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Abstract
The rise in obesity has largely been attributed to an increase in calorie consumption. We show that official government household survey data suggest that calories have declined in England from 1980 to 2013; while there has been an increase in calories from food out at restaurants, fast food, soft drinks and confectionery, overall there has been a decrease in total calories purchased. Households have shifted towards more expensive calories, both by substituting away from home production towards market production, and substituting towards higher quality foods. We show that this decline in calories can be rationalised with weight gain by the decline in the strenuousness of work and daily life.

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1 Introduction

The number of individuals who are overweight and obese has increased across the developed world, with the World Health Organization estimating that worldwide obesity has more than doubled since 1980, and that now “most of the world’s population live in countries where overweight and obesity kills more people than underweight” (World Health Organization (2015)). The media, policy makers and the economics and medical literatures have largely emphasised an increase in calorie consumption as the main cause, based on evidence that: (i) food prices have fallen, (ii) real food expenditure has increased, (iii) expenditure on some high calorie foods categories has increased, including soft drinks and confectionery, fast food and food out at restaurants and ready prepared meals, and (iv) food availability data suggests an increase in calories available.

Our contribution in this paper is twofold. First, we show that official government household survey data suggest that in fact calories have declined in England from 1980 to 2013. We bring together household level expenditure data with nutritional information over thirty years to provide a more complete picture of how diets have changed than has previously been available. We show that, while there has been an increase in real expenditure on food and calories from some categories, including food out at restaurants, fast food, soft drinks and confectionery, overall there has been a decrease in total calories purchased. Households have shifted towards more expensive calories, both by substituting away from home production towards market production, and substituting towards higher quality foods.

Second, we show that this decline in calories can be rationalised with weight gain by the decline in the strenuousness of market and home work and daily life. Weight gain results from a caloric imbalance. Calories have declined, but physical activity has declined by more. People’s daily lives have become more sedentary; changes in market and home work are an important part of the story, both because people spend a lot of time in these activities, and because there have been large changes in what they involve.
The literature has run horse races between calories or physical activity as candidates for explaining the rise in obesity, and shown that the latter is important. We emphasise that it is not simply a matter of one or the other - work behaviour and food demand interact in important ways and there are likely to be important nonseparabilities between them; this has implications for how we model demand and conduct policy analysis.

The fact that calories purchased fall over time in household expenditure survey data has been documented before (Prentice and Jebb (1995)). However, that analysis did not include information on food out, fast food, soft drinks and confectionery prior to 2001, and it has been thought that the observed decline in calories from food at home can be attributed to a shift away from food at home to these other food groups. We use information from other population surveys, along with statistical imputation methods (Rubin (1987, 1996); Schafer (1997, 1999) and Royston and White (2011)), to impute calories for these missing categories. We show that it is not plausible that these missing food categories explain the difference between household survey and food availability data. The increase in calories purchased from eating out and fast food, confectionery and drinks, is more than offset by a decrease in calories purchased for home consumption.

Our work relates to a large literature that seeks to understand the causes of the rise in obesity. The economics literature has emphasised an increase in food consumption as the main factor driving the rise in obesity (see, inter alia, Cutler et al. (2003), Bleich et al. (2008), Brunello et al. (2009)). Papers that have suggested that reduced physical activity and technological change also might play an important role have received less attention (see, inter alia, Lakdawalla et al. (2005) and Lakdawalla and Philipson (2009)). The medical literature has also highlighted excess food consumption (see, inter alia, Swinburn et al. (2009), Duffey and Popkin (2011)), although two recent studies for the US suggests that declining activity levels play an important role (Ladabaum et al. (2014) and Sturm and An (2008)). Hall et al. (2011) provide a quantification of the effect of energy imbalance on bodyweight.
A literature, mainly using US data, suggests that the declining cost of food plays an important role. In a highly cited paper, Cutler et al. (2003) use food availability data, which show an increase in calories, and stress changes in technology that have reduced the time and financial costs of calorie consumption; they argue that the amount of calories expended in work and physical activity has remained roughly constant; we show that this is not the case for England. Swinburn and Hall (2012) argue that cheaper food is the cause of obesity, and Swinburn et al. (2011) argue that this is true around the world.

More in line with our analysis, Lakdawalla and Philipson (2009) and Lakdawalla et al. (2005) suggest that 60% of weight growth is due to declining physical activity. Lakdawalla and Philipson (2007) suggest that reductions in job-related exercise play an important role in increased weight. 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 increase in the 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. Using data from the first three waves of the US National Health and Nutrition Examination Surveys, Rashad (2006) estimate a model of the determinants of adult obesity and finds that caloric intake, physical activity and smoking are all determinants of obesity.

The structure of the rest of the paper is as follows. In Section 2 we describe changes in food expenditure and calories in England over the period 1980-2013 using household survey data. In Section 4.1 we describe change in market and home work behaviours over the period 1980-2009. In Section 5 we rationalise the downward trend in calories with the increases in bodyweight, and show that changes in the strenuousness of work go a long way to account for the increase in weight. A final section provides a summary and some concluding discussion. Appendices provide further details on the data, imputation methods and other calculations. The complete data are available via the ESRC Data Archive.
2 Gluttony? Changes in food expenditure and calories

The media, policy makers and the economics and medical literatures have largely emphasised increased calories as the main cause of rising obesity based on the fact that: (i) food prices have fallen, (ii) total real food expenditure has increased, (iii) expenditure on some calorie dense foods has increased (in particular drinks and confectionery, fast food and food out at restaurants and ready prepared meals at home), and (iv) food availability data suggests an increase in calories available (see, inter alia, Bleich et al. (2008), Brunello et al. (2009), Chou et al. (2004) and Baum and Chou (2011), Finkelstein and Zuckerman (2008), Rashad (2006), Swinburn et al. (2011), Swinburn and Hall (2012)).

In this section we show that the same mechanisms are at play in England. However, we show that total calories have not increased, in large part because households have changed the types of foods they purchase, shifting towards more expensive calories. We use data from a number of sources. Our main data source for expenditure and calories are the Family Expenditure Survey and the National Food Survey, which were merged in 2001, and their successors the Expenditure and Food Survey and Living Costs and Food Survey; these are surveys that have consistently recorded food expenditure, quantities and nutrients from most food items since 1980. However, prior to 2001 some food items were not consistently recorded, and we use data on expenditures and prices to impute the missing data. See Appendix A for a detailed description of these data.

2.1 Background facts

The real price of food and drink (at home) fell substantially across OECD countries from 1980 until 2007, see Figure 2.1. From 2007 this trend is reversed, food prices increased due to an increase in world commodity prices and in the UK also due to the depreciation of Sterling. Real wages and job opportunities also changed over this period, affected by
the Great Recession. In our analysis below we thus distinguish between trends over the period 1980-2007 and 2007-2013.

**Figure 2.1: Real price of food (at home)**

The fall in real food prices has been accompanied by an increase in real food expenditure up to 2007, with a reversal in line with the sharp price increase in 2007, see left panel of Figure 2.2 (a). Griffith et al. (2015) show the same price and expenditure patterns for the 2005-2012 period using data from the Kantar World Panel, a consumer panel collected by the market research firm Kantar using home-installed scanners to record all food purchases brought into the home. They find that “growth in food prices outstripped growth in [nominal] food expenditures”.

Figure 2.2 (b) shows that the same trend is observed throughout the distribution - an increase up until 2007, followed by a decline from 2007-2013. At very low expenditures real food expenditures for all food and drink are below 1980 levels in 2013.

*Source: OECD Statistics on annual Consumer Price Indices (CPIs) by COICOP Divisions (1980==100) for food (at home) relative to all items.*
Equivalised real food expenditure increased by 15.9% at the mean from 1980 to 2007, and fell back by 9.7% from 2007 to 2013, see Table 2.1. Expenditure on all categories except alcohol increased between 1980 and 2013.

