Shopping around?
How consumers adjust to economic shocks

Rachel Griffith, Martin O'Connell and Kate Smith

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Motivation

- How do economic shocks feed through into outcomes?
- Study decisions consumers make in the grocery market:
  - food purchases are a large share of non-durable spending
  - important implications for health
- In response to economic shocks, households can:
  - adjust the nutritional composition of the foods they buy
  - use other mechanisms (shopping effort, buy in bulk, generic produce) that reduce price paid without changing nutritional composition of shopping basket
- Are some households better able to use these mechanisms than others?

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Contribution

- Outline a model of consumer behaviour in the grocery market:
  - consumers can adjust behaviour along a number of margins
  - exploit the changes in incomes and prices over the recession to study the relative importance of these different margins
  - use the model to pin down variation in the opportunity cost of time
- Concern about the impact of the recession on nutritional outcomes:

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Breadline Britain

Britain in nutrition recession as food prices rise and incomes shrink

Families filling up on high-fat processed foods as 900,000 fewer in two years manage 'five-a-day' fruit and vegetables

"Austerity Britain is experiencing a nutritional recession, with rising food prices and shrinking incomes driving up consumption of fatty foods, reducing the amount of fruit and vegetables we buy, and condeming people on the lowest incomes to an increasingly unhealthy diet."

BMJ

BMJ 2013;347:f7157 doi: 10.1136/bmj.f7157

MALNUTRITION AND ECONOMIC CRISIS

The rise of food poverty in the UK

"...we can only speculate that the cause is related to the rising cost of living and increasingly austere welfare reforms. The effects of these policies on nutritional status in the most vulnerable populations urgently need to be monitored."

Contribution

- Outline a model of consumer behaviour in the grocery market:
  - consumers can adjust behaviour along a number of margins
  - exploit the changes in incomes and prices over the recession to study the relative importance of these different margins
  - use the model to pin down variation in the opportunity cost of time
- Concern about the impact of the recession on nutritional outcomes:
  - important policy implications
  - contribute to the literature on health outcomes over economic downturns
  - document ways in which households reduced how much they spent per calorie without affecting the nutritional composition of their calories

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The Great Recession (2008-9)

- Period of large shocks to the economic environment:
  - increased unemployment
  - shocks to asset prices, wages
  - large increase in food prices; relative prices of different foods
- Consumers switched to buying cheaper calories

