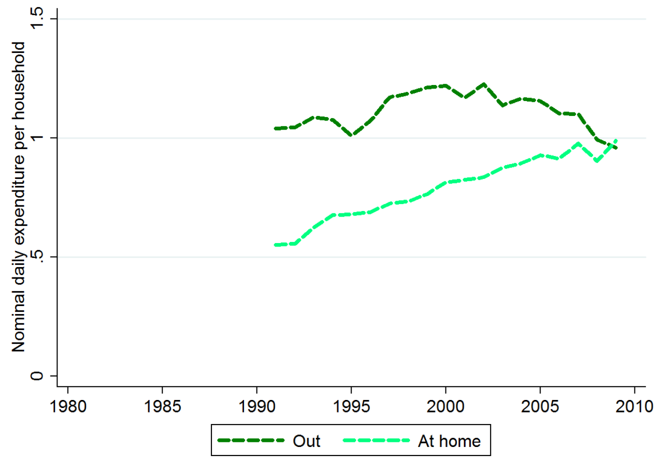
Source: Family Expenditure Survey

Figure B.3: *Nominal daily expenditure: beer and wine & spirits (per household)*



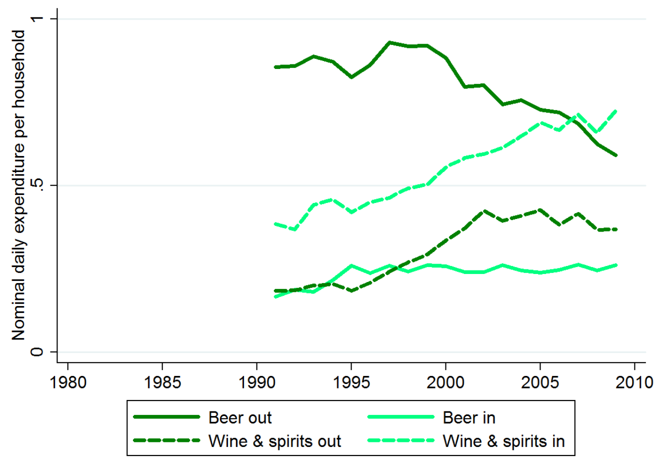
Source: Family Expenditure Survey

Figure B.4: *Nominal daily expenditure: alcohol at home and out (per household)*



Source: Family Expenditure Survey

Figure B.5: *: Nominal daily expenditure: alcohol at home and out by type (per household)*



Source: Family Expenditure Survey

Food out, takeaways, soft-drinks and confectionery

In this section we present more details on the composition of this aggregate category for the last 10 years of data. Note that we observe calories directly from the survey for the period 2001-2009 so we can look at each of the categories separately: food out, takeaways and soft-drinks and confectionery. Calories from the three categories declined between 2001 and 2009: food out declined by 18%, takeaways by 17% and soft-drinks and confectionery by 7%.

Figure B.6: *Calories per household per day: Food out, takeaways, soft-drinks and confectionery (2001-2009)*

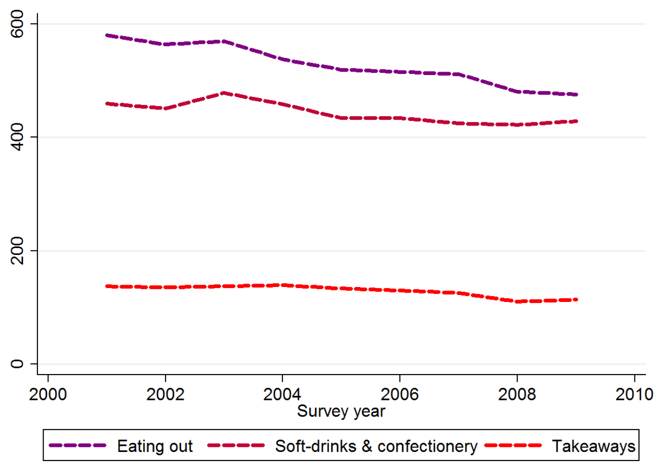
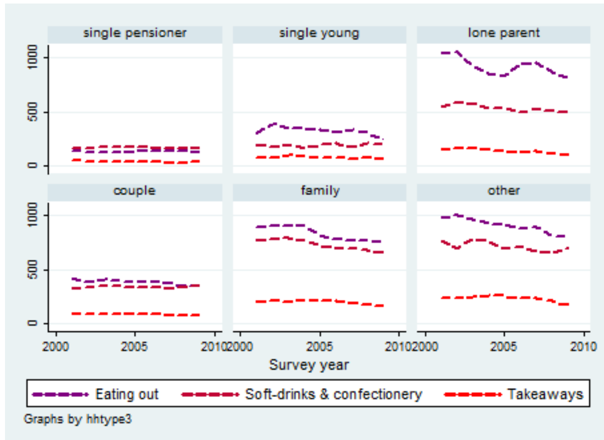