Table 2.1: Daily expenditure on food and drink (equivalised), 1980-2013

|                         | 1980 | 2007 | 2013 | Percentage change |
|-------------------------|------|------|------|-------------------|
| All food and drink      | 5.57 | 6.45 | 5.83 | 15.9              |
|                         |      |      |      | -9.7              |
| Food at home            | 2.83 | 3.33 | 3.00 | 17.7              |
| Eating out, fast food,  |      |      |      | -9.9              |
| Soft drinks and        | 1.44 | 1.98 | 1.86 | 37.8              |
| confectionery          |      |      |      | -5.9              |
| Eating out and fast    | 1.17 | 1.61 | 1.53 | 37.5              |
| food                   |      |      |      | -4.9              |
| Soft drinks and        | 0.26 | 0.37 | 0.33 | 39.4              |
| confectionery          |      |      |      | -10.4             |
| Alcohol                | 1.31 | 1.15 | 0.97 | -12.2             |
|                         |      |      |      | -15.6             |

Source: FES, EFS and LCFS.
Notes: Expenditure is equivalised using the OECD Oxford scale which assigns a weight of 1 to the first adult, 0.7 to all other adults and 0.5 to each child in the household. Expenditure is denoted in 2005 prices using the RPI price index for all food.
A number of papers have emphasised an increase in expenditure on some high calorie food types. For example, Cutler et al. (2003) suggest that consumption of calorie-dense snacks has increased over time, while Currie et al. (2010) focus on the role of fast food and eating out. We see this in the particularly strong increases in expenditure on eating out, fast food, drinks and confectionery as well, as shown in Table 2.1.

One of the key facts that has led people to focus on increased calorie consumption as a leading cause of the growth in obesity has been the FAO (2005) aggregate measure of calories per capita from food balance sheets. These data are based on measures of the total amount of food production (including imports excluding exports) and netting off food used for animal feeding and seeding, industrial, transport, storage and waste to obtain the amount of calories available for human consumption. This approach is attractive because in principle it provides a consistent measure for cross-country comparisons. However, FAO (2005) note several limitations, mainly associated with measurement error, especially food losses during production, storage and transport, and on feeding and seeding amounts (see also USDA (2015)). Dowler and Seo (1985) and Serra-Majem et al. (2003) find that these data typically overestimate consumption. Bleich et al. (2008) provide a summary of the size of the measurement error between food supply and actual consumption which varies by country (e.g., U.S. 26%; U.K.10%; Japan 25%). According to the 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 have compared data from household surveys and food balance sheets. They find differences in both levels and time trends, see for India (Deaton and Dreze (2010)), Japan (Dowler and Seo (1985)), the US (Crane et al. (1992)). A comparison of these data to UK data is shown in Appendix G.
2.2 The relationship between expenditure and calories: food at home

Although the share of expenditure on food at home in all food and drink has declined over time, food at home still accounts for the largest share of all food expenditures, and is a major source of calories. A major advantage of UK budget surveys is that, as well as recording expenditure, they also record quantities and calories for most food groups, see Appendix A. The UK household survey data report expenditure and quantities for 249 items in food at home as part of household diary. Calorie density are collected periodically by the Department for Environment, Food and Rural Affairs (DEFRA). For example, a 100 gram potato contains on average 80 calories. We calculate calories from food at home by summing the product of quantities and calorie density across all 249 food items.

Using these data we can obtain an accurate measure of the amount of calories purchased for consumption at home by a nationally representative sample of English households. It is important that we equivalise household data, because there have been significant changes in the composition of households. For example, the number of single, two-person and elderly households is increasing, resulting in smaller households compared to three decades ago. Details of the equivalence scale we use for calories can be found in Appendix C; it is based on official daily recommended calorie intake by age and gender of the household members.

Calories from food at home decline throughout the period 1980 to 2013 in England, despite the increase in real expenditures. Figure 2.3 (a) shows that the mean has fallen by around 600 calories per adult equivalent per day, while Figure 2.3 (b) shows that we see this decline across the distribution of individually allocated calories purchased for food at home.

\footnote{See Appendix G for a discussion about potential concerns about measurement error or under-reporting in the Household Budget Surveys.}
The decline in calories comes from an overall shift towards more expensive (per calorie), less calorie dense foods, even though we see an increase in some specific calorie dense foods. In Table 2.2 we see the shift towards less calorie dense foods: households substitute away from spending on fats (such as cooking oils, butter etc.), meat, dairy, sugary products (such as jam, honey etc.), beverages and eggs, and toward grains (such as bread, cereals, biscuits etc.), fruit and vegetables, fish and cheese. The expenditure share of six categories of calorie-dense foods (grains, meat, fats, sugary products and beverages, and other goods) falls from 61 to 56% between 1980 and 2013. At the same time, the expenditure share of two categories with a low calorie density (fruit and vegetables and fish) increases from 21 to 29.2%.
Table 2.2: Expenditure shares and calories from food at home

|                      | Expenditure shares | Calories |                      |
|----------------------|------------------|----------|-----------------------|
|                      | Share 1980       | Percentage change 1980-2007 | 2017-2013 | Level 1980 | Percentage change 1980-2007 | 2017-2013 |
| Meat                 | 0.28             | -17.3    | -0.5                 | 413        | -28.9                        | -9.0       |
| Grains               | 0.18             | 8.9      | 4.9                  | 845        | -14.8                        | -2.6       |
| Fruit and veg        | 0.18             | 44.9     | -3.3                 | 301        | 5.7                          | -2.9       |
| Dairy                | 0.13             | -22.1    | -7.5                 | 285        | -32.7                        | -5.9       |
| Fats and oils        | 0.04             | -47.4    | 10.5                 | 397        | -51.1                        | -0.7       |
| Drinks               | 0.04             | -40.1    | 4.0                  | 14         | -50.9                        | 2.9        |
| Fish                 | 0.03             | 37.9     | -2.6                 | 23         | 43.0                         | -3.5       |
| Other*               | 0.03             | 92.2     | 2.5                  | 27         | 114.2                        | 7.2        |
| Sugary               | 0.03             | -62.1    | 6.7                  | 278        | -73.7                        | -1.8       |
| Cheese               | 0.03             | 13.8     | 4.4                  | 68         | 0.0                          | -0.3       |
| Eggs                 | 0.02             | -46.1    | 14.5                 | 40         | -50.6                        | -4.3       |

Source: NFS.

Notes: Expenditure is equivalised using the OECD Oxford scale which assigns a weight of 1 to the first adult, 0.7 to all other adults and 0.5 to each child in the household. Calories are individually allocated using daily recommended calorie intake by age and gender of the household members; see Appendix C.

* includes ready meals

The right hand side of table 2.2 shows the amount of calories households purchase in each food group. Calories from the three largest groups (grains, meat and fats) account for 62% of total calories in 1980, and all decline over time. Calories from all other food groups decline, too, except for fish and processed foods. Equivalised real expenditure increases, which implies that households switch towards buying more expensive calories within all food groups, except for other (which includes processed ready meals) and fish. Households shift towards calories from fruit and vegetables, grains and fish, and away from meat, fats, sugary products, eggs and drinks.

These patterns illustrate that the mapping between food spending and calories is not straightforward. They also show that, in spite of the major shift in food prices (and real expenditure) after 2007, households switched between calorie sources in such a way that they maintained a consistent reduction in calories purchased for food at home over time. Figure 2.4 shows expenditure per 1000 calories from food at home, and shows that households switch to more expensive calories. After 2007 this trend reverses and
households shift to less expensive calories. Griffith et al. (2015) show similar patterns using market research data from the Kantar World Panel for the period 2005-2012 data and study the factors driving these patterns.

