DISCUSSION PAPER SERIES

No. 10096

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ISSN 0265-8003

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Discussion Paper No. 10096
August 2014

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CEPR Discussion Paper No. 10096

August 2014

ABSTRACT

Shopping around? How households adjusted food spending over the Great Recession*

Over the Great Recession real wages stagnated and unemployment increased. Concurrently, food prices rose sharply, outstripping growth in food expenditure, and leading to a reduction in calories purchased. This has led to concern about rising food poverty. We study British households to assess how they adjusted to changes in the economic environment. We show they switched to cheaper calories; implying food consumption was smoother than expenditure. We use longitudinal data to quantify the way households lowered their per calorie spending, and show they done this in part by increasing shopping effort, and without lowering the nutritional quality of their groceries.

JEL Classification: D12 and I31
Keywords: nutrition, opportunity cost of time and shopping behaviour

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*The authors gratefully acknowledge financial support from the European Research Council (ERC) under ERC-2009-AdG grant agreement number 249529, the Economic and Social Research Council (ESRC) under the Centre for the Microeconomic Analysis of Public Policy (CPP), grant number RES-544-28-0001, and under the Open Research Area (ORA) grant number ES/I012222/1.

Submitted 25 July 2014

1 Introduction

The Great Recession led to reductions in real incomes for households in the US and UK (Hoynes et al. (2012), De Nardi et al. (2012), Brewer et al. (2013)). In the US the unemployment rate close to doubled and wage growth stagnated. In the UK unemployment rose and real wages fell, but a key factor was the sharp rise in food prices, which rose by around 10% more than general prices (see Figure 3.1). Over this time spending on food failed to keep pace with rising food prices (for the UK see Crossley et al. (2013), for the US see Kumcu and Kaufman (2011)). This has led to concern about rising rates of food poverty in both the UK (see Taylor-Robinson et al. (2013)) and US (see Coleman-Jensen et al. (2013)), particularly in households with young children.

Our contribution in this paper is to show that households have been able to partly mitigate the impact of this reduced expenditure on their consumption by using increased shopping effort to obtain lower prices and by switching to cheaper foods. Households with young children experienced the biggest reduction in expenditure and consumption (measured by calories), but also made the biggest increase in shopping effort and the biggest switch to cheaper foods. We quantify the nutritional impact of this switching, and show that, while there are some big changes, the negative and positive implications roughly cancel out, meaning that diet quality has not deteriorated.

In order to study how households adjusted their food spending in response to changes in the economic environment we specify a model of food demand in which households can adjust behavior along a number of margins: by changing the quantity or characteristics of the calories they purchase, or by spending additional time and effort in searching for lower prices or in complementary home production activities. We use rich longitudinal data on the food spending of British households to study the quantitative importance of adjustment along these different margins over the period 2005 to 2012. British households have responded to the altered economic conditions by both reducing the total number of calories they purchase, and by switching to cheaper calories, meaning the number of calories purchased has fallen by less than real expenditure (Griffith et al. (2013)). In the US there is also evidence that consumers have switched to cheaper calories over this time period (for instance, Anderson et al. (2013) show that the price per calorie paid by households in the US that are deemed to be "food insecure" declined by 5% over this period). There is concern that these cheaper calories are less nutritious (e.g. Mabli et al. (2010)); we consider whether this is the case, or whether households

economized in ways that did not affect the nutritional composition of their food basket (for example, Leibtag and Kaufman (2003) find that low-income households buy more on sale and buy a greater proportion of store brand products, and Aguiar and Hurst (2007) find that older households pay lower prices through greater search effort).

In our model a household obtains utility from the size (total calories) and a vector of characteristics of their grocery basket. We distinguish between characteristics that measure the nutritional composition of food, and other "non-nutrient" characteristics. The household selects the optimal combination of calories and characteristics by weighing up the costs and benefits of each. Households can allocate time to shopping effort and home production in order to lower the price they pay for foods in their grocery basket (Becker (1965) and Stigler (1961)); but time shopping or engaged in home production means less time available for other enjoyable or productive activities, and therefore comes at a cost. The price per calorie that households pay for their grocery basket depends on basket characteristics, and effort and time allocated to shopping and home production. We estimate the empirical relationship between the price per calorie that households pay for their groceries and measures of household shopping behavior; we use these to quantify the relative importance of different margins of choice in reducing the price paid per calorie.

Over the period of the Great Recession changes in household behavior contributed to a reduction in price paid per calorie of 2.6 log points (around 3%). Our results suggest that roughly 40% of this saving was due to increased shopping effort and, in particular, greater use of sales. A further 35% of the decline was due to changes in the nutritional composition of households' shopping baskets. The remaining fraction was due to a switch towards generic (budget store brand) products. We explore differences in behavior across households by demographic characteristics and by permanent income. Households with pre-school aged children experienced the largest decline in real food expenditure, and switched most strongly toward cheaper calories; behavioral change contributed to a reduction in their per calorie spend of over 6%. Households at different points of the permanent income distribution experienced similar declines in real food expenditure, but high income households tended to respond by reducing the price they paid per calorie by more than lower income households; lower income household cut back on calories by more. Although all household types changed the nutritional composition of their shopping basket in such a way as to reduce their per calorie spend, the overall effect on nutritional quality was small because positive and neg-

ative effects cancel out. We use a composite measure of the nutritional quality of calories to show that substitution away from protein and vegetables was offset by a switch away from saturated fat and salt and towards fruit. Overall, the results suggest that households were able to mitigate the effect of the recession and rising food prices by changing their behavior in ways that did not adversely affect the nutritional quality of their food purchases.

This paper is related to a number of literatures. Most closely related is the paper by Aguiar and Hurst (2007) on how people substitute between expenditure and time use at different points in the life-cycle. They follow Becker (1965) by modeling utility from food as the outcome of a home production function, which combines cooking time with grocery purchases. They use cross sectional data to compare patterns of food expenditure and time use across consumers of different ages and argue that the fall in food expenditure at retirement can largely be explained by increased shopping effort and cooking time. We build on Aguiar and Hurst (2007) by adding product characteristics and by considering the extent to which households substitute between time, grocery basket size and basket characteristics in response to changes in economic conditions. As in Aguiar and Hurst (2007) we estimate the relationship between the price households pay for groceries and their choice variables; but we differ in two important ways. Firstly, Aguiar and Hurst (2007) were concerned with variation across households in price paid for a fixed basket of goods (due, in particular, to differences in time devoted to search). We also aim to capture factors that explain variation in price paid for a grocery basket with fixed characteristics, but in addition we are interested in capturing the difference in price paid resulting from households choosing different characteristics of their food basket. Secondly, Aguiar and Hurst (2007) compare the shopping behavior of households of different ages to infer how behavior changes over the life-cycle. In contrast we exploit rich longitudinal data on households' grocery purchases, and study within household variation in behavior over time in response to changes in the economic environment to identify the parameters of interest.

Our work also relates to a literature that describes changes in time use and shopping habits over the recession. Aguiar et al. (2013) use time use data from the US to show that over the Great Recession 30% of foregone market work hours were allocated to non-market work, and 7% were allocated to increased shopping effort. Unlike that paper, we do not directly observe time use, rather we infer it from observed grocery shopping behavior and outcomes.

A number of papers suggest that nutrition and health might improve as economic conditions worsen. Strauss and Thomas (1998) look at the evidence for the effect of economic activity on nutritional status (energy intake, weight, child stature) in Russia in the late 1990s. They find that individuals and households, *"are able to weather short-term fluctuations in economic resources, at least in terms of maintaining body mass index and energy intake."* They show that individuals switched to cheaper and less tasty calories in hard times. Ruhm (2000) investigates the relationship between economic conditions and health. He finds that diets become less healthy and obesity increases when the economic situation improves. Dehejia and Lleras-Muney (2004) draw on this to study the relationship between the unemployment rate at time of conception and outcomes at birth and find that babies conceived in recessions have a lower probability of bad outcomes such as low birth weight, congenital malformations, and post-neonatal mortality. Our finding that substitution towards time spent shopping is a crucial margin of consumer response in the face of adverse changes in economic conditions sheds light on one of the mechanisms that may lie behind this relationship.

The rest of the paper is structured as follows. Section 2 sets out a simple optimizing model of consumer grocery shopping and our empirical approach. Section 3 describes the data we use and how we measure various aspects of households' shopping behavior. Section 4 presents the empirical results. We discuss the estimates of the determinants of price paid per calorie, the relative importance of different margins of behavior in reducing price paid per calorie, both on average and for different household types, and the impact on the nutritional quality of food purchases. Section 5 shows our results are robust to functional form assumptions we make and a final section summarizes and concludes.

2 A model of grocery shopping

2.1 Model

We model the decision that a household makes over its grocery shopping. We assume the household's utility from food consumption (v) depends on the total number of calories in its shopping basket, C, and a k dimension vector of basket characteristics, $\mathbf{z}$.

We denote the price that the household pays per calorie for its grocery basket $P = P(e, \mathbf{z}; \phi)$. P depends on how much effort the household expends shopping, e. All else equal, more time shopping results in a lower price paid for groceries,

because the shopper finds better deals (that is we expect $\partial P/\partial e < 0$, although it is likely that there are diminishing returns to shopping effort, meaning $\partial^2 P/\partial e^2 > 0$). The characteristics of the shopping basket can also affect the price paid per calorie. For example, increasing the share of calories from protein or the share of branded rather than generic products will likely increase the price per calorie. Finally, we denote other factors that affect the price per calorie the household pays for its groceries (including common time varying factors, such as the prices at which firms offer food in the market) by ϕ.