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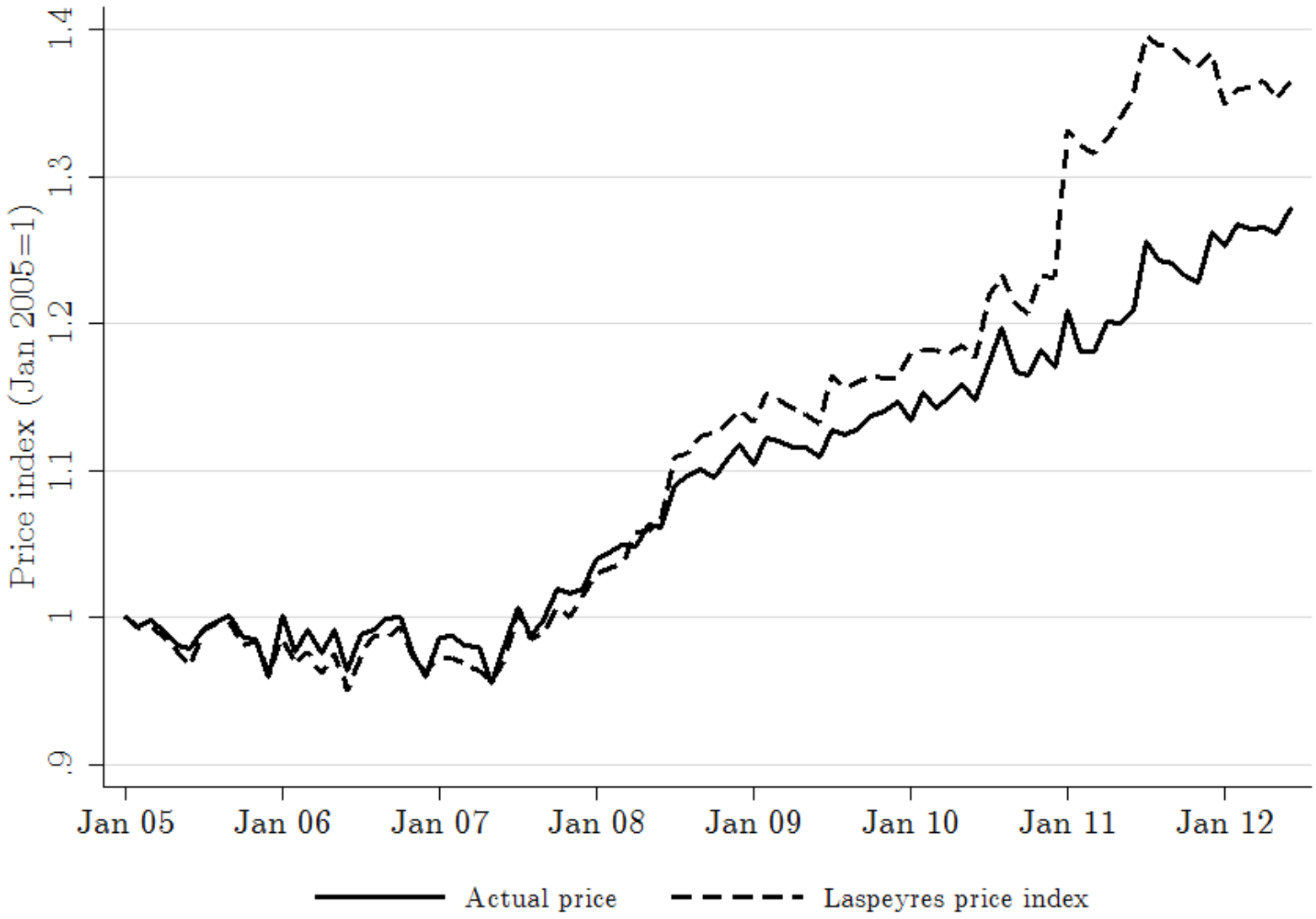
Changes in consumer behaviour mitigated price rises



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A simple model of grocery shopping

- Model the shopping decision of a consumer:
  - chooses how many calories to purchase
  - characteristics of the calories
  - storage requirement of her food bundle
  - how much time to dedicate to shopping
- Each of these margins of choice affect her utility and the price that she pays for her bundle

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Consumer's utility function

- Utility for the consumer is given by:

$$U(x, l, v(C, \mathbf{z}) - ds) \tag{1}$$

  - x: consumption of non-food
  - l: hours of leisure
  - v: sub-utility function for food consumption
  - C: total calories
  - s: amount of food requiring storage; d: disutility from storage
  - $\mathbf{z} = (z_1, \ldots, z_K)$: vector of calorie characteristics: $k = 1, \ldots, K_1$ are nutritional characteristics; $k = K_1 + 1, \ldots, K$ are other (non-nutrient characteristics)

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Price function

- The per-calorie price the consumer pays is given by:

$$P = P(e, s, C, \mathbf{z}; \phi) \tag{2}$$

  - e: effort the consumer expends shopping, $\partial P/\partial e < 0$, $\partial^2 P/\partial e^2 > 0$
  - s: evidence of strong non-linearities in price
  - C: economies of scale associated with buying more calories
  - $\mathbf{z}$: characteristics affect price e.g. more protein, higher price
  - ϕ: determinants of price other than the choice variables, $(e, s, C, \mathbf{z})$

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Budget constraint

- Monetary expenditure on food and non-food must equal labour income plus non-labour income:

$$P(e, s, C, \mathbf{z}; \phi)C + x = \eta n + Y \tag{3}$$

  - η: marginal return to an additional hour of labour
  - n: hours worked
  - Y: non-labour income