Figure B.7: *Calories per household per day: Food out, takeaways, soft-drinks and confectionery (By household type, 2001-2009)*



From household to individual calories

Data on food purchases are reported at the household level. The composition of households changes substantially over time. For example, the average household size is 2.99 in 1974 and falls to 2.36 by 2009. In 1974 the average number of children is 0.93, while by 2009 it falls to 0.47.

Comparing trends over time at the household-level could thus be misleading. Many studies convert household-level calories into calories of an adult equivalent which is calculated as the sum of caloric needs of all individuals in the household divided by 2550, the Estimated Average Requirements (EAR) for energy of a man aged 19 to 50. We improve on that method by using the full information on Estimated Average Requirements (EAR) for energy by age and sex from the Department of Health (DoH, 1991):

Table B.2: *Caloric needs by age and gender*

Age	Female	Male
4-6	1545	1715
7-10	1740	1970
11-14	1845	2220
15-18	2110	2755
19-50	1940	2550
51-59	1900	2380
60-74	1900	2330
75 plus	1810	2100

Source: DoH (1991).

Where we report individual level food data, we allocate household calories by assuming that the intra-household calories allocation is proportional to each member's Estimated Average Requirements (EAR), for member i of household h:

$$w_{ih} = \frac{EAR_{ih}}{\sum_{i=1}^{N} EAR_{ih}} \tag{B.1}$$

Since total household calorie purchases are the sum of its household members' purchases, $x_h = \sum_{i=1}^{N} x_{ih}$, individual calorie purchases are computed as a fraction w of household-level calorie purchases: $x_{ih} = x_h \cdot w_{ih}$.

This idea goes back to Chesher (1997) who used it to non-parametrically estimate calorie profiles over age using the NFS data. We attempt to show the robustness of our intrahousehold calories allocation rule showing that our results are similar to those obtained using a parametric version of Chesher's method. As described by Chesher in Section 5 in DEFRA (1998), average household calorie purchases can be expressed as the sum of the average calorie purchases of its members. Then, if average calorie purchases for each household member aged A could be expressed as $\alpha_M + \beta_M A$ if male and $\alpha_F + \beta_F A$ if female, we can estimate average calorie purchases by age and sex by estimating the following equation by Ordinary Least Squares:

$$x_{it} = \alpha_M NM_{it} + \alpha_F NF_{it} + \beta_M TM_{it} + \beta_F TF_{it} + \epsilon_{it} \tag{B.2}$$

Where i is an index for households, t is time, x represents household calorie purchases, NM is the number of males in the household, NF is the number of females in the household, TM is the sum of the ages of males in the household and TF is the sum of the ages of females in the household. We estimate equation B.2 for each year between 1980 and 2009 in order to obtain estimates of the average calorie purchases for males and females over time. Figure B.8 shows the results using a parametric Chesher method and our optimal sharing rule for males and Figure B.9 shows the corresponding results for females.

