Institute for Fiscal Studies

Shopping around?
How households adjust to changing economic conditions

Rachel Griffith, Martin O'Connell and Kate Smith

Institute for Fiscal Studies

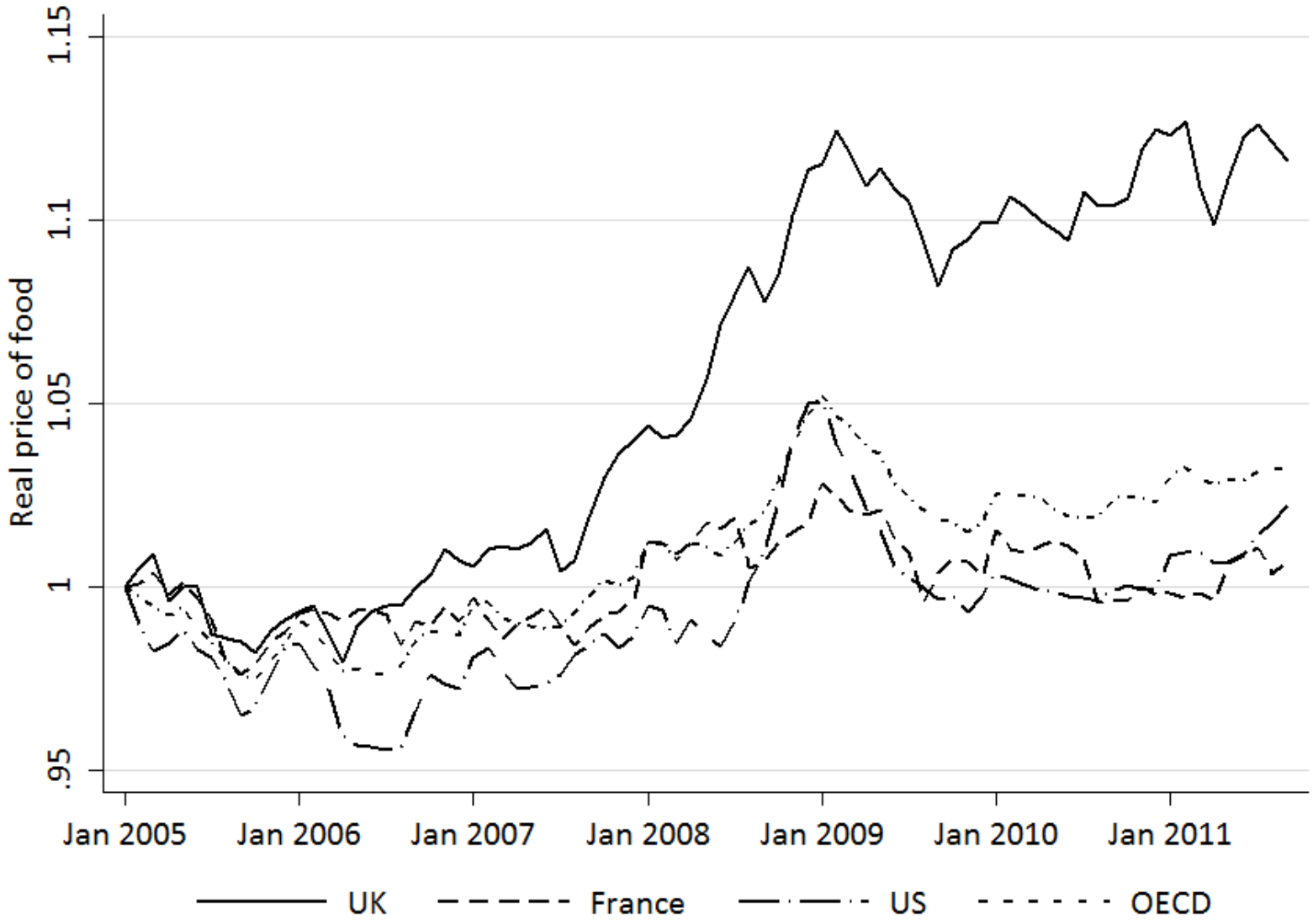
June 2014

Background

- The Great Recession (2008-9):
  - increased unemployment, reduction in real wages and falls in asset prices
  - large increase in the price of food - larger and more persistent than elsewhere
- Households responded by cutting food expenditure
- Policy concern about the prevalence of "food poverty/insecurity"

Institute for Fiscal Studies

Large food price increases



Institute for Fiscal Studies

Summary

- Study how households adjusted food spending in response to changes in economic environment over 2005-2012
- Show that households:
  - reduced the number of calories they bought
  - switched to cheaper calories
- Households able to mitigate the impact of deteriorating economic conditions on quality of diet

Institute for Fiscal Studies

How did households adjust?