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Time constraint

- Total non sleeping time, T, must be allocated between leisure, time spent working, n, and time spent grocery shopping, e:

$$l + n + e = T \tag{4}$$

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Consumer's problem

- Choose:
  - time use variables, (l, e)
  - total calories, calorie characteristics and storage requirement, $(C, \mathbf{z}, s)$
  - non-food, x,

  to maximise utility:

$$U(x, l, v(C, \mathbf{z}) - ds)$$

  subject to the budget and time constraints (combined):

$$P(e, C, \mathbf{z}, s; \phi)C + x + \eta e + \eta l = \eta T + Y$$

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Consumer's sub-problem

1. Chooses optimal quantity of non-food, leisure and total resources allocated to food shopping, M:

$$M = \eta T + Y - x - \eta l$$

2. Allocates total resources dedicated to food between calories, characteristics, storage and shopping time:

$$\max_{\{e,s,C,\mathbf{z}\}} v(C, \mathbf{z}) - ds$$

subject to

$$P(e, C, \mathbf{z}, s; \phi)C + \eta e = M$$

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Optimality condition for shopping effort

- Searching for lower prices may reduce the overall price she pays for her food, but time spent shopping leaves less time available for enjoyable leisure pursuits
- The first order condition for choice of shopping effort is:

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

i.e. select the amount of time spent shopping to equate the marginal gain in terms of lower food expenditure with her opportunity cost of time.

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Optimality condition for calories

- The first order condition for choice of total calories is:

$$\frac{\partial v}{\partial C} = \lambda \left(P + \frac{\partial P}{\partial C} C \right)$$

  where λ is the Lagrange multiplier on the consumer's constraint
- Select the number of calories that equates the marginal utility of calories with marginal cost of more calories

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Optimality condition for characteristics

- The first order condition for choice of basket characteristic k is:

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

- Select the quantity of each characteristic that equates the marginal utility with marginal cost (expressed in terms of utility)

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Optimality condition for storage

- The first order condition for choice of storage requirement s is:

$$\frac{d}{\lambda} = -\frac{\partial P}{\partial s} C$$

  where d/λ is the cost of storage expressed in monetary terms.
- At the consumer's optimal choice it will equal the marginal benefit of an increase the shopping basket's storage requirements which comes through lower expenditure.

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Empirical form

- Specify the following log-log form for the price function:

$$\ln P_{ht} = \alpha \ln e_{ht} + \beta \ln C_{ht} + \gamma \ln \mathbf{z_{ht}} + \theta \ln s + \phi_{ht} + \epsilon_{ht}$$

  where t indexes a year-month; observe multiple t for each household
- ϕ_{ht} denote other factors that influence P_{ht}:

$$\phi_{ht} = \tau_t + \mu_h$$

  - τ_t: common time effects, captures e.g. general inflation
  - μ_h: household fixed effect, captures e.g. differences in shopping 'productivity' across households

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Kantar data

- Observe grocery (food and drink) purchases of a representative panel of British households from 2005-12
- Participants record spending on all grocery purchases using electronic handheld scanners
- Data include information on exact price paid for a product, whether it was on promotion, nutritional composition and demographic details of households
- Sample contain over 28,000 households and over 1.1 million household-year-months

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Average price per calorie

- Aggregate over transaction level prices to compute average price per calorie:

$$P_{ht} = \sum_{i,s,d \in t} p_{isd} w_{hisd}$$

  - p_{isd}: price per calorie of product i in store s on date d
  - w_{hisd}: share of the household's calories bought on transaction (i, s, d)

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Shopping effort

- Households can exert more effort shopping in order to reduce the price that they pay for their grocery basket:
  - make more frequent shopping trips in order to compare the prices of products across time periods
  - shop at different stores to compare prices across retailers
  - spend more time in the store searching for deals and promotions to reduce the price they pay for their shopping basket, all else equal