Figure 2.4: *Expenditure per 1000 calories from food at home*

![Expenditure per 1000 calories from food at home](image)

*Source: NFS.*

*Note: Real expenditure is denoted in 2005 prices using the RPI price index for all food. We divide total real expenditure on food at home by total calories purchased in food at home and take the average across all households in our sample (see Appendix A).*

### 2.3 Expenditure and calories from other sources: eating out, fast food, soft drinks, confectionery and alcohol

In section 2.1 we showed that expenditures on eating out, fast food, soft drinks and confectionery increased (Table 2.1). The UK household survey data report expenditure and quantities for 236 food items that are eaten outside the home, including restaurants and fast food outlets, 30 alcohol products (both at home and out) and 36 other items that are mainly soft drinks and confectionery. Expenditure on these items is available from 1980. However, quantities and calorie density on some of these items were only collected on a consistent basis from 2001 onwards. An overview of the information available is shown
in Table 2.3. We use the information on the conditional (on demographics) distribution of real expenditure to impute calories for these (partially) omitted categories.

Table 2.3: Food spending and nutrition information in the National Food Survey

|                      | Food home | Eating out, fast foods, soft drinks and confectionery | Alcohol |
|----------------------|-----------|------------------------------------------------------|---------|
|                      | 1980 2001 | 1980 -2001                                           | 1980 2001 |
| Calories (per gram)  | NFS LCFS* | LCFS*                                                | LCFS*   |
| Food quantity (grams)| NFS LCFS  | LCFS*                                                | LCFS*   |
| Food expenditure (£) | NFS/FES LCFS* | FES LCFS*                                           | FES LCFS* |
| Household demogr.    | NFS/FES LCFS* | NFS/FES LCFS*                                      | NFS/FES LCFS* |
| Food Prices          | ONS ONS   | ONS                                                  | ONS ONS  |

Note: NFS: National Food Survey; FES: Family Expenditure Survey; ONS: Office of National Statistics; LCFS*: Expenditure and Food Survey 2001-2007 and Living Costs and Food Survey 2008-2013.

We impute real expenditure and calorie density in order to obtain a measure of calories from the omitted food categories for each household in the NFS. We combine these imputed data with measured calories from food at home to obtain calories from all food and drink. Appendix B provides a detailed description of our imputation strategy. We model the distribution of real expenditure on food categories conditional (on demographics) using data from the FES and multiple imputation by chained equations (Rubin (1987, 1996); Schafer (1999); Royston and White (2011) and Horton and Kleinman (2007)) to obtain purchased quantities (now measured as real expenditures rather than in grams) for the sample of households observed in the NFS prior to 2001. The data for the FES and EFS are drawn from the same population using similar sampling frames. We do a good job of imputing quantities and are able to match the moments of the distribution of quantities. For example, Figure 2.5 shows that we match the time trend and the cross-sectional distribution of quantity. Purchase infrequency and abstention lead to a spike at zero. Our imputation underfits at zero, but attributes marginally positive values as the discrepancy in the kernel density estimates around zero shows.
To convert these quantities into calories we also need a measure of calorie density. We backcast it using observed calorie density from the LCFS for 2001-2013 along with information on demographics, prices and expenditure. We take two alternative (extreme) approaches. First, we assume that calorie density remained constant at the average level observed for 2001-2013, conditional on household demographics. This allows for variation across demographic groups in the composition of the basket of products that households purchase - for example, households with young children might eat out at McDonalds, while young two earner couples might eat at fancy restaurants - but assumes
that the calorie density of any specific food group has remained constant over time within demographic group.

Figure 2.6: Actual and backcast calorie density

(a) food at home

(b) eating out and fast food

(c) soft drinks and confectionery

(d) alcohol

Source: NFS, LFS, EFS, LCFS.
Notes: See Appendix B for details.

Second, we attempt to model the time path of calorie density using additional information on seasonal variation, changes in food prices and changes in expenditures, also conditional on demographics. This assumes that these factors (seasonal variation, the relationship between prices and calorie density, and between expenditure levels and calorie density) have remained constant over time within demographic group. We back cast prices for eating out and fast foods separately from soft drinks and confectionery, because price trends were different (while expenditure trends differed less). Figure 2.6 shows the observed calorie density for 2001-2013 and the two alternative backcasts; further details
are in Appendix B.2. We obtain a measure of calories from the omitted food categories by taking the product of imputed quantity and the backcast calorie density.

Table 2.4 reports total calories in all food groups, including imputed and actual data, using both methods for backcasting calorie density. Calories purchased in restaurants and fast food establishments, soft drinks and confectionery increased in line with expenditure. The sizeable drop in alcohol expenditure (see Table 2.1) results in a reduction in calories from alcohol. Over time, individuals have substituted from alcohol consumed out to alcohol consumed at home, and (not shown here) away from beer towards wine and spirits; both patterns are associated with a shift towards cheaper calories.

Table 2.4: Daily individually allocated calories

| Backcast calorie density 1: demographic variation in calorie density | 1980 | 2007 | 2013 | Percentage change |
|---|---|---|---|---|
| Eating out, fast food, soft drinks and confectionery | 307<sup>a</sup> | 396<sup>a</sup> | 362 | 28.8 | -8.6 |
| of which: | | | | | |
| Eating out and fast food | 220<sup>a</sup> | 279<sup>a</sup> | 256 | 27.1 | -8.3 |
| Soft drinks and confectionery | 88<sup>a</sup> | 117<sup>a</sup> | 106 | 32.9 | -9.3 |
| Alcohol | 114<sup>a</sup> | 91<sup>a</sup> | 82 | -20.1 | -9.3 |
| All food and drink | 2916<sup>a</sup> | 2332<sup>a</sup> | 2233 | -20.0 | -4.2 |

| Backcast calorie density 2: demographic and time variation in calorie density | 1980 | 2007 | 2013 | Percentage change |
|---|---|---|---|---|
| Eating out, fast food, soft drinks and confectionery | 385<sup>a</sup> | 417<sup>a</sup> | 412 | 8.2 | -1.1 |
| of which: | | | | | |
| Eating out and fast food | 304<sup>a</sup> | 300<sup>a</sup> | 289 | -1.4 | -3.7 |
| Soft drinks and confectionery | 81<sup>a</sup> | 117<sup>a</sup> | 123 | 43.9 | 5.6 |
| Alcohol | 104<sup>a</sup> | 93<sup>a</sup> | 96 | -9.9 | 3.3 |
| All food and drink | 2937<sup>a</sup> | 2312<sup>a</sup> | 2259 | -21.3 | -2.3 |

Source: NFS, FES, EFS, LCFS.
Notes: Calories are individually allocated based on estimated average requirements; see Appendix C.
<sup>a</sup> based on imputed or partially imputed expenditure and calorie density backcast using method indicated, see Appendix B.

Figure 2.7 shows the shift in the mean and cumulative density function for each of the three main food groups (equivalent to Figure 2.3 for food at home). Calories from eating
out and fast foods and from soft drinks and confectionery increase across the distribution up 2007 and then fall back slight to 2013.

Figure 2.7: *Daily individually allocated calories purchased*

(a) Mean eating out and fast food

(b) CDF eating out and fast food

(c) Mean soft drinks and confectionery

(d) CDF soft drinks and confectionery

(e) Mean alcohol

(f) CDF alcohol

Source: NFS, FES, EFS, LCFS. Notes: Uses backcast 1, see Table 2.4 and Appendix B.2. Calories are individually allocated based on estimated average requirements; see Appendix C.
2.4 Total calories

Figure 2.8 (a) shows that considering all foods together there is a decline in calories purchased of around 20%; the decline in calories is continuous throughout the period 1980 to 2013, and holds across the distribution of calories, as shown in Figure 2.8 (b). These results are in line with recent findings for the US, which also show that calories have not increased over time; for example, Ladabaum et al. (2014) use US individual level survey data (NHANES) and show that, “Average daily caloric intake did not change significantly” over the period 1988-2010.