Figure B.8: *Calories per person per day: Males*

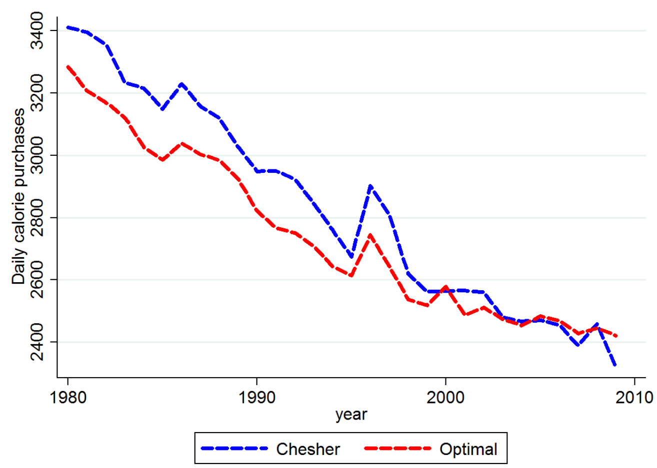
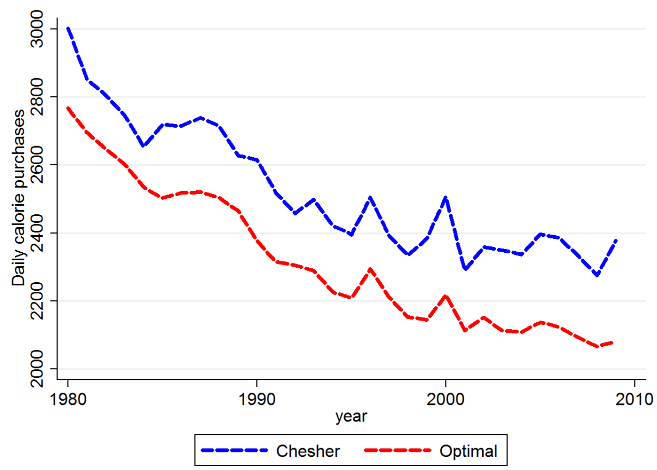


Figure B.9: *Calories per person per day: Females*



B.1.2 Obesity

National Heights and Weights Survey, 1980

With about 10,000 respondents, the National Heights and Weights Survey is a representative sample of adults in Great Britain aged 16-64 in 1980. Commissioned by the then Department of Health and Social Security, its aim was to monitor nutritional aspects and as a starting point to collect information on heights and weights in Great Britain.

Health and Lifestyle Survey (HALS) 1984/85, 1991/92

The first HALS was sponsored by the Health Promotion Research Trust and draw a sample of the adult population (aged 18 or more) in England, Wales and Scotland in 1984-1985. Its aim was to collect information on self-reported health, physiological measures, psychological and cognitive measures, dietary and exercise habits as well as social and working conditions. A second wave of the survey collecting information on surviving respondents of the first wave was carried out in 1991-1992. About 9,000 individual were interviewed in the first wave and 5,000 re-interviewed in the second wave.

Dietary and Nutritional Survey of British Adults 1986/87

A sample of the population of British adults aged 16 to 64 in 1986-1987, the Dietary and Nutritional Survey of British Adults collects information on physical measures, blood pressure, dietary and exercise habits as well as personal and household characteristics. Besides having a short interview, respondents are asked to fill a diary for seven weeks with their intakes of food and beverages consumed in and out of home. The sample consists of about 2,200 respondents.

Health Survey for England (HSE) for 1991 to 2010

Sponsored by the Information Centre for Health and Social Care the Health Survey for England started collecting information on health and factors that affect health among the English population in 1991. A cross-sectional annual survey, it draws a yearly sample of between 10,000 and 20,000 individuals representative of the English population living in private households. Respondents have a face-to-face interview and have clinical and physical measures taken. The survey contains a core questionnaire that is repeated every year and focuses on different health issues every year such as cardiovascular disease and associated risk factors, accidents, disability, physical activity and fitness, long-term health conditions, among others.

B.1.3 Physical activity

Labour Force Survey

Data from the Labour Force Survey (LFS) is used to obtain measures of work activity - employment and work hours. Conducted by the Office for National Statistics, the LFS is the largest household survey in the UK and provides official figures for employment and unemployment. It samples between 40,000 and 60,000 households and moved from annual to quarterly frequency in 1992. We follow Blundell et al. (2011) and use actual hours of work as our measure of the intensive margin of labour supply. The extensive margin is determined using cohort- and age-specific labour force participation rates.