Spending more time shopping has the advantage of potentially lowering the household's monetary expenditure on groceries, but it has the downside of leaving less time for the household to engage in leisure or market work. We denote the opportunity cost of time by ω. The time required to prepare calories for consumption is a special characteristic, denote this by z' (an element of $\mathbf{z}$). Like other characteristics of the grocery basket, the preparation requirement may affect the price per calorie, but unlike other characteristics preparation is also costly in terms of time.

We assume that preferences over total calories and characteristics are weakly separable from other arguments in the household's utility function, and that choices other than those over $(e, \mathbf{z})$ do not enter directly into the price function. This implies that changes in work status affect food consumption through changing resources available for food and the opportunity cost of time, but not through altering the relative desirability of different basket characteristics or the marginal rate of substitution between calories and any given characteristic. The household's problem can be stated as a cost minimization problem given by:

$$\min_{e,C,\mathbf{z}} P(e, \mathbf{z}; \phi)C + \omega(e + z'), \tag{2.1}$$

$$s.t. \quad v(C, \mathbf{z}) = \bar{v}. \tag{2.2}$$

The household's choice over consumption of non-food and over leisure and labor supply are captured in the opportunity cost of time ω, and the total resources allocated to food consumption is captured in $\bar{v}$. We assume that the household does not select zero shopping effort ($\partial p/\partial e \to -\infty$ as $e \to 0$ ensures this), or zero leisure or cooking time (appropriate Inada conditions on the utility function ensure this).

The first order condition for shopping effort is:

$$-\frac{\partial P}{\partial e}C = \omega; \tag{2.3}$$

the household puts effort into shopping up to the point where the marginal gain in terms of lower food expenditure equals the opportunity cost of time. The first order condition for the choice of total calories is:

$$P = \lambda \frac{\partial v}{\partial C}, \tag{2.4}$$

where λ is the Lagrange multiplier on the household's constraint (2.2) and can be interpreted as the reciprocal of the marginal utility of more resources allocated to food consumption (either an extra £ of expenditure or an extra £ worth of time spent shopping). Condition (2.4) says that the household will select the number of calories that equates the marginal cost of more calories with the marginal utility of calories (converted into monetary terms through multiplication by λ).

The first order condition for the choice of characteristic k (where $z_k \neq z'$) is:

$$\frac{\partial P}{\partial z_k}C = \lambda \frac{\partial v}{\partial z_k}. \tag{2.5}$$

Interpretation is similar to the calorie first order condition: for each characteristic k, the household will choose the quantity that equates its marginal cost with the marginal utility from that characteristic (expressed in monetary terms). Note that for the cooking requirement characteristic, the first order condition is $\left(\frac{\partial P}{\partial z'}C + \omega\right) = \lambda \frac{\partial v}{\partial z'}$. Like other basket characteristics, purchasing calories with a higher cooking requirement may affect the price the household pays per calorie, but unlike other characteristics it will also be costly in terms of time.

The ratio of condition (2.5) and (2.4) yields the marginal rate of substitution between calories and characteristic k:

$$\frac{\partial v/\partial z_k}{\partial v/\partial C} = \frac{\partial P}{\partial z_k}\frac{C}{P}. \tag{2.6}$$

At the optimum, the number of extra calories the household needs as compensation for a marginal loss in the amount of characteristic k that keeps her indifferent to the change equals the ratio of the marginal costs of characteristic k and calories.

Our interest lies in understanding how households adjusted their behavior to changes in the economic environment over the period of the Great Recession. British households were subject to reductions in their real incomes, driven by slow

nominal wage growth and reductions in asset prices. Importantly, they also faced much higher food prices. In problem (2.1)-(2.2) this would lead to changes in the resources the household had available for food consumption, v, the opportunity cost of time, ω and the market prices of foods, captured by ϕ. We quantify how important the different mechanisms of adjustment were, i.e. to what extent households responded by reducing the nutritional quality of their shopping baskets, or whether they were able to reduce the price they paid per calorie by using other mechanisms, such as increasing time and effort in searching out products with the lowest price when shopping.

Our empirical strategy is to specify a parametric form for the price per calorie function $P(e, \mathbf{z}; \phi)$ and use this to estimate the sensitivity of the price per calorie that households paid for their grocery baskets to the choice variables $(e, \mathbf{z})$.

2.2 Empirical functional form

At this point it is useful to introduce a household index h and a time index t. We have panel data on household daily food purchases, but we consider the household's aggregate shopping basket, and so aggregate each household's purchases to the monthly level; we observe each household for many months (on average 31 months). We measure the price per calorie that household h pays for its groceries in period t, P_{ht}, as a weighted average of the transaction prices that the household pays for the individual products in its grocery basket. Let i index a product (i.e. a barcode or UPC), s index a store and d index a date. Let c_i denote the number of calories in product i and p_{isd} the price of product i in store s on date d. P_{ht} is given by:

$$P_{ht} = \sum_{isd \in t} \left(\frac{p_{isd}}{c_i} \right) w_{hisd}, \tag{2.7}$$

where $\frac{p_{isd}}{c_i}$ is the price per calorie of product i in store s on date d. The weights are given by:

$$w_{hisd} = \frac{c_i b_{hisd}}{\sum_{i's'd' \in t} c_{i'} b_{hi's'd'}}, \tag{2.8}$$

where $b_{hisd} \in \{0, 1, 2, ...\}$ is the number of purchases of product i from store s on date d by household h. It is through their choice of products, b_{hisd}, that households are able to change the average price they pay per calorie. Similarly, each basket characteristic is defined as a weighted average of the "amount" of the characteristic in each product in the basket. Total calories purchased by a household in a month

is given by:

$$C_{ht} = \sum_{isd \in t} c_i b_{hisd}. \tag{2.9}$$

We do not directly observe the time that a household spends shopping; we use a vector of shopping trip characteristics to proxy shopping effort, outlined in Section 3.2.

As our baseline specification we assume that the price function, $P(\mathbf{e}, \mathbf{z}; \phi)$, can be approximated by a log-log specification (Triplett (2004), Aguiar and Hurst (2007)), although we show that our results are robust to an alternative polynomial specification. A number of variables are bounded between 0 and 1, for these we take the log of 1 plus the variable. In particular, we consider:

$$\ln P_{ht} = \alpha \ln \mathbf{e_{ht}} + \beta \ln \mathbf{z_{ht}} + \gamma \mathbf{x}_{ht} + \tau_{ht} + \eta_h + \epsilon_{ht}, \tag{2.10}$$

where τ_{ht} denote region-time effects, η_h denote household fixed effects and $\mathbf{x_{ht}}$ denote time varying household demographics (including age of the youngest child, age of the main shopper, the household's recommended calorie requirement and main shopper employment status). To estimate the parameters in equation (2.10) consistently we require that past, current and future realizations of the right-hand side variables are uncorrelated with the error term. Define $\mathbf{e_h} = (\mathbf{e}_{h1}, ..., \mathbf{e}_{hT})$, $\mathbf{z_h} = (\mathbf{z}_{h1}, ..., \mathbf{z}_{hT})$, $\mathbf{x_h} = (\mathbf{x}_{h1}, ..., \mathbf{x}_{hT})$ and $\boldsymbol{\tau_h} = (\tau_{h1}, ..., \tau_{hT})$; a sufficient condition for identification of the parameters of interest is that the household choice variables $(\mathbf{e_h}, \mathbf{z_h})$ are strictly exogenous, conditional on the other covariates:

$$\mathbb{E}(\epsilon_{ht} | \mathbf{e_h}, \mathbf{z_h}, \mathbf{x_h}, \boldsymbol{\tau_h}, \eta_h) = 0, \quad t = 1, \ldots, T. \tag{2.11}$$

While we believe that controlling for region-time and household fixed effects and time varying household characteristics control for the main potential omitted factors of concern, this is a crucial assumption that we now turn to discuss in further detail.

2.3 Identification

We are interested in identifying the causal effect of households' choice variables $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$ on the price per calorie they pay for their grocery basket. Our identification strategy exploits *differential within household* variation in households' shopping choices. The inclusion of household fixed effects, region-time effects and demographics will help mitigate a number of issues of potential concern.

We do not directly place restrictions on how the disaggregate product prices (p_{isd}) are set (and, in particular, whether the market environment is competitive or oligopolistic). However, we do require market prices to be uncorrelated with the household choice variables ($\mathbf{e_{ht}}, \mathbf{z_{ht}}$), conditional on the household fixed effects, region-time effects and demographics. Market prices are likely to vary over time due to general food price inflation and due to changes in aggregate market conditions feeding into firms' price setting decisions (e.g. firms may put more items on sale during a recession). These price changes may vary regionally. In the UK most supermarkets implement a national pricing policy, following the Competition Commission's investigation into supermarket behavior (Competition Commission (2000)), meaning that most regional variation comes from regional variation in supermarket coverage and from differences in temporary price reductions. Such changes will be captured by the region-time effects, τ_{ht} and also by the fact that we control for the availability of food on promotion, outlined in Section 3.2. Similarly, the types of supermarkets located in relatively wealthy areas may set higher prices, and households in such areas may be less inclined to spend time grocery shopping. Purely cross-sectional differences will be controlled for by the household fixed effects, and changes over time (including those that differ across regions) will be absorbed by the region-time effects.

A second possible issue arises if the household varying transaction weights, w_{hisd}, which we use to construct price per calorie, varied in ways other than through, but correlated with, the choice variables of interest. In particular, there may be a variable that influences price paid per calorie that is omitted from the model and that is correlated with those that are included, which would mean that the exogeneity condition (2.11) would not hold. The fact that we include region-time effects and household fixed effects means a problem would arise only if an omitted variable varied over time differentially across households. An example of a possible omitted variable is productivity differences in shopping technology across households. For instance, some households may be particularly adept at searching for good deals and consequently may pay less than other households for their groceries. Such households may spend less time shopping and may have preferences that lead them to select different basket characteristics than other households. However, it seems likely much of the difference in shopping technology would be fixed over time and therefore controlled for by household fixed effects.