The increase in calories from some categories (food out, fast food, soft drinks and confectionery) were offset by larger reductions in calories from food at home. Calories from food at home account for by far the largest share of total calories (Table 2.5), so that even a large increase in calories from the other categories does not counteract the decline in calories in food at home. In addition, the reduction in the calorie density in food at home (Figure 2.6 (a)) has moderated the shift towards market purchased foods.

Figure 2.8: Daily individually allocated calories purchased, all food

![Figure 2.8: Daily individually allocated calories purchased, all food](image)

Source: NFS, FES, EFS, LCFS. Notes: Uses actual calories from food at home and backcast 1 for eating out, fast food, soft drinks, confectionery and alcohol, see Table 2.4 and Appendix B.2. Calories are individually allocated based on estimated average requirements; see Appendix C.

One notable feature of the data, which will be relevant to our discussion later, is that working households obtain more of their calories from market prepared foods. Figure 2.9
shows calories from each food group for males (left hand figures) and females (right hand figures) and by work status. Working men and women purchase fewer calories for food at home and more calories from alcohol than their non-working counterparts. Working men also purchase more calories from eating out, fast food, soft drinks and confectionery than non-working men. Browning and Meghir (1991) show that there are important nonseparabilities between consumer spending and work status. While their analysis does not differentiate between food types, we expect such nonseparability to be particularly important at the decision margin between food purchased for preparation at home and food purchased for consumption outside of the home. There is little difference in calories from all food and drink for men by work status (Figure 2.9 (g)). However, working women purchase fewer calories overall (Figure 2.9 (h)), because they do not compensate for the reduced calories at home with an increase in eating out, fast food, soft drinks and confectionery as men do. Overall this means that working women purchase on average around 100 fewer calories than non-working women.
Figure 2.9: *Daily individually allocated calories purchased, by work status and gender*

(a) Male: home

(b) Female: home

(c) Male: eating out, fast food, soft drinks and confectionery

(d) Female: eating out, fast food, soft drinks and confectionery

(e) Male: alcohol

(f) Female: alcohol

(g) Male: total

(h) Female: total

Source: NFS, FES, EFS, LCFS.

Notes: Uses actual calories from food at home and backcast 1 for eating out, fast food, soft drinks, confectionery and alcohol, see Table 2.4 and Appendix B.2. Calories are individually allocated based on estimated average requirements; see Appendix C.
Table 2.5: *Expenditure and calorie shares by food groups*

|                      | Food at home | Eating out and fast food | Soft drinks and confectionery | Alcohol |
|----------------------|--------------|--------------------------|-------------------------------|---------|
| **Expenditure shares** |              |                          |                               |         |
| 1980                 | 59.6         | 17.6                     | 5.2                           | 17.6    |
| 2007                 | 57.0         | 22.3                     | 6.4                           | 14.3    |
| 2013                 | 57.5         | 23.0                     | 6.5                           | 13.0    |
| change 1980-2013     | - 2.1        | + 5.4                    | + 1.3                         | - 4.6   |
| **Calorie shares**   |              |                          |                               |         |
| 1980                 | 84.8         | 7.9                      | 3.2                           | 4.1     |
| 2007                 | 78.4         | 12.4                     | 5.2                           | 4.0     |
| 2013                 | 79.7         | 11.7                     | 4.9                           | 3.7     |
| change 1980-2013     | - 5.7        | + 4.0                    | + 1.7                         | - 0.1   |
| **Real expenditure per 1000 calories** | 1.44 | 4.38 | 1.99 | 8.44 |

Source: NFS, FES, EFS, LCFS. Notes: Uses actual calories from food at home and backcast 1 for eating out, fast food, soft drinks, confectionery and alcohol, see Table 2.4 and Appendix B.2. Calories are individually allocated based on estimated average requirements; see Appendix C.

The large difference between expenditure and calorie shares (Table 2.5) arises because market provided calories, i.e. those from eating out, fast food, soft drinks and confectionery, cost more than home produced calories. In linking expenditure and calories, we need to take two mechanisms into account: i) the difference in the calorie density of these foods - eating out, fast food and confectionery are more calorie dense per gram than food at home, and soft drinks are more calorie dense than other drinks, and ii) the large differences in the price per gram. While food eaten out, fast food, soft drinks and confectionery are more calorie dense than food at home, they are also more expensive than food at home. 1000 calories purchased in eating out (restaurant foods) cost on average more than 3 times as much as the same number of calories from food at home. Calories from alcohol are more than seven times as expensive as those from food at home. This explains the large differences between expenditure and calorie shares, shown in Table 2.5.
It is well known that equating expenditure with consumption can lead to mistaken conclusions about how households are affected by changes in their economic environment. Real expenditure increased as households substituted towards market provided foods and other high cost calories, such as processed foods. The large food price increase after 2007 reversed the rise in real expenditure, but seemed to have little effect on calories. Households have been able to substitute flexibly between foods in response to changes in relative food prices and in the economic environment. This is in line with a substantial literature showing that households are able to insure themselves against shocks in a number of ways. For example, households may increase their time spent searching for lower prices (Stigler (1961); Aguiar and Hurst (2007, 2005); Aguiar et al. (2013)), time in home production (Becker (1965), Crossley et al. (2015)) or change the characteristics of the foods they purchase (Dubois et al. (2014), Griffith et al. (2015)) in order to smooth their consumption. Recent evidence from the US suggests that as economic conditions worsened over the Great Recession households spent more time shopping and as a consequence pay lower prices (Kaplan and Menzio (2014)), increase their use of sales, switch to generic products (Nevo and Wong (2014)) and switch to low-price retailers (Coibion et al. (2014)).

3 Weight gain, a puzzle

The dramatic increase in bodyweight across the world has been well documented (World Health Organization (2015), Baum and Chou (2011), Bhattacharya and Sood (2011)). We emphasize a few key facts for England over the period 1980 to 2013 using data from the Health Survey for England, the National Heights and Weights Survey, the Health and Lifestyle Survey and the Dietary and Nutritional Survey of British Adults; see Appendix D for details. The mean weight of an adult male has increased by 8.9kg, and that of an adult female by 7.7 kg (see Figure 3.1), an average increase of 12% per annum. Weight has increased for all age groups, but by more for men and women between their 20s and
30s. Bleich et al. (2008) show that weight gain is similar across countries. While obesity is more prevalent in lower socio-economic groups, we see similar increases in weight across the socioeconomic distribution; Sturm and An (2008) and Wang and Beydoun (2011) show that this is also true for the US, and Bonnet et al. (2014) for France. Bhattacharya and Sood (2011) show that obesity almost tripled between 1962 and 2000 in the US, and that it is rising in most OECD countries. They also show that, while there are socio-economic differences in the prevalence of obesity, time trends are remarkably similar across educational attainment.

Weight increases across the distribution: median weight goes up by over 10kg for both men and women, the 10th percentile increases from 51kg to 56kg for women and 61kg to 69kg for men and the 90th percentile shifts from 77kg to 92kg for women and from 90kg to 105kg for men. The weight increase is not explained by height, which has increased only very slightly over this period. Body mass index (BMI), which is weight in kilograms squared over height in centimeters, has also risen. The share of adults that are overweight (defined as a BMI over 25) has risen and about 75% of men and 60% of women were classed as overweight or obese in 2010.

Figure 3.1: Bodyweight of English adults

![Bodyweight of English adults](source)

Source: Health Survey for England (HSE); Health and Lifestyle Survey (HALS); Dietary and Nutritional Survey of British Adults (DNSBA); National Heights and Weights survey.

Note: Individuals aged 25-79 in England.
This leads to a puzzle: why is weight increasing if calories have declined? Weight gain arises from a caloric imbalance between energy consumed and energy expended. In the next section consider whether we can rationalise the reduction in calories with weight gain by looking at changes in the strenuousness of market and home work and other activities.