Time use data

We use time use data from the Multinational Time Use Study (MTUS) archive located at the Centre for Time Use Research at the University of Oxford. The MTUS is a harmonized dataset on time use containing information from more than 60 surveys from 25 different countries. We use harmonised data from the UK obtained from the following surveys:

- ESRC Time Budget Survey 1983-1984
- Time use in British Households and Communities 1987
- OPCS Omnibus Survey Time Use Module 1995
- National Survey of Time use 2000-2001
- Omnibus Survey, One Day Diary of Time Use Module 2005

B.1.4 Change in occupations mix

There have been large changes in the nature of work; that are reflected in changes in the occupations mix over time. Figure B.10 shows the proportion of workers in each of the 9 occupations categories during the period 1980 to 2009. While 38% of workers were classified as managers, professional or intermediate level workers in 1980, the figure is 58% in 2009. The decline in the proportion of workers in manual occupations is depicted in Figure B.11. We classify foremen, farmers, agricultural workers and both skilled and semi-skilled manual workers as workers in manual occupations. While 46% of workers were classified in manual occupations in England in 1980, only 28% of the workers are considered to be in manual occupations in 2009.

Figure B.10: *Occupations composition*

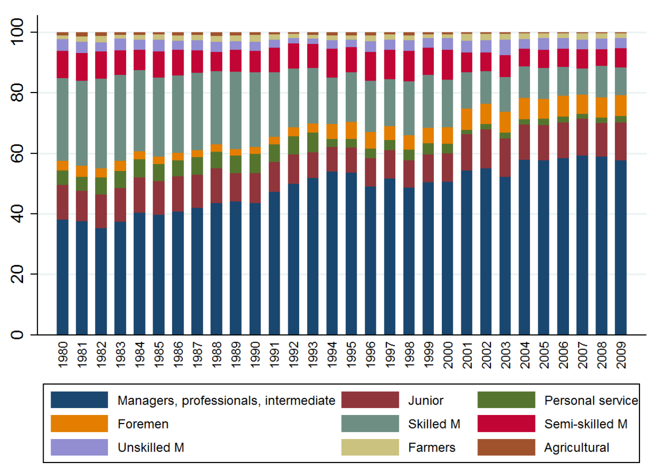
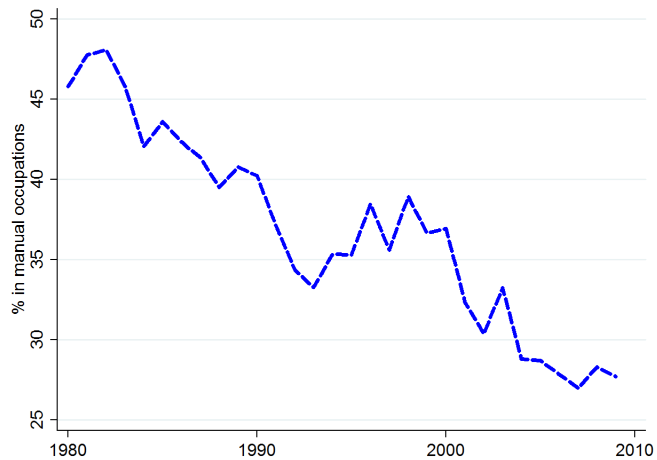


Figure B.11: *Percentage of workers in manual occupations*



B.2 Alternative data sources and robustness checks

There are three alternative sources of data on calories and nutrients usually used in the literature:

- *Household budget surveys*: Collect information on households expenditure and quantities bought on a detailed list of items. Households are usually required to record all daily food and beverages purchases in a diary. The resulting measure represents food available for consumption at the household level and it is expected to overestimate intakes as it includes wastage. Each food item has its corresponding nutrient conversion factor allowing the estimate of household nutrient purchases. Individual purchases have to be recovered from household purchases. Examples of these type of surveys are the National Food Survey and Living Costs and Food Expenditure that we use for the UK and the Consumer Expenditure Survey (CEX) in the US.

- *Household intake surveys*: As opposed to measuring household expenditure, these type of surveys measure individual intakes of food and beverages. Household members are required to record all their daily food consumption in a diary for a given period of time. Nutrient conversion factors are then assigned to the different food items in order to obtain measures of nutrient intakes. We discuss below the main problems that researchers have found when using these type of surveys to measure calorie intakes.

- *Aggregate food balance sheets*: Collected by the United Nations Food and Agriculture Organization (FAO) but also the US Department of Agriculture, they measure food availability for human consumption at the country level. The FAO reports quantities as well as calories, protein and fats available for human consumption at the country level in a given time period. This data source has been widely used in the nutrition literature as it covers a large number of countries for more than 50 years. Examples of studies using this data to measure calories and nutrients are Cutler et al. (2003) in the US and Bleich et al. (2008) in the OECD countries.