It is also possible that households' preferences over individual food products may change in such a way that is not captured by the included basket characteristics and leads to a lower price per calorie. Two possible reasons for this are changes

in household demographics (e.g. the birth of a baby) or the employment status of its members. To control for such changes we include a vector of time-varying household characteristics, including the age of the youngest child, the age of the main shopper and the calorie requirement of the household (see Department of Health (1991)). The inclusion of the household's calorie requirement also captures the potential for economies of scale in grocery purchases, i.e. shopping for more people might allow households to reduce the price that they pay per calorie in ways not captured by the characteristics of the basket, $\mathbf{z_{ht}}$. We also include dummy variables indicating whether the main shopper and head of household work full time or part time. We expect that much of the effect of variation in employment status will be captured by our proxies for shopping effort, but inclusion of these variables will control for any that is not.

Of course in the end we cannot rule out that our estimates are influenced by omitted variable bias, but for this to cause us a problem the source would need to an omitted variable that varies over time-region differentially within households and that is not captured by demographic transitions.

3 Measuring shopping behavior

We use information on food (including drinks and alcohol) that is purchased and brought into the home by a representative panel of British households over the period January 2005–June 2012. The data are from the Kantar Worldpanel and are collected via in-home scanning technology. Participants record spending on all grocery purchases via an electronic hand held scanner in the home. Purchases from all types of store – supermarkets, corner stores, online, local speciality shops – are covered by the data. The data include information on the exact price paid for the product, whether or not the product purchased was on promotion (e.g. ticket price reduction, "Buy One Get One Free", etc.), nutritional information (number of calories, amount of salt, protein, saturated fat and other information that is listed on food labels) and demographic details of the households. See Griffith and O'Connell (2009) and Leicester and Oldfield (2009) for further discussion of the data.

Our sample contains 14,694 households and over 450,000 "shopping baskets", which we define as all purchases made by a household in a month. We use the transaction level data to compute the average price per calorie, P_{ht}, that each household pays for its groceries in each period using equations (2.7)-(2.8). In 2005-2007 the average price was £1.56 per 1000 calories. By 2010-2012 this had

increased by 30p to £1.86. This increase was driven both by changes in the market prices that households faced and by changes in the choices that households made over the characteristics of their basket and other shopping behavior. In this section we describe changes in food expenditure and calories, and we set out how we measure the household choice variables. We use these in Section 4.1 to separate out the part of the change in price paid per calorie that was due to household behavior: we show that household behavior acted to decrease the price per calorie households paid for their groceries.

Throughout our analysis we compare the time period 2005-2007 with 2010-2012. The intervening period, 2008-2009 (the period during which the UK economy was technically in recession), was characterized by reductions in real incomes and rising food prices; since then incomes have remained depressed and the level of food price has remained high. Comparison of the pre and post recession periods thus allows us to compare household behavior in two distinct economic environments.

3.1 Food expenditure and prices

Our focus is on the grocery baskets that households purchase for home consumption. In Table 3.1 we show how real grocery expenditure and calories changed between 2005-2007 and 2010-2012. We define real food expenditure as nominal expenditure per month deflated with the food and drinks component of the CPI. Calories are expressed per person per day. Both figures are "equivalized" to account for differences in household size and composition. We construct an "adult-equivalent index" based on the estimated average requirement (EAR) for energy of household members (Department of Health (1991)), which vary by age and sex. We sum the EARs of all household members and divide by 2550; this equals 1 for a household containing only one adult male aged 19-59. If the household contained 1 adult male, 1 adult female (EAR=1940) and one female infant (EAR=698) then the index would be 2.035=(2550+1940+698)/2550; this means that if the household purchased 5188 calories this would be "equivalized" to 2550 and so be comparable to a single adult male purchasing 2550 calories.

The table shows that, on average, households reduced their real grocery expenditure by over 6% between 2005-2007 and 2010-2012. They also reduced the number of calories they bought per adult equivalent per day by 1.1%, from 2300 to 2274. The fact that households reduced their grocery expenditure by more than calories purchased indicates that they switched toward cheaper calories. To

explore how households have achieved this we estimate equation (2.10), relating the price per calorie that households pay for their monthly grocery basket to the measures of the choice variables ($\mathbf{e_{ht}}, \mathbf{z_{ht}}$) described below.

Table 3.1: *Changes in real food expenditure and calories*

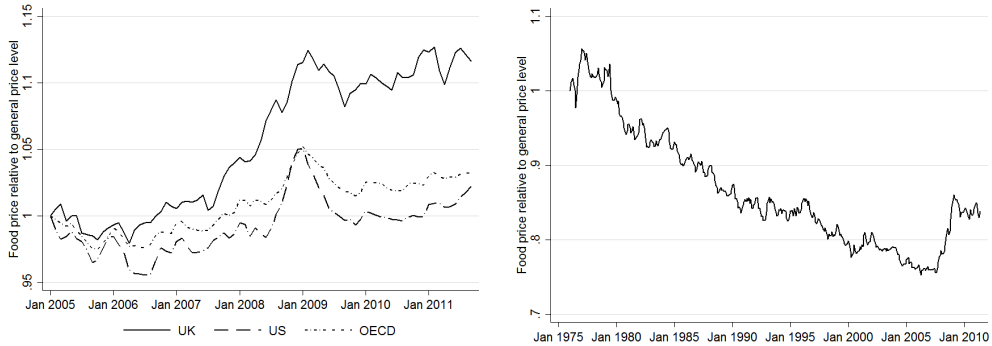
	2005 -2007	2010 -2012	Change	% change
Real expenditure (£ per adult equivalent per month)	114.52	107.27	-7.25	-6.33
Calories (per adult equivalent per day)	2300	2274	-25	-1.10

Notes: Real food expenditure is nominal expenditure on food at home deflated by the CPI component for food and drink at home (in 2008 prices). Real expenditure is per adult equivalent per month; calories are per adult equivalent per day. The percentage change is the average within household change in the variable.

In the UK an important determinant of the reduction in real food expenditure was the sharp rise in food prices. Following shocks to world commodity prices, food prices across the OECD rose between 2008-2009 (Department for Food and Rural Affairs (2010)). However, the UK experienced a larger rise in food prices and, unlike other countries, the higher food price level persisted (see left hand panel of Figure 3.1). This recent rise in food prices reverses a long run trend toward cheaper food. Over the last forty years in the UK, the price of food, relative to the general price level, has fallen substantially, and, in contrast to the Great Recession, previous recessions have seen larger than trend falls in food prices (see right hand panel of Figure 3.1). Higher food prices, increased unemployment and depressed wages levels are all likely to have a played an important role in driving lower food expenditure in both the UK and US (although the relative importance of these factors has differed).

We do not have the same kind of detailed information on food purchases that are consumed outside the home (e.g. restaurant food), or purchases from takeaways. However, from the Living Costs and Food Survey (LCFS) we know that food out (which includes takeaways and food eaten in restaurants) constitutes approximately 36% of total food expenditure, but it accounts for only 12-13% of total calories purchased. The LCFS suggests that average real expenditure and calories for food out declined by around 10% between 2005-2007 and 2010-2012. These data are also reassuring as they suggest that average real expenditure and calories for food at home both fell by around 6% and 1% respectively - similar changes to those we see in the Kantar data that we use (see Table 3.1).

Figure 3.1: *Food prices*



Notes: Left hand panel – data from the OECD and is the consumer price of food relative to the consumer price of all items (calculated using the CPI). Right hand panel – data from the UK ONS and is the consumer price of food relative to the consumer price of all items (calculated using the Retail Price Index (RPI)).

Table 3.2: *Changes in food at home and food out*

Real expenditure (£ per adult equivalent per month)	2005 -2007	2010 -2011	Change	% change
Food at home	121.02	114.00	-7.02	-5.8
Food out	70.45	63.76	-6.69	-9.8
Calories (per adult equivalent per day)				
Food at home	2505	2478	-27	-1.1
Food out	381	342	-39	-10.3

Notes: Data from the Living Costs and Food Survey 2005-2011. Real expenditure on food at home is nominal expenditure on food at home deflated by the CPI component for food and drink at home (in 2008 prices). Real expenditure on food out is nominal expenditure on food out deflated by the CPI component for food eaten out (in 2008 prices). Real expenditure is per adult equivalent per month; calories are per adult equivalent per day.

3.2 Shopping effort

An important determinant of the price that households pay for their groceries is how much time and effort they allocate to shopping. For example, the shopper will decide how much time to spend comparing prices and searching for good deals on a shopping trip - the more time she spends in store comparing prices the less she is likely to pay per calorie for a grocery basket with a given set of characteristics. The shopper must also decide how frequently to shop, and how many different stores to visit. More frequent shopping and visiting more stores provides the opportunity to compare prices across days and retailers, potentially allowing the shopper to find better value products. Aguiar and Hurst (2007) find that older households

both shop more frequently, spend more time shopping and pay less for a fixed basket of groceries than they cost at average prices. Conversely, households may find better deals by making less frequent trips and instead buying a larger share of their basket on each trip.

We do not directly observe the amount of time households allocate to grocery shopping. We proxy shopping effort using outcome measures from our data. Table 3.3 describes these measures, showing the average value across households in 2005-2007 and 2010-2012, as well as the average within household change and percentage change between these two periods.