4 Sloth? Changes in the strenuousness of market and home work

We use individual level nationally representative data from a number of surveys to document changes in activity levels, and particularly the strenuousness of market and home work, to rationalise the observed decline in calories and increase in weight. Energy expended in an activity depends on the time spent doing the activity, how strenuous it is, and the metabolism of the person engaged in the activity.

The Multinational Time Use Study (MTUS) reports comparable data on time use by adults in England for 1983 and 2005 (earlier and later years are not available, Gershuny and Fisher (2013)). Table 4.1 shows that men spend less time at work in 2005 than they did in 1985, and more time at sedentary activities such as sleep and watching TV. Women spend more time at work and less time at home work and more time at both sedentary activities like watching TV and sports. Sports take up a very small share of total time of either gender.
Table 4.1: *Time Use, % of the day people report spending on activity*

| % of time doing activity | Females 1983 | Females 2005 | change | Males 1983 | Males 2005 | change |
|--------------------------|--------------|--------------|--------|------------|------------|--------|
| market work              | 7.4          | 12.0         | + 4.6  | 20.4       | 19.3       | - 1.1  |
| home work                | 21.1         | 17.2         | - 4.0  | 8.7        | 8.9        | + 0.2  |
| sleep                    | 31.9         | 34.0         | + 2.1  | 31.6       | 32.9       | + 1.3  |
| travel                   | 4.3          | 5.5          | + 1.2  | 5.0        | 5.8        | + 0.8  |
| leisure                  | 35.2         | 31.4         | - 3.9  | 34.3       | 33.1       | - 1.2  |
| of which:                |              |              |        |            |            |        |
| watching tv              | 8.4          | 8.6          | + 0.2  | 10.5       | 10.8       | + 0.3  |
| sports                   | 0.9          | 1.3          | + 0.4  | 1.5        | 1.4        | - 0.1  |

*Source: Multinational Time Use Study, Centre for Time Use Research, University of Oxford.*

*Note: Individuals aged 25-65 in England.*

We measure the strenuousness of activities using metabolic equivalents of tasks (METs). METs are defined as the metabolic rate of an activity compared to the metabolic rate while resting, lying or sitting quietly (resting metabolic rate). The latter is normalised to one, so a MET of 3 means that an activity is three times as strenuous as resting. METs are available for all occupations (Tudor-Locke et al. (2011)) and for all non-work activities (Tudor-Locke et al. (2009)).

### 4.1 Work

Our main interest is in market and home work. This is because it takes up a large share of people’s time, and because work patterns have changed substantially over the last thirty years (Costa (2000)). In addition, we saw in Section 2 that work patterns were related to food purchasing patterns.

We use data on labour market activities for England from the Labour Force Survey, and match these with data on the strenuousness of occupations available in Tudor-Locke et al. (2011) (see Appendix E). Females are now more likely to be in the labour market, while males (at least in some cohorts) have retired early and now work shorter hours.
Female labour force participation amongst 25-64 years olds has increased from 55% to 69%, with particularly strong increases among younger women (aged 25-39). Hours of work (conditional on working) have remained constant around 26-27 hours per week on average, but have increased over time among women aged 45-49 (see Figure 4.1 (a) and (c)). For males, we see a reduction in hours worked by 9.3%, and a drop in participation rates at older ages (see age groups 55 to 64 in Figure 4.1 (b) and (d)).

Figure 4.1: Labour force participation and hours worked

There are large differences in the strenuousness of work across occupations. A sedentary job that involves sitting at a desk all day, such as a computer programmer, has a MET of 1.5. An active job, such as a janitor or building cleaner, has a MET of 4.5, and a very strenuous jobs, such as in mining, logging, a roof bolter, or a rigger, has a
MET of around 8 (Tudor-Locke et al. (2011)). The shift from manufacturing to service industries, which has been particularly pronounced in the UK (Schettkat and Yocarini (2006), Bleich et al. (2008)), and other changes in occupations have led to a decline in the strenuousness of work.

We combine data from the Labour Force Survey (LFS) on participation, occupation and hours with a measure of the strenuousness of each occupation, based on the metabolic equivalents of tasks (METs) compiled by Tudor-Locke et al. (2011) for US occupations. The occupation level METs detailed in Tudor-Locke et al. (2011) have been computed for the US 2002 Census Occupational Classification System (OCS). To apply them to the LFS, we map the US occupation codes into British Standard Occupational Classification (SOC) 1990 codes. To obtain a consistent occupation classification coding over the period 1980-2009 we map detailed occupation codes across time taking the approach suggested in Nickell and Saleheen (2008), based on the three-digit SOC 1990 codes (374 occupations); see Appendix E for details.

The 374 three-digit occupations can be classified into nine broad groups (Managers and Administrators, Professionals, Associate Professionals and Technical Occupations, Clerical and Secretarial Occupations, Craft and Related Occupations, Personal and Protective Services, Sales, Plant and Machine Operatives and Other). Table 4.2 shows the change in the occupation mix of the workforce by these broad occupations, for males and females respectively. The first column shows the average strenuousness of occupations within that broad classification. For males there is a decline in employment in the strenuous occupations, which include crafts, plant and machine operatives and some manual labour occupations, and in the moderately strenuous occupations in sales. In parallel, employment in the most sedentary occupations increases, including managers and administrators. There is an additional 10% of the male workforce in these jobs in 2008 compared to 1981. For females there is a similarly strong rise in managerial and administrative occupations, and a decline in the most strenuous occupations, such as craft and related, plant and machine operatives, and some unspecific manual occupations.
Table 4.2: Occupation and strenuousness, by gender

| by occupation groups based on SOC 1990 classification | Mean MET (sd) | Percent of workforce | Change 1981-2009 |
|-----------------------------------------------------|---------------|----------------------|------------------|
| **Males**                                           |               |                      |                  |
| 1. Managers and Administrators                      | 1.65 (0.4)    | 17.46                | 6.02             |
| 4. Clerical and Secretarial                         | 1.72 (0.0)    | 7.56                 | -1.44            |
| 2. Professional                                     | 1.96 (0.3)    | 9.62                 | 3.37             |
| 3. Assoc. Professional and Technical                 | 2.13 (0.5)    | 5.91                 | 6.35             |
| 7. Sales                                            | 2.13 (0.3)    | 4.69                 | 1.76             |
| 8. Plant and Machine Operatives                     | 2.47 (0.6)    | 5.91                 | -1.44            |
| 6. Personal and Protective Service                  | 2.60 (0.2)    | 4.69                 | 2.03             |
| 5. Craft and Related                                | 3.43 (0.7)    | 25.22                | -8.03            |
| 9. Other                                            | 3.54 (0.6)    | 7.57                 | -1.93            |
| **Females**                                         |               |                      |                  |
| 1. Managers and Administrators                      | 1.62 (0.3)    | 7.35                 | 9.24             |
| 4. Clerical and Secretarial                         | 1.72 (0.0)    | 26.96                | -5.69            |
| 3. Assoc. Professional and Technical                 | 2.16 (0.3)    | 3.65                 | 7.29             |
| 2. Professional                                     | 2.24 (0.3)    | 7.38                 | 5.77             |
| 7. Sales                                            | 2.34 (0.2)    | 9.61                 | -2.18            |
| 6. Personal and Protective Service                  | 2.54 (0.2)    | 16.22                | 5.63             |
| 5. Craft and Related                                | 2.81 (0.6)    | 4.93                 | -3.63            |
| 8. Plant and Machine Operatives                     | 2.95 (0.6)    | 7.84                 | -5.76            |
| 9. Other                                            | 3.05 (0.2)    | 16.06                | -9.83            |

by strenuousness of three-digit occupation

| Males | Sedentary occupations | 1 − 2 | 35.65 | 38.82 | 43.35 | 46.72 | +11.07 |
|       | Moderate              | 2 − 3 | 35.88 | 34.71 | 34.36 | 32.52 | -3.36  |
|       | Strenuous             | ≥ 3   | 28.46 | 26.47 | 22.29 | 20.76 | -7.70  |

| Females | Sedentary occupations | 1 − 2 | 36.16 | 41.63 | 42.75 | 42.24 | +6.06  |
|         | Moderate              | 2 − 3 | 42.73 | 42.95 | 47.16 | 49.75 | +7.02  |
|         | Strenuous             | ≥ 3   | 21.10 | 15.43 | 10.10 | 8.00  | -13.10 |

Notes: Workforce shares from Labour Force Survey (LFS), METs based on Tudor-Locke et al. (2011), see Appendix E. Sedentary occupations: METs ≤ 2, moderate: METs 2-3, strenuous: ≥ 3. Individuals aged 25-65 in England.