B.2.1 Calorie intakes versus calorie purchases

We measure calorie purchases not intakes, i.e. the data come from diaries of food spending and quantities bought rather than from diaries of eating behaviour. It has been shown for many countries that there is large underreporting in intake surveys, especially for women (e.g. Bingham et al. 1995, Briefel et al. 1997, Rennie et al. 2007). Table B.3 compares daily average calorie intakes from British Nutrition Surveys and our calorie purchase data with Estimated Average Requirements for energy from the Department of Health. It shows large underreporting in intake surveys, especially for women, relative to average energy requirements. Average calorie *purchases* - on the contrary- are above estimated average energy requirements.

The calorie purchase data makes allowance for cooking losses and waste from inedible foods, but not for other food waste. According to Defra (2007) about 11% of calories are wasted.[1] Incorporating these waste estimates, average calorie purchases are very close to EARs.

Calorie purchases are likely less prone to systematic underreporting since the diary does not reveal their eating, just their spending behaviour. An additional source of anonymity is that a respondent records food spending for the household and not his or her individual spending.

[1] The data do not account for visitors to the household. Free food is included until 2000, and estimated afterwards (4.3% of calories from all foods per person per day)

Table B.3: *Calorie purchases versus intakes*

Year	Women			Men		
	Nutrition survey	NFS/EFS	EAR	Nutrition survey	NFS/EFS	EAR
1986/87	1,680	2,145[a]	1,940	2,450	2,703[a]	2,550
2000/01	1,635	2,267	1,940	2,308	2,842	2,550
2008/09	1,645	2,186	1,940	2,255	2,702	2,550
Incorporating 11% of calorie wastage						
1986/87	1,680	1,909[a]	1,940	2,450	2,405[a]	2,550
2000/01	1,635	2,018	1,940	2,308	2,529	2,550
2008/09	1,645	1,945	1,940	2,255	2,587	2,550

Source: DoH (1991). [a]: only food at home.

B.2.2 Household surveys versus food balance sheet data

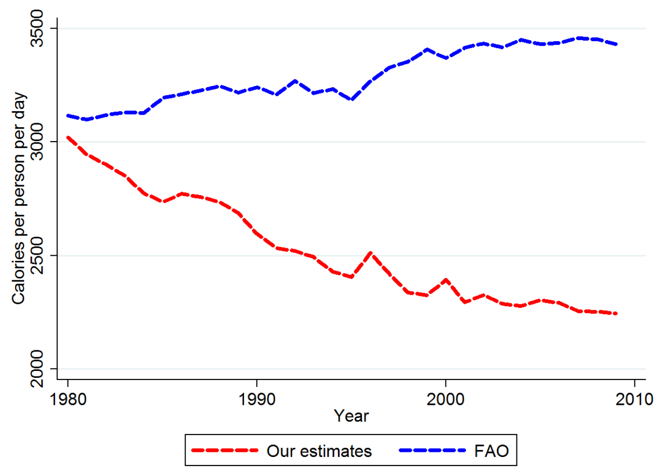
A second source of information usually used in nutritional studies is the United Nations Food and Agriculture Organization's (FAO) food balance sheet. It covers production, trade, feed and seed, waste and food availability for roughly 180 countries since 1961. The FAO reports quantities as well as calories, protein and fats available for human consumption at the country level in a given time period. FAO's food balance sheets data have been used to study the contribution of energy intake to the obesity problem in developed and developing countries (See for instance: Cutler et al. (2003) in the US and Bleich et al. (2008)). Due to lack of long term series data from household surveys, researchers have used FAO's food balance sheet data as proxies for calorie intakes. But there are a number of potential problems with FAO's data that are worth mention.

Researchers have used food available for human consumption as a proxy for food consumption. But FAO estimate food availability as a residual and thus its error, either level or sign, is not quantifiable. According to FAO's food balance sheet handbook: "...At a minimum, this means the quantity of food available for human consumption would have to be estimated independently based on other existing statistical sources of information. One such form would be household survey which collects quantities of food items consumed or acquired". A number of studies (see below) have tried to compare data from household surveys and food balance sheets but no general explanation for the difference between the two data sources has been reached. Differences in levels are expected but household surveys and FAO's food balance sheets should result in similar trends over time. That is not the case for several countries, in particular India (Deaton and Dreze (2010)), Japan (Dowler and Seo (1985)), the US (Crane et al. (1992)) and the UK (see Figure B.12).