Table 3.3: *Proxies for shopping effort*

	2005 -2007	2010 -2012	Change	% change
Number of shopping trips (Ntrips)	14.87	14.87	-0.00	-0.00
Number of chains visited (Nstores)	3.70	3.83	0.13	3.44
Share of calories from discounter (DISCOUNTER)	10.24	11.85	1.61	15.67
Share of calories bought on sale (SALE)	24.84	33.93	9.09	36.60
Share of available calories on sale (SALE_AV)	17.19	22.71	5.51	32.06

Notes: The numbers are the mean of each variable in 2005-2007 and 2010-2012 and the average within household change and percentage change. Variable names are shown in brackets. SALE_AV is not a measure of shopping effort; rather we control for it when estimating the price function and, conditional on it, interpret SALE as a measure of shopping effort.

The first row of Table 3.3 shows the average number of shopping trips households make per month and the second row shows the average number of separate retailers that they visit. Between 2005-2007 and 2010-2012 households did not change the number of shopping trips that they undertook but they did increase the number of different retailers that they visited. A particularly relevant type of retailer is the discounters; in the third row we report the average share of calories bought from discounters, which increased from 2005-2007 to 2010-2012. Discounters are chains that advertise lower prices compared with other retailers, they are generally less conveniently located and offer a less attractive shopping experience. It is unusual for a household to buy its entire grocery basket at a discounter, because they typically offer a restricted range of products. We measure the share of calories a household purchases at discounter outlets, which averages 10%. This compares to an average of around 25% in Tesco, and over two-thirds in the big four supermarkets (Tesco, Asda, Morrisons and Sainsbury's) combined. In the UK the main discounters are Aldi, Iceland, Kwik Save, Lidl and Netto. Prices paid at discounters are typically lower than those paid at other supermarket chains, although

some of this is due to differences in the grocery basket composition, meaning that it is important to control for basket characteristics.

Our fourth proxy for shopping effort is designed to capture the amount of time households spend shopping *while in the store*. We measure how intensively households make use of sales as the share of calories they purchase on sale. The idea is that buying a larger than average share of groceries on sale, conditional on basket characteristics, indicates more effort in the shop seeking out the products that the household wants that are also on sale. For this interpretation to be valid it is important to account for changes in the number of calories that were available on sale. We therefore control for the share of available calories on sale in the supermarkets that the household visited. Since we also include household fixed effects, this means that the coefficient on the share of calories purchased on sale in the price regression reflects the impact of buying more calories on sale *than the household normally does and holding fixed the share of available calories on sale*. Table 3.3 shows that the share of calories purchased on sale increased substantially from 25% in 2005-2007 to just under 34% in 2010-2012. The share of calories available on sale also increased, but by less - from 17% in 2005-2007 to 23% in 2010-2012. The increase in share of calories available on sale is evident (and of a similar magnitude) across all main food groups.

3.3 Basket characteristics

As well as choosing shopping effort and total calories, households choose the characteristics of their shopping basket, $\mathbf{z_{ht}}$. Basket characteristics include the nutritional characteristics (macronutrients, micronutrients and major food groups) and two other characteristics: the share of calories that are bought as budget store brands (i.e. generics) rather than branded products, and package size (to reflect non-linear pricing and bulk discounts). Households may have reduced the price they pay for their groceries without changing the nutritional composition of their calories by adjusting these other characteristics.

Table 3.4 details the nutrient characteristics that we include in $\mathbf{z_{ht}}$. These include the share of non-alcohol calories from each of the macronutrients – protein, saturated fat, unsaturated fat, sugar and non-sugar carbohydrates. All calories are derived from macronutrients (and alcohol), meaning that the shares sum to one. The table shows that between 2005-2007 and 2010-2012, on average, households switched towards carbohydrates (sugar and non-sugar) and unsaturated fat and away from calories from protein and saturated fat. We also include the amount of

fibre and salt per 100g in the shopping basket in $\mathbf{z_{ht}}$. Households, on average, have increased the fibre intensity and reduced the salt intensity of their groceries. It is likely that the marginal impact on price paid per calorie of changing nutrients will vary across nutrients because the cost of producing foods with different nutrients varies and because firms might price nutrients differently (for example, Stanley and Tschirhart (1991) find different hedonic prices for nutrients in breakfast cereals). We also control for the nutritional composition of shopping baskets by including in $\mathbf{z_{ht}}$ the share of calories from each of 11 (exhaustive) food groups. Between 2005-2007 and 2010-2012 households, on average, switched towards fruit, grains, poultry and fish, and prepared foods and away from vegetables, red meat and nuts, drinks and alcohol.

We do not have time-use data so do not directly measure how much time households allocated to cooking. However, by controlling for both the nutritional and food group composition of households' grocery baskets, we are able to proxy for the cooking requirement of households' calories (to the extent that cooking times vary across these food groups). For example, if a household switches from purchasing vegetables and raw meats to purchasing processed or prepared foods this indicates a reduction in the required cooking time of its shopping basket. Although we can control for this, we are not able to separately identify how an additional minute of cooking time affects price paid per calorie without specifying the home production process.

Table 3.5 details the other (non-nutrient) characteristics we include in $\mathbf{z_{ht}}$. The measure in the first row is the share of calories from budget store brand (or generics). In the UK, there are two types of store brand product: budget and standard. Standard store brands are similar to national brands – they are advertised by the supermarkets, comparably priced and are generally of similar quality to equivalent national brands. In contrast, budget store brands are seldom advertised, are typically sold in plain packaging and are sold for substantially lower prices. The average unit price of budget store brands (across 110 product categories and 16 retailer chains) is just under £2, compared to an average of over £4 for the largest national brand in each product category (Griffith et al. (2014)). Budget store brands are similar to generic brands in the US market. All else equal, it is likely that households value budget store brands less than branded products, and there is evidence that households substitute towards generic products when economic conditions worsen (see Gicheva et al. (2010), Kumcu and Kaufman (2011)). Between 2005-2007 and 2010-2012 households switched to buying a larger share of their calories as budget store brands.

Table 3.4: *Nutrient characteristics*

Share of calories from:	2005 -2007	2010 -2012	Change	% change
Protein (shr_prot)	14.88	14.76	-0.12	-0.81
Saturated fat (shr_sfat)	14.83	14.59	-0.23	-1.57
Unsaturated fat (shr_ufat)	22.64	22.79	0.15	0.67
Sugar (shr_sug)	22.73	22.82	0.09	0.41
Non-sugar carbohydrates (shr_othcarbs)	24.92	25.03	0.11	0.43
g per 100g of:				
Fibre (fibre)	1.12	1.19	0.07	6.32
Salt (salt)	0.50	0.49	-0.00	-0.10
Share of calories from:				
Fruit (shr_Fruit)	5.08	5.28	0.20	3.86
Vegetables (shr_Veg)	6.97	6.43	-0.54	-7.81
Grains (shr_Grains)	16.40	16.65	0.24	1.48
Dairy (shr_Dairy)	9.53	9.49	-0.04	-0.46
Cheese and fats (shr_CheeseFats)	11.73	11.73	0.01	0.06
Poultry and fish (shr_PoultryFish)	3.09	3.30	0.21	6.87
Red meat and nuts (shr_RedMeatNuts)	8.34	7.84	-0.51	-6.07
Drinks (shr_Drinks)	1.87	1.82	-0.04	-2.36
Prepared sweet (shr_PrepSweet)	19.06	19.53	0.47	2.47
Prepared savory (shr_PrepSavory)	14.78	14.82	0.04	0.30
Alcohol (shr_Alcohol)	3.14	3.11	-0.04	-1.15

Notes: The numbers are mean of each variable in 2005-2007 and 2010-2012 and the average within household change and percentage change. Variable names are shown in brackets.

Griffith et al. (2009) present evidence of strong non-linear pricing in the UK grocery market. Households are able to lower the per calorie price they pay, while keeping other attributes of their shopping basket fixed, by switching to larger pack sizes of the brands they purchase. To capture this we include the share of calories purchased in "big" pack sizes. We define a product as having a "big" pack size if its size is above the median pack size of all transactions involving products belonging to the same brand. The second row of Table 3.5 shows that households switched to buying smaller pack sizes between 2005-2007 and 2010-2012.

4 Empirical results

In this section we present estimates of the relationship between price paid per calorie and households' choice variables $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$ (see equation (2.10)). We use the estimates to pin down the contribution that changes in households' behavior

Table 3.5: *Other basket characteristics*

Share of calories from:	2005-2007	2010-2012	Change	% Change
Generic products (GEN)	10.92	12.97	2.05	18.75
Big pack sizes (BIG)	32.31	30.86	-1.46	-4.51

Notes: The numbers are mean of each variable in 2005-2007 and 2010-2012 and the average within household change and percentage change. Variable names are shown in brackets.

made to the price that they paid, and we explore the importance of various margins of adjustment. We also describe heterogeneity across household types and assess the impact that changes in basket characteristics had on the nutritional quality of households' grocery baskets.

4.1 Estimates of price function

Table 4.1 shows the coefficient estimates of equation (2.10). Column 1 shows the estimated coefficients omitting household effects. In column 2 we include household fixed effects. The difference in coefficient estimates is marked. For instance, the absolute value of the sales coefficient more than halves once we include household fixed effects. This reflects the fact that there are differences in household shopping technology, which lead them to pay a lower price per calorie and that are correlated with their use of sales. A similar change is evident for other choice variables, underlining the importance of exploiting differential within household changes in behavior. In column 3 we also control for time-varying household characteristics (age of youngest child, age of main shopper, household calorie requirement and employment status). This has very little impact on the coefficient estimates. In what follows we use the coefficient estimates from column 3.