In the bottom part of the tables we group the 374 three-digit occupations by strenuousness to further demonstrate this trend. Sedentary occupations are those with METs less than 2, moderate are occupations between 2 and 3, while strenuous occupations are those with METs greater than or equal to 3. Men shift away from moderately active...
and strenuous occupations towards sedentary occupations, while females shift away from strenuous occupations towards both moderately strenuousness and sedentary occupations.

To illustrate the impact of the distinction between a strenuous and a non-strenuous occupation consider a simple example. An average sized man working a 40 hour week will burn about 30kg a year at work in a sedentary occupation. If he were working in a (moderately) strenuous job, he would be burning (49) 69 kg a year at work. To make up for the difference between the sedentary and the strenuous job, the man in the sedentary occupation would have to jog an additional 10.6 hours a week in his leisure time; jogging has a MET of 7.5, and is one of the most strenuous common activities.

In summary, we show that daily activity at work has declined for several reasons. First, men have reduced their labour supply at the extensive margin through reduced labour force participation at older ages (see also Banks and Smith (2006)), and through a reduction in work hours at all ages. Second, and in contrast to men, female labour force participation has increased, and in some age groups hours worked have also increased (see, inter alia, Blundell et al. (2011) for the US, UK and France, and Costa (2000) for females in the US). As women have increased time spent on market work they have reduced time in home work. Third, there is a 7-8% decline in strenuousness at work for males and females (see Figure 4.2 (a)). Figures 4.2 (b) and (c) reiterate that this is driven by shifts from strenuous to sedentary occupations. Note that we do not have any information on the time variation in the strenuousness of occupations, so we believe that we are likely underestimating the mean in earlier years and the distributional shift, as technological progress has made many manual occupations less strenuous.

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2The same exercise for women yields 28 (sedentary), 47 (moderately strenuous) and 66 (strenuous) kg per year. We assume METs of 1.5, 2.5 and 3.5 and gender average weight, height and age.
Figure 4.2: Strenuousness of work

(a) mean

(b) density female

(c) density male

Notes: Strenuousness is calculated based on workforce shares from Labour Force Survey (LFS), using SOC 1990 occupation groups, and METs from Tudor-Locke et al. (2011), see Appendix E. Individuals aged 25-65 in England.

5 Rationalising weight gain

Does the reduction in the strenuousness of work, and other activities shown in Section 4.1, rationalise the decline in calories and the increase in weight? In order to gain insight into this question we do the following calculation: given the data on weight gain and calories, and the information we have on time spent asleep and at work, and the strenuousness of occupations, what would the change in strenuousness of other activities (not work or
sleep) need to be rationalised? We compare the change in that level of strenuousness to other (incomplete) facts that we have about changes in time use and strenuousness of other activities.

Weight gain arises from a caloric imbalance. We can characterise an individual’s weight in period $t + 1$ as:

$$W_{it+1} = W_{it} + C_{it} - \sum_k M_{ikt} H_{ikt} R_{it}$$  \hspace{1cm} (5.1)

where $i$ denotes an individual, $t$ denotes time and $k$ denotes an activity. Weight at the start of the period $W_{it+1}$ depends on last period’s weight, $W_{it}$, plus energy consumed, $C_{it}$, minus energy expended, $M_{ikt} H_{ikt} R_{it}$. $M_{ikt}$ denotes the MET of activity $k$, $H_{ikt}$ the share of hours spent on activity $k$, which sum to one ($\sum_j H_{ijt} = 1$), and $R_{it}$ is the individual’s resting metabolic rate (RMR).  

We can solve for the unknown MET ($k = o$), which represents the strenuousness of the remainder of people’s time not accounted for by activities that we measure (market work and sleep),

$$M_{iot} = \frac{W_{it} - W_{it+1} + C_{it} - \sum_{k \neq o} M_{ikt} H_{ikt} R_{it}}{H_{iot} R_{it}}.$$  \hspace{1cm} (5.2)

We observe weight, calories, labour market participation, hours of market work, occupation and strenuousness of occupation. We use information on METs and time spent on market work ($k = w$) and sleep ($k = s$). We do not observe them all in the same dataset, so we cannot solve equation (5.2) at the individual level. However, these data are sampled from the same population. We take expectations, and make a number of simplifications (see Appendix F for the details), to obtain,

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3 This is based on the first law of thermodynamics, similar to Hall et al. (2011). This is an approximation, which does not strictly apply to living beings (for a critical discussion, see Feinman and Fine (2004) and Jequier (2002)).

4 We measure RMR using the Mifflin-St Jeor equation.
\[ E[M_{tot}] = (E[W_{it}] - E[W_{it+1}] + E[C_{it}]) E[H_{iot}^{-1}] E[R_{it}^{-1}] - E[M_{iwt}] E[H_{iwt}] E[H_{iot}^{-1}] - 0.33 E[H_{iot}^{-1}] \\
\quad + (E[W_{it}] - E[W_{it+1}] + E[C_{it}]) Cov[H_{iot}^{-1}R_{it}^{-1}] - E[M_{iwt}] Cov[H_{iwt}H_{iot}^{-1}] \\
\quad + E[H_{iot}^{-1}] Cov[C_{it}R_{it}^{-1}] + E[R_{it}^{-1}] Cov[C_{it}H_{iot}^{-1}] \\
\quad - E[H_{iwt}] Cov[M_{iwt}H_{iot}^{-1}] - E[H_{iot}^{-1}] Cov[M_{iwt}H_{iwt}] \] (5.3)

where \( H_{iot} = (1 - H_{iot} - M_{iot}) \) is the time spent on other activities (not at work and not asleep).

The first line of equation 5.3 is the expectation of all of the relevant terms if you omit all covariance terms. The second line includes a term that is a function of the covariance between an individual’s resting metabolic rate and hours of non-market work non-sleep time, \( Cov[H_{iot}^{-1}R_{it}^{-1}] \). We estimate the magnitude of this using the Health Survey for England (and related bodyweight data) and find it to be very small. The second line also includes a term that is a function of the correlation between hours at work and the inverse of the hours at non-market work non-sleep time, \( Cov[H_{iwt}H_{iot}^{-1}] \). We use data from the LFS to estimate this and find that it is positive and stronger for males.

The third line includes terms that reflect the covariance of calories with the inverse of an individual’s resting metabolic rate, \( Cov[CR_{it}^{-1}] \), which we estimate using data from the Kantar Worldpanel. This would be negative if everyone maintained a constant weight (people with higher metabolic rates would consume more calories). We find this is small, but sometimes positive for females (in particular working females). The next term is the covariance between calories and the inverse of hours at non-market work non-sleep, \( Cov[CH_{iot}^{-1}] \). We know from Browning and Meghir (1991) that food spending and leisure are non-separable (suggesting that this term may not be zero). Altonji (1986) and Ziliak and Kniesner (2005) find that food expenditures and leisure are substitutes, but how does this translate to calories? We showed in section 2.4 in the main body of the paper that there is a correlation between labour force participation and the foods that individuals purchase. We obtain an estimate of this using data from the Kantar Worldpanel and we

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find that this covariance is negative, and larger for females, in particular for non-working females. In line with this, there is evidence that weight (negatively) affects some aspects of labour market activity and performance, such as productivity, wages and job mobility (Cawley, 2004, JHR; Harris, 2015, and others).