Figure B.12 shows average calories per person from UK household surveys - and own estimations - and FAO food balance sheet. While based on household budget survey data we estimate a decline of 26% in calories per person between 1980 and 2009, FAO reports an increase of 10%. Moreover, calories per person from household surveys represented 97% of those obtained using food balance sheets. What is puzzling is the different trend since then. But that is not a problem only for the UK. Deaton and Dreze (2010) find similar trends for India. They briefly discuss the use and reliability of FAO data to study calorie intakes and state that *"the reliability of FAO data is at best uncertain"*. Moreover, when referring to FAO's "food supply" figures, Deaton and Dreze (2010) argue that are *"derived from rather speculative "balance sheets" of national production and utilisation, instead of household surveys, which are often more reliable"*. Crane et al. (1992) study the trends in macronutrients per capita estimated from food supply data and the trends from intake household surveys for the US in the period 1965 to 1988. They use data from several intake household surveys and food supply data from the US Department of Agriculture and find that the trend in macronutrients from the two sources expressed in grams diverge. While they report an increase in fats, carbohydrates and proteins from food supply data, the trend is declining when using household survey data. Moreover, they also find an increase in calories per capita according to food supply and a decline when measured by intakes. Dowler and Seo (1985) show similar trends for Japan between 1953 and 1975.

Several studies have compared results from the FAO's food balance sheets and household surveys for given years. Pomerleau et al. (2003) compare FAO data on fruit and vegetables with reported intakes. In general they find that FAO overestimates intake in 14 out of 15 countries included in the study with the overestimation ranging from 5 to 270%. It is expected that calories data from FAO overestimate calorie intakes as FAO reports availability and does not take into account waste or losses. Other studies that arrive to similar findings are Rodríguez-Artalejo et al. (1996), Serra-Majem et al. (2003) and Rodrigues et al. (2007).

Figure B.12: *FAO vs Our estimates*



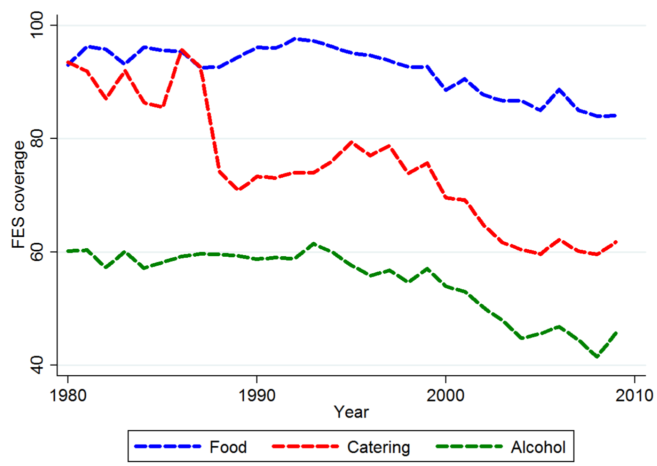
In a review commissioned by the FAO to understand the limitations and propose improvements to the food balance sheets data, Jacobs and Sumner (2002) state that food stock, feed and other uses are particularly prone to error. Food for human consumption is computed as a residual and thus if any of its components is measured with error, food supply is also going to be measured with errors. Take the example of cereals, they represent between 21% and 26% of total calories during 1980 to 2009. Cereals for feed represent 48% of total food supply implying that if we are interested in food supply, errors in the measurement of feed should not be taken lightly.

B.2.3 Expenditure: Household surveys versus National Accounts

The coverage of total expenditure in household budget surveys relative to consumption in the National Accounts has been studied, among others, by Deaton (2005), Attanasio et al. (2006) and Brewer and O'Dea (2012). According to Attanasio et al. (2006) the coverage problem is more important in the US than in the UK. The EFS/FES in the UK has had historically followed quite closely consumption in the National Accounts but coverage problems have recently been detected by Brewer and O'Dea (2012). National Accounts data is not exempted from problems but it is a good benchmark to which compare household level data.