The unconditional correlation between price paid per calorie and number of shopping trips is negative, but Table 4.1 shows that once we control for other choice variables and household fixed effects, the estimated coefficient on number of shopping trips is positive, although small. Conditional on shopping basket characteristics and household caloric requirements, undertaking an additional shopping trip results in a slight increase in price per calorie. This result differs from Aguiar and Hurst (2007); they find that older households pay lower prices because they shop more frequently than other households. Our setting differs in that we focus on within household changes in behavior over a period of economic turbulence. We also find little impact of visiting an additional retailer on price paid per calorie

Table 4.1: *Coefficient estimates*

	(1) $\ln(P_{ht})$		(2) $\ln(P_{ht})$		(3) $\ln(P_{ht})$	
ln(Ntrips)	-0.031^{***}	(0.001)	0.021^{***}	(0.001)	0.022^{***}	(0.001)
ln(Nstores)	0.045^{***}	(0.001)	0.010^{***}	(0.001)	0.010^{***}	(0.001)
ln(DISCOUNTER+1)	-0.068^{***}	(0.003)	-0.065^{***}	(0.002)	-0.066^{***}	(0.002)
ln(SALE+1)	-0.348^{***}	(0.003)	-0.143^{***}	(0.003)	-0.141^{***}	(0.003)
ln(SALE_AV+1)	-2.148^{***}	(0.012)	-0.578^{***}	(0.011)	-0.577^{***}	(0.011)
ln(BOB+1)	-1.119^{***}	(0.003)	-0.501^{***}	(0.003)	-0.499^{***}	(0.003)
ln(BIG+1)	-0.467^{***}	(0.003)	-0.218^{***}	(0.003)	-0.216^{***}	(0.003)
ln(shr_sug+1)	0.361^{***}	(0.012)	0.141^{***}	(0.009)	0.142^{***}	(0.009)
ln(shr_sfat+1)	1.941^{***}	(0.014)	1.098^{***}	(0.012)	1.094^{***}	(0.012)
ln(shr_ufat+1)	1.025^{***}	(0.014)	0.379^{***}	(0.011)	0.374^{***}	(0.011)
ln(shr_prot+1)	5.512^{***}	(0.019)	4.073^{***}	(0.015)	4.063^{***}	(0.015)
ln(fibre)	-0.004^{***}	(0.001)	-0.063^{***}	(0.001)	-0.064^{***}	(0.001)
ln(salt)	-0.026^{***}	(0.001)	-0.010^{***}	(0.000)	-0.010^{***}	(0.000)
ln(shr_Fruit+1)	2.402^{***}	(0.010)	1.602^{***}	(0.009)	1.595^{***}	(0.009)
ln(shr_Veg+1)	0.578^{***}	(0.007)	0.459^{***}	(0.006)	0.459^{***}	(0.006)
ln(shr_Dairy+1)	-0.327^{***}	(0.009)	-0.005	(0.008)	-0.005	(0.008)
ln(shr_CheeseFats+1)	-0.554^{***}	(0.010)	-0.249^{***}	(0.008)	-0.245^{***}	(0.008)
ln(shr_RedMeatNuts+1)	-0.549^{***}	(0.010)	-0.084^{***}	(0.008)	-0.080^{***}	(0.008)
ln(shr_PoultryFish+1)	-0.843^{***}	(0.014)	-0.566^{***}	(0.011)	-0.559^{***}	(0.011)
ln(shr_Drinks+1)	1.147^{***}	(0.013)	0.949^{***}	(0.011)	0.948^{***}	(0.011)
ln(shr_PrepSweet+1)	0.333^{***}	(0.007)	0.289^{***}	(0.006)	0.289^{***}	(0.006)
ln(shr_PrepSavory+1)	0.608^{***}	(0.007)	0.657^{***}	(0.006)	0.658^{***}	(0.006)
ln(shr_Alcohol+1)	2.485^{***}	(0.008)	2.163^{***}	(0.008)	2.162^{***}	(0.008)
Region-time effects	Yes		Yes		Yes	
Household fixed effects	No		Yes		Yes	
Time varying hh characteristics	No		No		Yes	

Notes: Estimated with 466,341 observations on 14,694 households' monthly grocery purchases over 2005-2012. Standard errors in parentheses. $^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$.

– the coefficient is statistically insignificant. Our other two measure of shopping effort turn out to be more important. Buying a larger share of calories from discounters, all else equal, lowers price paid per calorie. Purchasing more calories on sale, conditional on controlling for how much food is available on sale, leads to a reduction in price paid per calorie. Both of the "other basket characteristics" have the expected coefficient sign: purchasing a higher share of calories from generic products, or switching towards larger pack sizes acts to lower price paid per calorie, all else equal.

The coefficients on the macronutrients (sugar, saturated fat, unsaturated fat and protein) measure the effect of these variables relative to the omitted category, non-sugar carbohydrates. Protein is considerably more expensive than the other macronutrients; non-sugar carbohydrates are the cheapest. More fibrous and more salty food acts to lower price per calorie. The food group coefficients are the effect

on price per calorie relative to grains (the omitted category). The coefficients suggest that, all else equal, increasing the share of calories from alcohol and fruit increases price per calorie by the most, and increasing the shares of cheese and fats and poultry and fish increase price per calorie by the least. Poultry and fish are a relatively expensive source of calories; the negative coefficient for this group is explained by the fact that we control separately for the share of calories from protein in the regression, and they are a relatively cheap source of protein.

4.2 Quantifying the determinants of price per calorie

We use the estimates of the price regression to quantify the effect of within household changes in shopping effort and shopping basket characteristics on the price households paid per calorie. In Table 3.1 we show details of the within household change in the average price paid per calorie between the period before (2005-2007) and after (2010-2012) the Great Recession. The average price per calorie households paid increased by 17.7 log points (around 19.4%) over this time. We can use the estimated price regression to compute how the price paid per calorie would have changed in the absence of changes in households' choice variables $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$. Had households not changed their shopping effort, or the characteristics of their grocery basket, average price per calorie would have increased by 20.3 log points (around 22.5%). Therefore within household behavioral changes led to a 2.6 log point (approximately a 3.1%) reduction in price paid per calorie.

Using the estimated coefficients from the price equation we can quantify the contribution that the within household changes in each choice variable made to the decline in price paid per calorie. To do this, we calculate the average within household change in each of the choice variables, $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$, and combine these changes with the coefficient estimates from equation (2.10) in Table 4.1. The bottom three rows of Table 4.2 show the contribution made by changes in shopping effort, nutrient characteristics (including food groups) and other characteristics. Increased shopping effort acted to lower the average price paid per calorie by 1.06 log points; changes in the nutrient characteristics acted to lower price paid by 0.93 log points; changes in the other characteristics of the shopping basket acted to lower price paid by 0.60 log points.

In Table 4.3 we present more details of the contribution of changes in each choice variable to the overall 2.6 log point decline in price paid per calorie. The use of sales is the most important mechanism that households use out of the proxies for shopping effort. The reduction in price per calorie through changing

Table 4.2: *Changes in log price paid per calorie; estimates from model*

	All households
Predicted change	17.74
Counterfactual change	20.34
Behavior change	-2.59
of which	
shopping effort	-1.06
nutrient characteristics	-0.93
other characteristics	-0.60

Notes: Numbers are the average within household change. Row 1 is change in predicted $\ln(P_{ht})$*. Row 2 is change in predicted* $\ln(P_{ht})$ *holding fixed the choice variables* $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$*. Row 3 is change in predicted* $\ln(P_{ht})$ *holding fixed all variables other than the choice variables* $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$*. All numbers are multiplied by 100.*

the nutritional characteristics was principally due to a switch away from protein, saturated fat and alcohol (all relatively costly per calorie) and towards fibre, non-sugar carbohydrates and vegetables (which are relatively cheap per calorie). Of the remaining shopping basket attributes a switch towards more calories from budget store brands was important in reducing per paid per calorie, it lead to a 0.84 log point reduction. Substitution to smaller pack sizes acted to increase price paid per calorie by 0.24 log points.

We argue that the use of sales (conditional on the availability of products that are offered on sale) is a proxy for effort or time spent shopping. The model we outline in Section 2.1 (condition (2.3) in particular) implies that we can use observed changes in households' shopping effort and their grocery purchases to infer how the opportunity cost of time has varied over time. As Aguiar and Hurst (2007) point out, this measure of the opportunity cost of time has the advantage that it allows us to be agnostic about households' behavior in the labor market. Given the functional form we assume for the price function, we can write the opportunity cost of time as $\omega_{ht} = -\alpha \frac{\tilde{P}_{ht} C_{ht}}{1+e_{ht}}$ where $\tilde{P}_{ht}$ is expressed in "real" terms (meaning that variation over time in $\tilde{P}_{ht}$ captures changes in price paid per calorie resulting from changes in household behavior; general food price inflation is removed). The solid line in Figure 4.1 plots the average path of the implied opportunity cost of time over 2005-2012. Over this time period households reduced their real food expenditure, but increased their shopping effort (as measured by our proxy), and this suggests a fall in the opportunity cost of time. As a comparison the dashed line shows real mean gross hourly wages. Our estimate of the opportunity cost of time tracks the cost of time as measured by mean wages reasonably closely.