- Outline a simple model of consumer shopping behaviour
- Household can adjust to changes in economic environment by choosing:
  - number of calories to purchase
  - characteristics of the shopping basket
  - time to spend searching for lower prices
- Use model to motivate empirical study of the relative importance of each adjustment mechanism

Institute for Fiscal Studies

A model of grocery shopping

- Household's utility from shopping basket: $v(C, \mathbf{z})$
  - C: total calories
  - $\mathbf{z}$: a vector of calorie characteristics
    - includes nutrient and 'non-nutrient' characteristics
    - z' denotes 'cooking requirement' of calories
- Price paid per calorie for grocery basket: $P = P(e, \mathbf{z}; \phi)$
  - e: shopping effort; expect $\partial P / \partial e < 0$
  - ϕ: unobserved characteristics

Institute for Fiscal Studies

A model of grocery shopping

- Household chooses shopping effort, total calories and characteristics of grocery basket to minimise costs:

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

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

- Household choice over non-food and over labour/leisure are captured by opportunity cost of time, ω, and total resources allocated to groceries, $\bar{v}$

Institute for Fiscal Studies

A model of grocery shopping

First order conditions

- shopping effort

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

- total calories

$$P = \lambda \frac{\partial v}{\partial C}$$

- characteristics:

$$\frac{\partial P}{\partial z_k} C = \lambda \frac{\partial v}{\partial z_k} \qquad z_k \neq z'$$

$$\frac{\partial P}{\partial z'} C + \omega = \lambda \frac{\partial v}{\partial z'}$$

Institute for Fiscal Studies

Empirical strategy

- Use panel data on households' food purchases to estimate relationship between price paid per calorie, P, and choice variables, $(e, \mathbf{z})$
- Control for other factors that influence P
- Use to quantify impact of changes in behaviour on price paid per calorie over the recession
- And the relative contribution of each margin of adjustment

Institute for Fiscal Studies

Empirical form

Measuring price paid per calorie

- Let h denote households, t denote time
- Measure the price household pays for its monthly grocery basket, P_{ht}, as weighted average of the transaction prices the household pays:

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

- where i indexes products, s stores and d dates and:
  - p_{isd} is the transaction price
  - c_i is number of calories in product i
  - $w_{hisd} = \frac{c_i b_{hisd}}{\sum_{i's'd' \in t} c_{i'} b_{hi's'd'}}$
  - $b_{hisd} \in \{0, 1, 2, ...\}$ is the number of purchases of product i from store s on date d

Institute for Fiscal Studies

Empirical form

Price function

- We specify the price function as having a log-log functional form:

$$\ln P_{ht} = \alpha \ln \mathbf{e_{ht}} + \beta \ln \mathbf{z_{ht}} + \gamma \mathbf{x_{ht}} + \tau_{ht} + \eta_h + \epsilon_{ht}$$

where

  - $\mathbf{e_{ht}}$, $\mathbf{z_{ht}}$: vectors of choice variables
  - $\mathbf{x_{ht}}$: time-varying household characteristics
  - τ_t: common region-time (year-month) effects
  - η_h: household effects

- Assume that:

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

where $\mathbf{e_h} = (\mathbf{e}_{h1}, ..., \mathbf{e}_{hT})$ etc.