We use data from Brewer and O'Dea (2012) to assess the coverage of food expenditure in the FES and subsequent surveys during the period covered in our study. Figure B.13 shows the percentage of expenditure captured in the FES relative to the National Accounts for our three expenditure categories: food at home, alcohol and food out (catering). The level of coverage of food expenditure is relatively high but has declined over time, particularly from the mid-1990s. While the FES captured 93% of food expenditure in the National Accounts in 1980, coverage has declined to 84% in 2009. The cases of alcohol and food out are more worrisome. Alcohol coverage has declined from 60% in 1980 to 46% in 2009 and food out coverage has declined from 94% to 62% during that period.

Figure B.13: *Expenditure FES coverage compared to National Accounts (in %)*



Source: Brewer and O'Dea (2012)

Given the declining coverage and assuming that the National Accounts are correct, what would be the trend in calories assuming that expenditure coverage is the same as for calories? Figures B.14, B.15, B.16 and B.17 show coverage adjusted calories for the total and our three categories: food at home, alcohol and food out. The declining pattern of total calories over time has not change even after the adjustment by expenditure coverage. This is because 80% of calories are from food at home; category for which the coverage problem is not that important. The decline in average household calories purchases after accounting for expenditure coverage is -28%, compared with -39% when using unadjusted calories.

Figure B.14: *Total calories per household: our estimates and corrected for FES expenditure coverage*

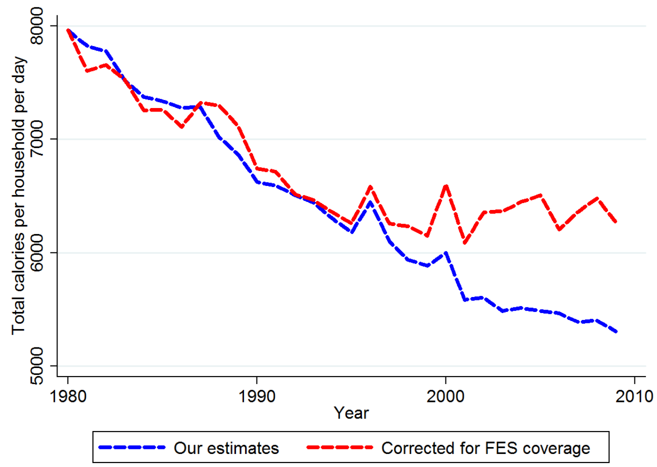


Figure B.15: *Calories per household from food in: our estimates and corrected for FES expenditure coverage*

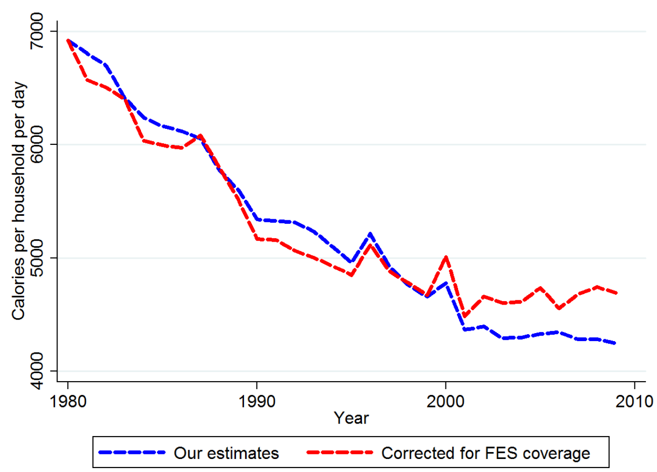


Figure B.16: *Calories per household from eating out, takeaways, soft-drinks and confectionary: our estimates and corrected for FES expenditure coverage*