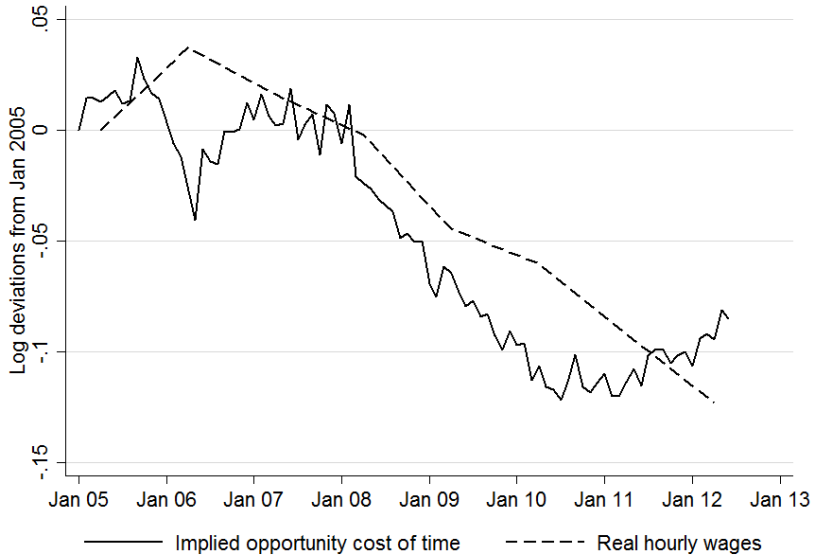
Table 4.3: *Contribution of choice variables to change in price paid per calorie*

	Contribution
Shopping effort:	
Number of shopping trips	-0.02
Number of chains visited	0.03
Savings from discounter	-0.09
Savings from sales	-0.97
Total	-1.06
Nutrient characteristics:	
Protein	-0.43
Saturated fat	-0.22
Unsaturated fat	0.05
Sugar	0.01
Fibre	-0.39
Salt	0.06
Fruit	0.28
Vegetables	-0.23
Dairy	0.00
Cheese and fats	-0.00
Poultry and fish	-0.11
Red meat and nuts	0.04
Drinks	-0.04
Prepared sweet	0.11
Prepared savory	0.02
Alcohol	-0.08
Total	-0.93
Other characteristics:	
Share from generic products	-0.84
Share of groceries from big pack sizes	0.24
Total	-0.60
Total	-2.59

Notes: The table reports the contribution each variable made to the fall in price paid per calorie. The contribution is given by the product of the coefficient in column 3 of Table 4.1 and average change in log of the transformed variable, controlling for fixed effects (multiplied by 100).

The Great Recession affected different types of households to varying degrees. For example, Crossley et al. (2013) show that younger households were particularly hard hit by the recession. We next turn to investigate variation in changes in grocery shopping behavior across different types of households. We look first by household type and second by a measure of household permanent income.

Figure 4.1: *Implied opportunity cost of time*



Notes: Solid line shows deviations of logged opportunity cost of time from its value in January 2005, after deseasonalising and controlling for fixed effects, and is smoothed using a 7-point moving average. The dashed line plots real hourly wages: mean gross hourly wages from the Annual Survey of Hours and Earnings deflated using the food and drink component of the CPI.

4.3 Variation by household type

There is considerable policy interest in how households with young children have been affected by the recession. For example, Coleman-Jensen et al. (2013) show that in the US food insecurity is more prevalent in households with children under six than in the whole population, and changes in food purchasing decisions, particularly those that affect nutritional quality, have important health consequences for young children (see, for instance, Currie (2009) and Case et al. (2005)). We groups households by four types: households with pre-school children, households with school-aged children (and none at pre-school ages), non-pensioner households without children, and pensioner households.

Table 4.4 shows the levels and percentage changes in real monthly grocery expenditure per adult equivalent and calories per adult equivalent per day for the different household types between 2005-2007 and 2010-2012. On average, the grocery expenditure of all household types failed to keep pace with the rise in food prices, meaning that real expenditure fell. Households with pre-school children reduced real expenditure by the most at 12.7%; households with school age children also experienced a relatively large reduction of 10.1%. In addition,

households with children (both pre-school and school age) reduced the number of calories that they purchased per adult equivalent.

This is in contrast to households without children who reduced real expenditure by about half the amount as households with children; non-pensioner and pensioner households show a a similar reduction in expenditure, but reduce calories by less. Non-pensioner households do not, on average, reduce calories at all, while pensioner households reduce calories by less than one-third the amount that households with children.[1]

Table 4.4: *Changes in real food expenditure and calories, by household composition*

	Households with children		Households without children	
	Youngest child is:			
	Pre-school	School age	No pensioners	Pensioners
Real expenditure (£ per adult equivalent per month)				
2005-2007	94.15	93.00	116.65	129.09
2010-2012	82.21	83.60	110.72	121.69
% change	-12.68	-10.10	-5.08	-5.73
Calories (per adult equivalent per day)				
2005-2007	2011.44	2041.00	2287.97	2529.90
2010-2012	1931.19	1947.68	2294.50	2496.58
% change	-3.99	-4.57	0.29	-1.32

Notes: Real food expenditure is nominal expenditure on food at home deflated by the CPI component for food and drink at home (in 2008 prices). Real expenditure is per adult equivalent per month; calories are per adult equivalent per day. "Pre-school" denotes children aged between 0 and 5; "school age" between 6 and 17. "Pensioner" households are those in which at least one member is aged 65 or over. The percentage change is the average within-household change in each variable.

We use the estimates of the price regression to explore how different household types were able to reduce the price they paid per calorie. The first three rows of Table 4.5 show the average change, the counterfactual change (i.e. change in the absence of any change in behavior) and the change due to adjustments in behavior. The remaining rows separate the change due to behavior into the contributions made by within household changes in: shopping effort, nutrient characteristics and other characteristics. Table 4.6 breaks this down and provides details of the

[1]One potential concern that we might have is that because we are looking *within* household, as children age they purchase more foods outside of the home, and this might be driving our results. To check this we use repeated cross-sectional data from the *Living Costs and Food Survey 2005-2011* and find that the change in calories per adult equivalent per day is 2.9% for households with pre-school children and 3.2% for households with school age children.

contribution made by each of the individual choice variables that we include in the price regression.

Table 4.5: *Changes in log price paid per calorie, by household composition*

	Households with children		Households without children	
	Youngest child is:			
	Pre-school	School age	No pensioners	Pensioners
Predicted change	13.98	18.57	17.74	18.13
Counterfactual change	19.16	19.80	20.31	20.66
Behavior change	-5.19	-1.23	-2.57	-2.53
of which				
shopping effort	-1.66	-1.36	-1.00	-0.87
nutrient characteristics	-2.76	0.37	-0.99	-0.93
other characteristics	-0.77	-0.24	-0.59	-0.73

Notes: Row 1 is change in predicted $\ln(P_{ht})$*. Row 2 is change in predicted* $\ln(P_{ht})$ *holding fixed the choice variables* $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$*. Row 3 is change in predicted* $\ln(P_{ht})$ *holding fixed all variables other than the choice variables* $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$*. All numbers are multiplied by 100. "Pre-school" denotes children aged between 0 and 5; "school age" between 6 and 17. "Pensioner" households are those in which at least one member is aged 65 or over. Numbers are the average within household change.*

Households with pre-school children acted to decrease the per calorie price they paid by over 5 log points – considerably more than other household types. Approximately 30% of this was due to increased shopping effort and, in particular, a greater use of sales. Households with young children also switched to buying more of their groceries in the form of generic products. The remaining reduction in the average price per calorie is due to changes in the nutritional composition of their shopping basket, mainly, a fall in the share of calories bought as protein and saturated fat. Households with school-age children also reduced the price that they paid per calorie, but by less than households with younger children: the majority of the fall is due to an increase in the use of sales.

Households without children (both pensioner and non-pensioner) changed their behavior in similar ways to each other. The overall effect of changes in their shopping behavior was to reduce the price they paid per calorie by 2.5 log points. Like other household types, households with no children lowered their price paid per calorie by making greater use of sales, and like households with pre-school children, they switched towards cheaper nutrients and food groups.

Table 4.6: *Contribution of choice variables to change in price paid per calorie, by household composition*

	Households with children		Households without children	
	Youngest child is:			
	Pre-school	School age	No pensioners	Pensioners
Shopping effort:				
Number of shopping trips	-0.13	-0.14	0.02	-0.01
Number of chains visited	-0.02	-0.02	0.04	0.03
Savings from discounter	-0.13	-0.02	-0.07	-0.12
Savings from sales	-1.38	-1.18	-0.99	-0.78
Total	-1.66	-1.36	-1.00	-0.87
Nutrient characteristics:				
Protein	-1.42	1.04	-0.39	-0.77
Saturated fat	-0.71	-0.49	-0.20	-0.07
Unsaturated fat	-0.01	0.12	0.01	0.04
Sugar	0.10	-0.04	0.03	0.00
Fibre	-0.54	-0.36	-0.42	-0.32
Salt	0.08	0.07	0.07	0.04
Fruit	0.33	-0.07	0.46	0.30
Vegetables	-0.44	-0.06	-0.14	-0.34
Dairy	0.00	0.01	-0.00	-0.00
Cheese and fats	0.06	-0.01	-0.01	0.02
Poultry and fish	-0.13	-0.24	-0.09	-0.09
Red meat and nuts	0.02	0.01	0.03	0.06
Drinks	0.06	0.30	-0.13	-0.09
Prepared sweet	0.31	-0.09	0.11	0.18
Prepared savory	0.11	0.06	-0.27	0.31
Alcohol	-0.58	0.10	-0.05	-0.19
Total	-2.76	0.37	-0.99	-0.93
Other characteristics:				
Share from generic products	-1.11	-0.43	-0.75	-1.02
Share of calories from big packs	0.34	0.19	0.17	0.29
Total	-0.77	-0.24	-0.59	-0.73
Total	-5.19	-1.23	-2.57	-2.53

Notes: The table reports the contribution each variable made to the fall in price paid per calorie. The contribution is given by the product of the coefficient in column 3 of Table 4.1 and average change in log of the transformed variable, controlling for fixed effects (multiplied by 100). "Pre-school" denotes children aged between 0 and 5; "school age" between 6 and 17. "Pensioner" households are those in which at least one member is aged 65 or over.