Institute for Fiscal Studies

Identification

- Interested in identifying how changes in household choice variables $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$ affect P_{ht}
- Exploit *differential within household variation* in shopping choices using detailed measures of grocery shopping behaviour
- Require market prices p_{isd}s to be uncorrelated with $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$, conditional on fixed effects, region-time effects and demographics

Institute for Fiscal Studies

Identification

- Interested in identifying how changes in household choice variables $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$ affect P_{ht}
- Exploit *differential within household variation* in shopping choices using detailed measures of grocery shopping behaviour
- Require market prices p_{isd}s to be uncorrelated with $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$, conditional on fixed effects, region-time effects and demographics
  - UK supermarkets implement national pricing policies
  - Supermarket coverage varies geographically – region-time effects absorb differential price trends across region

Institute for Fiscal Studies

Identification

- Interested in identifying how changes in household choice variables $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$ affect P_{ht}
- Exploit *differential within household variation* in shopping choices using detailed measures of grocery shopping behaviour
- Require market prices p_{isd}s to be uncorrelated with $(\mathbf{e_{ht}}, \mathbf{z_{ht}})$, conditional on fixed effects, region-time effects and demographics
- Require that household level transaction weights w_{hisd}s do not vary in ways other than through, but correlated with, explanatory variables
  - Possible issues: differences in shopping productivity across households, or demographic transitions
  - Inclusion of household fixed effects and demographic variables help deal with this

Institute for Fiscal Studies

Data - Kantar Worldpanel

- Data on all grocery purchases made by a representative panel of British households over 2005-2012:
  - includes groceries brought into the home
  - recorded using handheld scanner in home
  - details of individual products and stores
  - exact price and quantity
  - nutritional and other product and store characteristics
- Use data from 14,694 households and over 450,000 'shopping baskets'

Institute for Fiscal Studies

Changes in food expenditure and calories

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

Notes: Numbers per adult equivalent. Real food expenditure is nominal expenditure on food at home deflated by the CPI component for food and drink at home (in 2008 prices).

▸ Food out

Institute for Fiscal Studies

Proxies for shopping effort ($\mathbf{e_{ht}}$)

	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

Institute for Fiscal Studies

Basket characteristics ($\mathbf{z_{ht}}$) - nutrients

- Macronutrients:
  - share of calories from: protein, saturated fat, unsaturated fat, sugar, non-sugar carbohydrates
- Micronutrients:
  - grams of salt and fibre per 100g of groceries
- Food groups:
  - fruit, vegetables, grains, dairy, cheese and fats, poultry and fish, red meat, drinks, prepared sweet, prepared savoury, alcohol

▸ Details

Institute for Fiscal Studies

Basket characteristics ($\mathbf{z_{ht}}$) - Other

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

Institute for Fiscal Studies

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	

Determinants of change in price paid per calorie

- We use coefficient estimates to quantify contribution changes in behaviour made to price per calorie households paid

	Log point change between 2005-2007 and 2010-2012
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