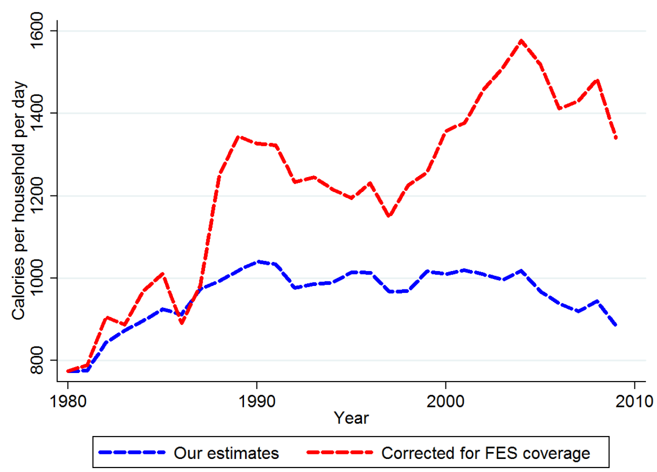
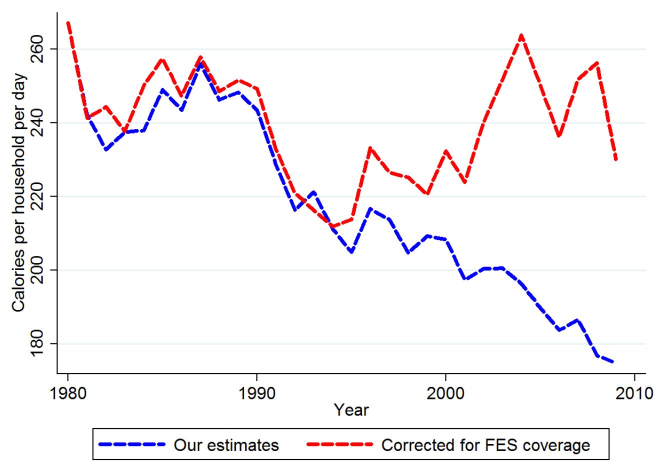


Figure B.17: *Calories per household from alcohol: our estimates and corrected for FES expenditure coverage*



B.2.4 Alcohol

A second robustness check for our estimation of the quantities purchased of alcohol can be performed using annual alcohol clearances by Her Majesty Revenue and Customs (HMRC). HMRC reports historic series of the amount of good cleared for consumption as well as the amount of duty collected on alcohol since 1980. Figure B.18 shows an index of the amount of litres of alcohol cleared by HMRC between 1980 and 2009 together with an index of real alcohol expenditure from the FES. The base year for the index is 1980.

Figure B.18: *Alcohol: Real expenditure in the FES and amount of good cleared by HMRC (1980=100)*

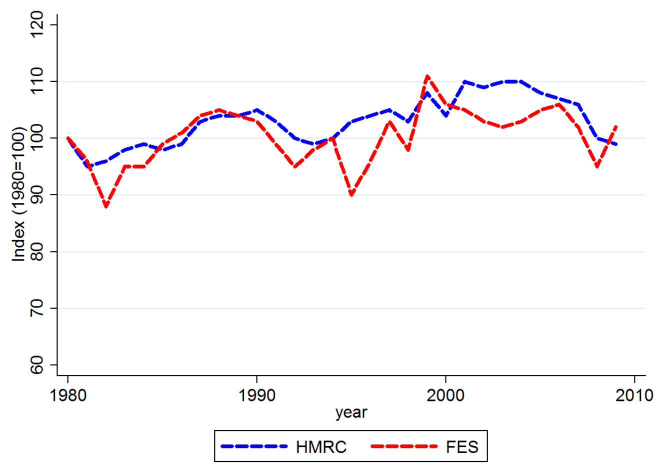
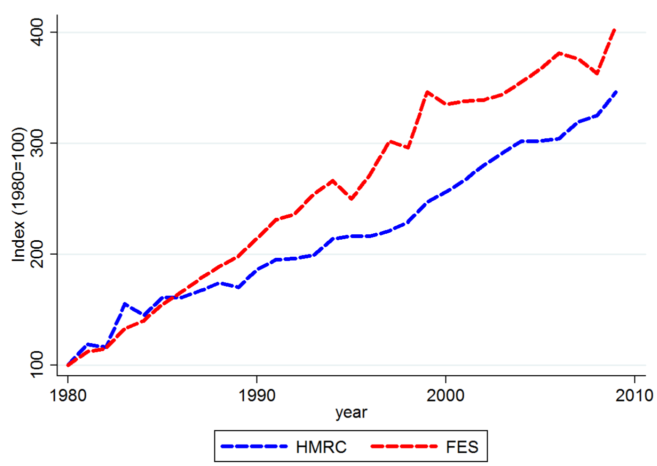


Figure B.19: *Alcohol: Expenditure in the FES and duty collected by HMRC (1980=100)*



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