4.4 Variation by permanent income

We are also interested in how the recession affected households at different income levels. We conduct a similar analysis to the previous section using the social grade of the household as a proxy for permanent income. Social grade is based on the occupation of the main income earner.[2] Households in social grades A and B (higher and intermediate managerial, administrative and professional) have a high permanent income; social grades C1 (clerical and junior managerial, administrative and professional) and C2 (skilled manual workers) have a middle level of permanent income; social grades D and E (semi- and unskilled manual workers, state pensioners and the unemployed) have low permanent income. There is a strong correlation between income and the social grade classification – on average, households in social grade A have a main income earner with a net annual income of almost £40,000, whereas those in grade E have a main income earner with a net annual income of less than £5,000.

Table 4.7: *Changes in real food expenditure and calories, by permanent income*

	Permanent income		
	High	Middle	Low
Real expenditure (£ per adult equivalent per month)			
2005-2007	118.56	115.02	110.77
2010-2012	112.24	107.36	104.76
% change	-5.33	-6.66	-5.42
Calories (per adult equivalent per day)			
2005-2007	2166	2282	2383
2010-2012	2190	2256	2349
% change	1.11	-1.13	-1.41

Notes: Real food expenditure is nominal expenditure on food at home deflated by the CPI component for food and drink at home (in 2008 prices). Real expenditure is per adult equivalent per month; calories are per adult equivalent per day. Permanent income is measure using social grade; grade AB/C/DE correspond to high/middle/low permanent income. Numbers are the average within household change.

Table 4.7 shows the average change in expenditure and calories over the recession for households with different permanent incomes. Reductions in real food expenditure over 2005-2007 to 2010-2012 are similar across these permanent income groups. In the UK, the incomes of households towards the bottom of the

[2]See http://www.nrs.co.uk/nrs-print/lifestyle-and-classification-data/social-grade for details.

income distribution were, to some extent, protected from the immediate impact of the Great Recession by the benefit system (Brewer et al. (2013)). However, all households were subject to higher food prices and it is likely that this was primarily responsible for the fall in real food expenditure. However, households in the high permanent income group slightly increased total calories purchased, while those in the other two groups slightly reduced the number of calories that they bought. Conversely, households from the highest permanent income group cut back more strongly than other income groups in the price per calorie they paid for their groceries.

Table 4.8: *Changes in log price paid per calorie, by permanent income*

	Permanent income		
	High	Middle	Low
Predicted change	16.83	17.46	18.74
Counterfactual change	20.00	20.29	20.53
Behavior change	-3.16	-2.82	-1.79
of which			
shopping effort	-1.12	-1.11	-0.95
nutrient characteristics	-1.31	-1.06	-0.45
other characteristics	-0.73	-0.66	-0.38

Notes: Row 1 is change in predicted $\ln(P_{ht})$*. Row 2 is change in predicted* $\ln(P_{ht})$ *holding fixed the choice variables* $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$*. Row 3 is change in predicted* $\ln(P_{ht})$ *holding fixed all variables other than the choice variables* $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$*. All numbers are multiplied by 100. Permanent income is measure using social grade; grade AB/C/DE correspond to high/medium/low permanent income. Numbers are the average within household change.*

Table 4.8 shows the change in average price per calorie paid by each permanent income group, separating out the decline due to change in behavior and Table 4.9 shows the individual contribution made by each individual measure. Households with higher permanent income reduced the price they paid per calorie by the most – by over 3.1 log points. They saved 1 log point through greater use of sales. Households from the low permanent income group also increased their use of sales, although this made a slightly lower contribution to the reduction in the price per calorie they paid. Households from all income groups switched to a cheaper combination of nutrients and food groups. However, the magnitude of this effect was nearly three times as large for households from the top permanent income groups compared with those from the bottom group. Much of this was driven by a strong move away from calories from protein by high income households. High

and middle income households switched much more strongly to generic products than households from the lowest group.

Table 4.9: *Contribution of choice variables to change in price paid per calorie, by permanent income*

	Permanent income		
	High	Middle	Low
Shopping effort:			
Number of shopping trips	0.00	-0.03	-0.05
Number of chains visited	0.01	0.02	0.04
Savings from discounter	-0.12	-0.09	-0.05
Savings from sales	-1.01	-1.01	-0.89
Total	-1.12	-1.11	-0.95
Nutrient characteristics:			
Protein	-0.96	-0.44	-0.03
Saturated fat	-0.18	-0.20	-0.30
Unsaturated fat	0.09	0.05	0.04
Sugar	0.02	0.01	-0.00
Fibre	-0.38	-0.38	-0.39
Salt	0.07	0.06	0.05
Fruit	0.20	0.21	0.45
Vegetables	-0.25	-0.23	-0.18
Dairy	0.00	0.00	0.00
Cheese and fats	-0.06	-0.01	0.02
Poultry and fish	-0.09	-0.12	-0.13
Red meat and nuts	0.03	0.04	0.04
Drinks	0.02	-0.06	-0.05
Prepared sweet	0.17	0.12	0.03
Prepared savory	-0.07	-0.05	0.14
Alcohol	0.07	-0.05	-0.15
Total	-1.31	-1.06	-0.45
Other:			
Share from generic products	-0.92	-0.88	-0.63
Share of groceries from big pack sizes	0.19	0.22	0.25
Total	-0.73	-0.66	-0.38
Total	-3.16	-2.82	-1.79

Notes: The table reports the contribution each variable made to the fall in price paid per calorie. The contribution is given by the product of the coefficient in column 3 of Table 4.1 and average change in log of the transformed variable, controlling for fixed effects (multiplied by 100). Permanent income is measure using social grade; grade AB/C/DE correspond to high/medium/low permanent income.

4.5 Effects on nutritional quality

A concern about the shift to cheaper calories has been that this has led households to compromise on the quality of the foods they buy (Mabli et al. (2010)), although other work has suggested that health and diet quality might increase over recessions (Ruhm (2000)). We consider what impact the substitution between nutrients and across food groups has had on the nutritional quality of households' shopping baskets. Almost 40% of the reduction in the price paid per calorie was due to households substituting between nutrients and across food groups. If the prices of nutrients differ a lot then relatively small changes in the balance of nutrients in a shopping basket can have a large effect on the price paid per calorie, but a much smaller impact on the nutritional quality of the basket.

In Section 3 we presented the levels, within household changes and percentage change in the calorie shares of the macronutrients and key food groups, and the intensity of some micronutrients (Table 3.4). Tables 4.10 and 4.11 shows the change in the average *number* (rather than shares) of calories purchased (per adult equivalent per day) from each macronutrient and food group, and the amount purchased (per adult equivalent per day) of salt and fibre. It is not obvious whether the changes in households' choice of nutrients over this period led to an improvement or worsening of the nutritional quality of their shopping baskets, because there are changes that go in both directions.

The number of calories from protein fell for all household types; on average, the share of protein in the diets of most people in the UK is below recommended levels, and so we may be concerned about this fall. In the other direction, saturated fat fell, and most people in the UK purchase more than the recommended levels of saturated fat, so this suggests an improvement in nutritional quality. The amount of fibre purchased (which is generally considered to be a nutritional "good") increased for most household types (apart from households with pre-school children), and the amount of salt purchased (which is generally considered to be a nutritional "bad" because most people consume more than recommended amounts) fell for all household types; this suggests that there was an improvement in nutritional quality along these dimensions. All household types reduced the number of calories that they bought from vegetables (a food group that most people under-consume relative to recommended levels), while increasing the number of calories that they bought from processed savory food. Household types except those with a high permanent income reduced the number of calories that they bought from alcohol – for households with pre-school children, this reduction was over 16%.

Table 4.10: *Changes in number of calories from fruit, vegetables, processed food, sugar and saturated fat*

	Household type							
	Pre-school children		School age children		No pensioners, no children		Pensioner households	
	Change		Change		Change		Change	
Calories from:	Level	%	Level	%	Level	%	Level	%
Protein	-19	-6.6	-8	-7.6	-1	-0.7	-10	-2.6
Saturated fat	-27	-9.1	-24	-23.9	-4	-4.2	-7	-1.8
Unsaturated fat	-20	-4.5	-15	-14.8	1	1.1	-4	-0.6
Sugar	-0	-0.0	-26	-26.4	9	8.5	-7	-1.2
Grams of:								
Fibre	-0.2	-1.3	-0.1	-0.1	1.0	1.0	0.2	1.0
Salt	-1.0	-13.8	-0.6	-0.6	-0.1	-0.1	-0.0	-0.3
Calories from:								
Fruit	1	0.6	-5	-4.6	8	7.6	3	2.0
Vegetables	-26	-19.7	-9	-9.4	-9	-8.7	-23	-12.4
Grains	4	1.1	-3	-3.3	9	8.8	-6	-1.5
Dairy	-24	-10.4	-26	-26.0	5	4.8	3	1.0
Cheese and fats	-15	-6.9	-10	-9.9	2	2.1	-5	-1.6
Poultry and fish	3	4.9	6	5.5	5	4.6	3	3.9
Red meat and nuts	-12	-8.4	-10	-9.9	-9	-9.2	-21	-9.6
Drinks	-0	-0.7	5	4.7	-3	-2.8	-3	-7.4
Prepared savory	9	2.5	-26	-25.6	12	12.0	12	2.3
Prepared sweet	-10	-3.0	-13	-12.9	-11	-11.4	8	2.6
Alcohol	-8	-16.3	-2	-3.6	-1	-1.7	-3	-3.9

Notes: Calories levels are per adult equivalent per day. Grams are per adult equivalent per day. The level change is the average within household change in the level (either calories or grams) of each variable from 2005-2007 to 2010-2012; the % change is the average within household percentage change in each variables from 2005-2007 to 2010-2012.