The final line captures the covariance between strenuousness of work and the inverse of hours of non-market work non-sleep and hours of market work. If people in more strenuous jobs work shorter hours then $\text{Cov}[M_{i}H_{a}^{-1}]$ would be negative. Using the LFS we find that it is negative and slightly stronger for females. Finally, the covariance between the strenuousness of work and working hours, $\text{Cov}[M_{i}H_{w}]$, is negative but very small. This is to be expected, if people in more strenuous jobs work shorter. We obtain an estimate of the magnitude of this using the LFS. All estimates are summarised in Table 5.1.

|             | $\text{Cov}[C_{it}R_{it}^{-1}]$ | $\text{Cov}[C_{it}H_{tot}^{-1}]$ | $\text{Cov}[H_{iwt}H_{tot}^{-1}]$ | $\text{Cov}[M_{iwt}H_{tot}^{-1}]$ | $\text{Cov}[M_{iwt}H_{iwt}]$ |
|-------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **All**     |                                 |                                 |                                 |                                 |                                 |
| female      | 0.003                           | -0.844                          | 0.052                           |                                 |                                 |
| male        | -0.003                          | -0.103                          | 0.097                           |                                 |                                 |
| $H_{w} = 0$ |                                 |                                 |                                 |                                 |                                 |
| female      | -0.003                          |                                 |                                 |                                 |                                 |
| male        | -0.008                          |                                 |                                 |                                 |                                 |
| $H_{w} > 0$ |                                 |                                 |                                 |                                 |                                 |
| female      | 0.006                           | -0.405                          | 0.050                           | -0.035                          | -0.008                          |
| male        | -0.001                          | -0.467                          | 0.076                           | -0.029                          | -0.003                          |

*Notes: See details in Appendix F.*

Using these estimates, we compute the strenuousness of activities other than work and sleep that rationalises the observed weight gain, the decline in calories, the decline in time spent at work and in the strenuousness of work. Recall from section 4.1 that these are expressed in terms of metabolic equivalents of tasks (METs), the metabolic rate of an activity compared to the metabolic rate while resting, lying or sitting quietly. It is normalised to one, so a MET of 2 means that an activity is twice as strenuous as resting.
Table 5.2 shows the METs that rationalise the weight gain and calorie decline over time, for females in the top part of the table and males in the bottom half.

The right hand column summarises the change in observed METs at work discussed in Section 4.1. The left hand columns show the implied METs that are needed to rationalise all observed trends; we show this separately for individuals engaged in market work and those not in work. In order to rationalise the data on weight, calories and market work, working females would have had to reduce the average strenuousness of other activities from 2.45 in the early 1980s to 1.80 in the second half of the 2000s. To give an example of what this implies: if women reduce the amount of time they spend on home work by 4% over this period, and instead spent that time watching TV, this change would account for about one-fifth of the observed decline in strenuousness of these other activities.

Non-working females would have needed to engage in more strenuous activities in the early 1980s than working women in order to rationalise the data; this is consistent with what we know about the strenuousness of home work, i.e. that home work is on average more strenuous than the types of market work females do; they would have had to reduce the average strenuousness of other activities from 2.56 in the early 1980s to 2.02 in the second half of the 2000s, a reduction in just over 20%.

Working men would have had to reduce the strenuousness of non-work activities from 2.25 to 1.40, a reduction of just under 40%. For example, if an average sized male had switched from cycling to work to commuting by car, this would explain about a third of the 0.85 reduction in strenuousness of other activities. The data imply that non-working males engage in less strenuous activities than non-working females; they would have had to reduce the average strenuousness of their other activities from 2.40 in the early 1980s to 1.80 in the late 2000s, a reduction of around one-third.
| Year   | Females          | Males          |
|--------|------------------|----------------|
|        | calculated METs | observed METs  |
|        | not working      | working        |                   |
| 1980-84| 2.557            | 2.452          | 2.303            |
| 1985-89| 2.550            | 2.368          | 2.293            |
| 1990-94| 2.346            | 2.161          | 2.223            |
| 1995-99| 2.242            | 2.026          | 2.199            |
| 2000-04| 2.163            | 1.902          | 2.169            |
| 2005-08| 2.023            | 1.814          | 2.156            |

Notes: Numbers in left hand columns are solution to equation (5.3). Number in right hand column is mean METs based on strenuousness of occupation, see Section 4.1. For details on the method, see Appendix F.

To help gain intuition, we consider some of the components of equation 5.2. Table 5.3 shows the implied METs from other activities, as reported in Table 5.2 but averaged over both working and non-working people, in the first column. In the second column we report the change in weight (in kilograms); this is expressed in negative terms, since the more weight an individual gains the lower is the strenuousness of other activities needed to rationalise any given level of calories and activity at work. This column shows that the largest weight gain was in the 1980s, with much lower weight gain in more recent years (when calories were much lower). The third column shows the level of calories purchased, scaled by resting metabolic rate; this is an intuitive way to report calories, a value of 1 would mean that individuals were obtaining just sufficient calories to keep themselves at their current weight if they did no activity. The reported value can be interpreted as the level of strenuousness implied by simply the calories data, if we didn’t account for anything else. We can see that this falls, as the amount of calories purchased...
declines. The fourth column reports hours worked (as a share of total time); for females this increases, while for males it falls slightly. The final column reports average METs in work (as reported in Table 5.2), which falls for both males and females.

Table 5.3: Some components of the calculation

| METs other time | $W_t - W_{t+1}$ | Cal/RMR | Hours work | METs work |
|----------------|-----------------|---------|------------|-----------|
| **Females**    |                 |         |            |           |
| 1980-84        | 2.493           | -1.465  | 1.974      | 0.079     | 2.303    |
| 1985-89        | 2.460           | -1.026  | 1.938      | 0.086     | 2.293    |
| 1990-94        | 2.241           | -0.470  | 1.795      | 0.098     | 2.223    |
| 1995-99        | 2.113           | -0.326  | 1.722      | 0.103     | 2.199    |
| 2000-04        | 2.002           | -0.365  | 1.664      | 0.106     | 2.169    |
| 2005-08        | 1.889           | -0.153  | 1.600      | 0.109     | 2.156    |
| **Males**      |                 |         |            |           |
| 1980-84        | 2.286           | -0.599  | 1.882      | 0.194     | 2.528    |
| 1985-89        | 2.226           | -1.297  | 1.853      | 0.199     | 2.494    |
| 1990-94        | 1.929           | -0.686  | 1.702      | 0.193     | 2.432    |
| 1995-99        | 1.774           | -0.473  | 1.633      | 0.194     | 2.398    |
| 2000-04        | 1.594           | -0.328  | 1.555      | 0.190     | 2.371    |
| 2005-08        | 1.459           | -0.092  | 1.491      | 0.187     | 2.349    |

Notes: Number in column 1 are the solution to equation (5.3). Number in column 2 are from various data sources, see Appendix D. Numbers in column 3 are as described in Section 2. Numbers in columns 4 are from the LFS. Numbers in column 5 are authors’ calculations, see Section 4.1.

Does this implied decline in the strenuousness of non-work activities make sense? Non-work activities differ considerably in their strenuousness. Lying or sitting quietly has a MET of 1. Home work is also an important component of time use and physical activity. We compute the strenuousness of home work based on Tudor-Locke et al. (2009) and detailed information on time spent on these tasks from the British Time Use Surveys for several years (1974-75, 1983-1984, 1987, 1995, 2000-2001 and 2005). These have been harmonised in the Multinational Time Use Survey (MTUS).