▸ Robustness

Institute for Fiscal Studies

Determinants of change in price paid per calorie

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

Implied opportunity cost of time

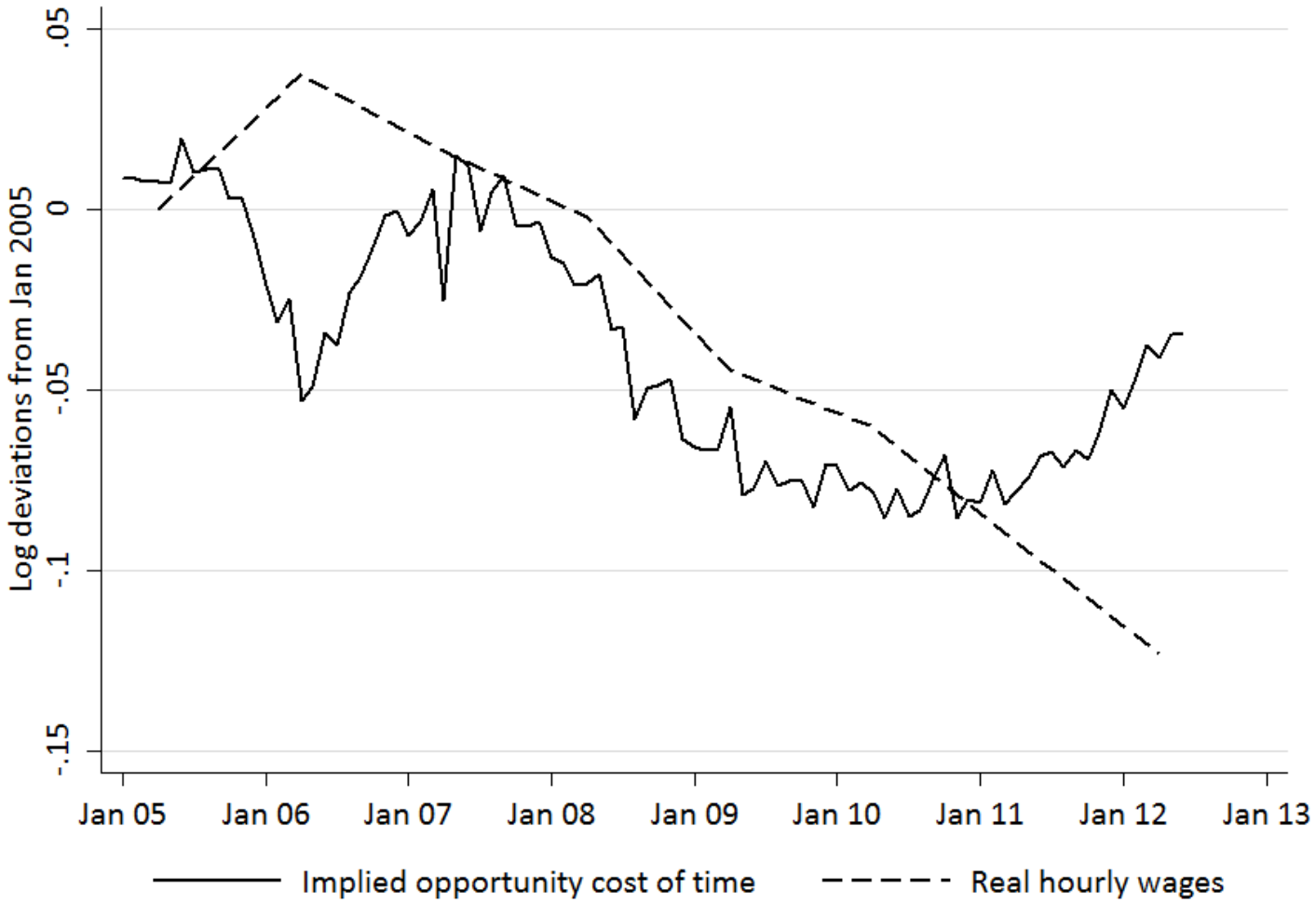
- Can use first order condition for choice of shopping effort to infer path of opportunity cost of time
- Model implies

$$\omega_{ht} = \alpha \frac{P_{ht} C_{ht}}{1 + e_{ht}}$$

Institute for Fiscal Studies

Implied opportunity cost of time

- Can use first order condition for choice of shopping effort to infer path of opportunity cost of time



Institute for Fiscal Studies

Changes in nutritional quality

- 36% of fall in average price paid per calorie due to behaviour is a result of changes in nutritional characteristics
  - Households switched away from protein, saturated fat, vegetables and alcohol...
  - and towards calories higher in fibre, unsaturated fat, carbohydrates and from prepared savoury foods
- We use a single index measure of diet quality (the Healthy Eating Index) which aggregates changes in nutrients and food groups
  - Suggests slight improvement in diet
  - Largest (but still small) increase for households with young children

Institute for Fiscal Studies

Summary

- Period of Great Recession saw large changes to economic environment
- Led to concerns over widespread 'food insecurity'
- We show that:
  - calorie purchases fell but by less than 'real' food expenditure
  - households switched to cheaper calories
  - on average, 64% of switch was due to more shopping effort and adjustment of non-nutrient basket characteristics
  - rest due to adjustment of nutrient characteristics, but little evidence of decline in nutritional quality of grocery basket
- Households were relatively successful in weathering economic turbulence with respect to food consumption

Institute for Fiscal Studies

Changes in food at home and food out (from LCFS)

Real expenditure	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				
Food at home	2505	2478	-27	-1.1
Food out	381	342	-39	-10.3

Notes: Numbers per adult equivalent. Real expenditure is nominal expenditure deflated by the corresponding CPI component. Numbers from LCFS.

Back

Institute for Fiscal Studies

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

Back

Robustness

	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%

Back

Institute for Fiscal Studies