Table 4.11: *Changes in number of calories from fruit, vegetables, processed food, sugar and saturated fat*

	All		Permanent income					
	households		High		Medium		Low	
	Change		Change		Change		Change	
Calories from:	Level	%	Level	%	Level	%	Level	%
Protein	-6	-1.8	-1	-0.4	-6	-1.9	-5	-1.4
Saturated fat	-9	-2.6	-0	-0.1	-8	-2.3	-12	-3.5
Unsaturated fat	-3	-0.5	11	2.3	-2	-0.5	-5	-0.8
Sugar	-3	-0.6	12	2.4	-4	-0.8	-7	-1.3
Grams of:								
Fibre	0.5	2.4	0.8	4.2	0.4	2.1	0.5	2.5
Salt	-0.2	-2.7	-0.2	-3.1	-0.3	-3.5	-0.1	-1.1
Calories from:								
Fruit	3	2.8	6	4.5	2	1.7	5	4.7
Vegetables	-15	-9.3	-12	-7.6	-15	-9.6	-14	-8.2
Grains	2	0.5	4	1.0	3	0.9	2	0.5
Dairy	-2	-1.1	-1	-0.6	-2	-0.9	-3	-1.4
Cheese and fats	-2	-0.8	10	3.8	-1	-0.4	-5	-1.7
Poultry and fish	4	5.9	5	6.8	5	6.4	5	6.7
Red meat and nuts	-14	-7.2	-7	-3.8	-13	-6.9	-17	-8.3
Drinks	-2	-3.6	1	2.4	-2	-5.0	-2	-3.9
Prepared savory	6	1.4	20	5.0	6	1.5	-1	-0.3
Prepared sweet	-4	-1.1	-3	-0.9	-6	-1.9	-1	-0.2
Alcohol	-2	-2.8	2	2.9	-2	-2.3	-3	-4.5

Notes: Calories levels are per adult equivalent per day. Grams are per adult equivalent per day. The level change is the average within household change in the level (either calories or grams) of each variable from 2005-2007 to 2010-2012; the % change is the average within household percentage change in each variables from 2005-2007 to 2010-2012.

To gain a better understanding of the overall impact of these changes on nutrition we use the United States Department of Agriculture's (USDA) Healthy Eating Index (HEI) (see Guenther et al. (2007)). The HEI gives a score between 0 and 100 based on the density (i.e. amount per 1000 calories) of different food groups and nutrients consumed. Guenther et al. (2007) comment that density standards are appealing, *"not only because they allow a common standard to be used, but because they have the advantage of being independent of an individual's energy requirement."* This means that changes in the HEI will largely abstract from changes in the quantities purchased (shown in Tables 4.10-4.11) that are due to changes in the total number of calories purchased. The HEI is used by Beatty

et al. (2014) to analyze changes in the dietary quality of the US population over the 1989-2008 period.

We calculate the average within household change in the HEI and its component scores between 2005-2007 and 2010-2012, see Table 4.12. The overall HEI slightly increases (by less than 1 point) over this period. This is a small change – the standard deviation of the HEI across all households is 10. A shift away from vegetables, grains, milk and meat was offset by a reduction in the saltiness of food purchased and a lower calorie share of saturated fat.

We also look at changes by the different household types. Households with pre-school children improved their HEI score by the most (although this is still a small increase): despite a relatively large fall in the scores for vegetables and meat, they increased their scores for fruit, salt, saturated fat and alcohol by more than enough to compensate. The HEI score of the shopping baskets of pensioner households declined: unlike households with pre-school children, they did not decrease their saturated fat purchases by enough to compensate for the switch away from meat and vegetables, although pensioner households had the highest HEI scores to begin with. There is a correlation between average nutritional quality and permanent income: households with higher permanent incomes have a higher HEI score than households in the lowest permanent income band. The magnitude of the difference in the average HEI score between high and low income households is similar to that found by Beatty et al. (2014) in the US. However, low income households increased their nutritional quality by more than households with higher permanent income; primarily by switching towards fruit, away from saturated fat and alcohol and reducing the salt content of their grocery purchases. Nonetheless, these are not large changes in the nutritional quality of households' grocery baskets – overall, it seems that households were able to maintain the nutritional quality of their grocery basket while reducing their spend per calorie.

Table 4.12: *Changes in the Healthy Eating Index*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
				Household type				Permanent income		
	Max score	Mean score	All households	Pre-school children	School age children	No children, no pensioners	Pensioner households	High	Middle	Low
Mean HEI in 2005-2007	100		49.0	48.7	46.1	47.8	51.5	50.4	49.0	48.0
Total change to 2010-2012			0.72	1.52	1.03	1.46	-0.23	0.58	0.75	1.14
of which										
'Good' change			1.45	3.02	1.90	1.93	0.91	1.43	1.47	1.69
'Bad' change			-0.72	-1.51	-0.87	-0.46	-1.14	-0.85	-0.71	-0.54
			which consists of changes in the component scores:							
Total fruit	5	3.06	-0.02	0.12	-0.05	0.02	-0.05	-0.01	-0.03	0.00
Whole fruit	5	3.36	0.08	0.26	-0.07	0.18	0.03	0.12	0.06	0.11
Total vegetables	5	3.20	-0.13	-0.34	-0.05	-0.04	-0.20	-0.12	-0.13	-0.10
Dark green/orange veg	5	1.61	0.00	-0.07	0.07	0.09	-0.09	0.05	-0.01	0.02
Total grains	5	3.69	-0.03	0.08	0.01	-0.04	-0.07	-0.07	-0.02	-0.01
Whole grains	5	1.55	-0.11	-0.38	-0.14	-0.08	-0.06	-0.21	-0.13	-0.02
Milk	10	5.28	-0.05	-0.59	-0.31	0.07	0.06	-0.17	-0.05	0.02
Meat	10	7.96	-0.22	-0.13	-0.06	-0.17	-0.33	-0.22	-0.20	-0.19
Oils	10	4.93	-0.18	0.09	-0.20	-0.14	-0.30	-0.06	-0.14	-0.21
Sodium	10	6.42	0.93	1.31	0.93	1.00	0.77	0.99	0.98	0.87
Saturated fat	10	2.70	0.27	0.80	0.60	0.24	0.06	0.24	0.27	0.30
Calories from SoFAAS	20	5.22	0.18	0.36	0.28	0.33	-0.05	0.03	0.16	0.37

Notes: Row 1 shows the mean overall HEI score for all households (column (3)) and each household type (columns (4)-(10)) in 2005-2007; row 2 shows the average within household change in the HEI from 2005-2007 to 2010-2012. This is the sum of the changes in the component scores; these are shown in the bottom panel of the table. 'Good change' (shown in row 3) is the sum of the positive changes in the bottom panel; 'Bad change' (shown in row 4) is the sum of the negative changes in the bottom panel. Column (1) shows the maximum score for each component; these sum to 100 (the maximum score for the HEI). Column (2) shows the mean component score in 2005-2007 across all households. "Calories from SoFAAS" is the share of calories from solid fat, added sugar and alcohol.

5 Robustness

To check that our results are not driven by the double-log functional form we assume for the price function we repeat all our analysis using an alternative polynomial specification:

$$P_{ht} = a_1\mathbf{e_{ht}} + a_2\mathbf{e_{ht}}'\mathbf{e_{ht}} + b_1\mathbf{z_{ht}} + b_2\mathbf{z_{ht}}'\mathbf{z_{ht}} + \gamma\mathbf{x}_{ht} + \tau_{ht} + \eta_h + \epsilon_{ht}, \tag{5.1}$$

maintaining the same exogeneity assumption (2.11). Rather than repeat all tables from Section 4 we note that the both the baseline and alternative specification predict approximately a 3% fall in average price paid per calorie due to variation in household behavior and in Table 5.1 we report the percentage contribution that each of changes in shopping effort, nutrient characteristics and other characteristics made to this reductions. This shows that both specifications paint the same picture.

Table 5.1: *Changes in log price paid per calorie, alternative specification*

	Specification	
	Double-log	Polynomial
% change in price per calorie due to behavior change	-3.1	-3.0
share due to		
shopping effort	40.8%	45.6%
nutrient characteristics	35.8%	34.1%
other characteristics	23.1%	20.3%

Notes: Row 1 is the percentage change in P_{ht}, holding fixed all variables other than the choice variables $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$*. It shows average within household changes. Rows 3-5 show the fraction of the decline that is attributable to each set of choice variables.*

6 Summary and conclusions

The period of the Great Recession led to big changes in the economic environment faced by households. Households were subject to depressed real wages, higher unemployment and asset price reductions. At the same time, and perhaps even more importantly when considering food consumption, food prices rose starkly. While some households may have been shielded by the benefit system from the income and asset price shocks associated with the recession, all households faced increases in the price of food relative to the overall price level. In this paper we assess how households adjusted to deteriorating economic circumstances when making gro-

cery purchase decisions. We show that, on average, and for all household types, there was a reduction in real monetary resources allocated to buying food. Most households also cut back on how much food they bought (i.e. number of calories) but this reduction was lower than the reduction in expenditure; thus over the Great Recession consumption of calories was smoother than food expenditure.

Households switched to cheaper calories, limiting the reduction in how much food that they bought. This has raised concerns that people have switched to poorer quality foods. We specify a model that highlights a number of ways in which households can limit their per calorie spend; not all of them involve changing the nutritional composition of the shopping basket. Using rich longitudinal data we exploit within household changes in behavior to show that much of the decline in per calorie spend was driven by margins of change which do not involve altering the nutritional quality of food baskets. Households spent more effort shopping (in particular increasing their use of sales) and switched to lower priced generic products. Nevertheless, for most household types, there was a switch to cheaper nutrients and food groups. Using a single index measure of diet quality we quantify the nutritional importance of these changes and show that, at least according to this particular measure, nutritional quality did not materially fall. In this respect, households were relatively successful in weathering the economic turbulence.

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