We observe six home work activities in the time use data (MTUS) - cooking, cleaning, do-it-yourself (DIY) home maintenance, gardening, shopping and child care. The strenuousness of these activities varies between 1.95 and 3.25 METs. We use the share of time in all home work to compute average home work MET over time and show that
the strenuousness of home work for women has remained constant, while it has decreased by 11% for males (see Table 5.4). Women shift from moderately strenuous activities like cooking and cleaning into both less strenuous tasks like childcare and more strenuous tasks like gardening, and these roughly average out. Men, in contrast, shift their time mainly from strenuous to moderately strenuous home work activities, which accounts for the overall reduction.

Additionally, some of the six activities in home work have probably become less strenuous over time, e.g. due to the expansion of household appliances. For example, 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%.

We probably underestimate the reduction in strenuousness in our analysis, since the METs that we use are time-invariant and computed in the 2000s. However, to the extent that these appliances are time-saving (e.g. the microwave in cooking) rather than reducing strenuousness, we observe this via the reduction in time spent doing home work.

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+. Home work time increases substantially from prime child-bearing age and remains relatively constant thereafter. As we saw in Table 4.1, time spent on home work has fallen by around 4% for women and we calculated that, keeping strenuousness within activity constant, replacing this time with TV watching would explain about one-fifth of the reduction in the MET of other time. Men increase their time spent on home work activity by a small amount, but at the same time they reduce the strenuousness of the activities they engage in when doing home work.

In terms of other uses of time, travel to work and shopping are also important activities, because people do them regularly so they take up a considerable amount of time. Riding in a car has a MET of 1.3, riding a bike to work has a MET of 4, so it requires 4 times the energy expenditure at rest. We saw in Table 4.1 that travel time has increased.
Table 5.4: Change in home work composition and strenuousness of home work, by gender, 1974-2005

| Gender | 1974 | 1983 | 1987 | 1995 | 2000 | 2005 | change* in % |
|--------|------|------|------|------|------|------|--------------|
| **Average strenuousness of home work** |      |      |      |      |      |      |              |
| Females |      |      |      |      |      |      |              |
| working | 2.36 | 2.37 | 2.37 | 2.33 | 2.34 | 2.32 | -0.04, -1.7  |
| not working | 2.35 | 2.33 | 2.33 | 2.34 | 2.38 | 2.33 | -0.02, -0.9  |
| Males |      |      |      |      |      |      |              |
| working | 2.69 | 2.52 | 2.54 | 2.44 | 2.44 | 2.38 | -0.31, -11.5 |
| not working | 2.74 | 2.45 | 2.53 | 2.53 | 2.49 | 2.43 | -0.31, -11.3 |
| **Time shares of household activities by strenuousness** |      |      |      |      |      |      |              |
| Females |      |      |      |      |      |      |              |
| strenuous | 0.08 | 0.10 | 0.11 | 0.09 | 0.11 | 0.09 | +0.01, +12.5 |
| moderately strenuous | 0.71 | 0.64 | 0.61 | 0.62 | 0.64 | 0.61 | -0.10, -14.1 |
| not strenuous | 0.21 | 0.26 | 0.28 | 0.29 | 0.25 | 0.29 | +0.08, +38.1 |
| Males |      |      |      |      |      |      |              |
| strenuous | 0.50 | 0.31 | 0.34 | 0.26 | 0.24 | 0.19 | -0.31, -62.0 |
| moderately strenuous | 0.30 | 0.40 | 0.38 | 0.47 | 0.49 | 0.51 | +0.21, +70   |
| not strenuous | 0.20 | 0.29 | 0.28 | 0.28 | 0.27 | 0.30 | +0.10, -50   |

Source: MTUS, 1974-2005.

Note: *Changes in strenuousness are rounded to two decimal points. We group activities into three categories: strenuous (includes maintenance (MET: 3.09) and gardening (3.05)), moderately strenuous (cooking and washing up (2.35) and cleaning (2.37)), and not strenuous activities (shopping (2.06) child care (1.95)).
The most frequent commuting modes (car and public transport) are not strenuous, with METs between 1 and 2, so increased commuting time may crowd out a more strenuous activity. Additionally, BHPS data (1991-2008) on commuting mode suggests that the share of workers with a strenuous commute, i.e. cycling or walking, has decreased from 25% to 14% for females and from 15% to 13% for males, while the percentage commuting by car or public transport has increased from 75% to 82% for females and from 83% to 87% from males. While sport and exercise is a high MET activity, it is not a large part of energy expended for most people. In contrast, Table 4.1 showed that people do spend on average between 8% and 11% of their time watching TV.

6 Discussion and concluding comments

In this paper we show that looking at real expenditures on food can give a misleading picture of diet. Real expenditures on food at home have been roughly constant, and, if anything increased over time. However, changes in the composition of food at home have led to a reduction in its calorie density, leading to a marked decline in calories from food at home. While there has been an increase in real expenditure and calories from eating out, fast foods, confectionery and soft drinks, it does not full compensate for the decline in calories purchased for food at home. Around 10% of the decline in calories from food at home is due to reduction in the calorie density within food categories, the remainder is due to shifts in diet across food categories, away from sugary products like jam and honey, and fats, like butter, towards fruit and vegetables, fish and cereals.

Second, we document a strong correlation between market work and calories. Households that spend more time in market work buy more market produced foods. Market produced foods are on the whole more expensive than home produced foods, and this means that trends in expenditure do not necessarily mirror changes in calories.

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5We distinguish between travel and commuting, as the time use data summarise all travel activity, while the BHPS records time and mode of commuting to work.
We also document the substantial reduction in the strenuousness of market and home work, and show that it is plausible that this rationalises the contemporaneous reduction in calories and increase in weight. This has important policy implications. Our results do not say that people are not eating too much, they are eating more than they are burning in physical activity. However, of the 75 different policy interventions around the world designed to tackle obesity identified in Dobbs et al. (2014), 47 were targeted at only food prices or food availability, while only 10 focused on physical activity (mostly in the form of promoting sports and improving infrastructure), and only 11 take a comprehensive approach that combines nutrition and physical activity interventions (the remaining 8 programs focus on general health or ex-post interventions such as drugs and bariatric surgery). Our results suggest that most people are reducing their caloric intake, but apparently not by enough to compensate for the decline in the strenuousness of activities. Policies targeting physical activity therefore seem like to also be an important and complementary focus in tackling the rise in obesity.

These empirical facts raise a number of interesting questions for future work. In this paper we have focused on calories, and not on the nutritional composition of these calories. There is growing evidence that diet-related disease is likely to be related not only to the level of food consumption but also to the composition of diet. For example, the recent literature has emphasised the role that sugar might play in rising obesity and diet related disease (Lustig et al. (2012) and Qi et al. (2012)). These data could be used to better understand the ways that the nutritional composition of calories have changed over time, and how these relate to other behaviours.

In addition, in future work it would be interesting to learn more about the correlation between work and food consumption patterns. Does this correlation represent a non-separability between food demand and labour market activities (i.e. does the marginal utility of consumption depend on work status)? The correlation could be driven, for example, by nonseparabilities arising through home production, (e.g. the shadow price of food depending on work status because of time on food preparation, as in Crossley
et al. (2015), or because of time spent purchasing foods, as in Aguiar and Hurst (2007); Aguiar et al. (2013). It could also potentially arise if preferences over weight vary with income (Philipson et al. (2003), Grossman (1972) or Galama (2015)). Alternatively, the correlation could arise for econometric reasons, through preference heterogeneity that is correlated with work status, or due to omitted variables that are correlated with work status. Understanding why this correlation exists is important for our ability to estimate elasticities of demand correctly and for evaluating different policy interventions.

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