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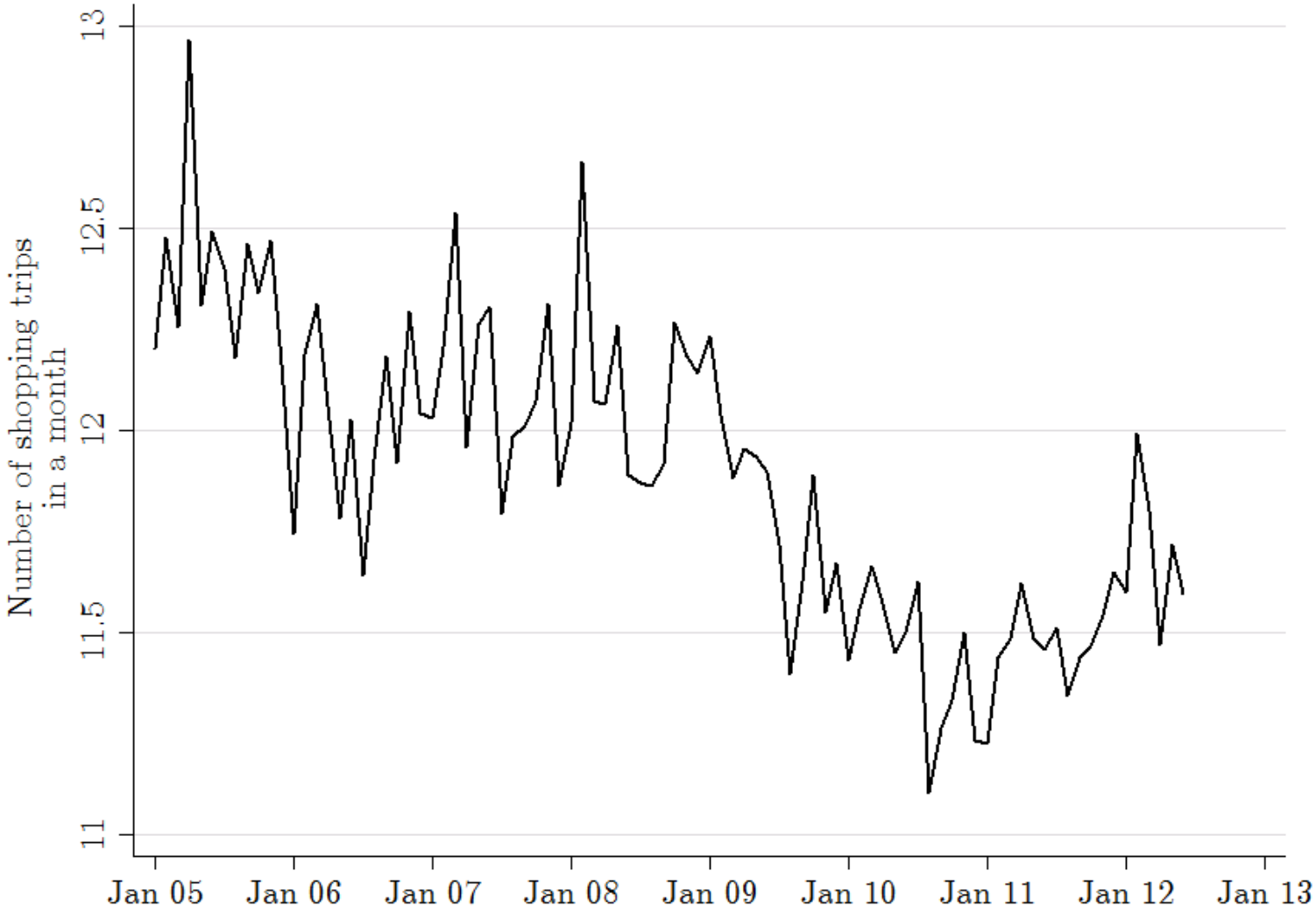
Number of shopping trips



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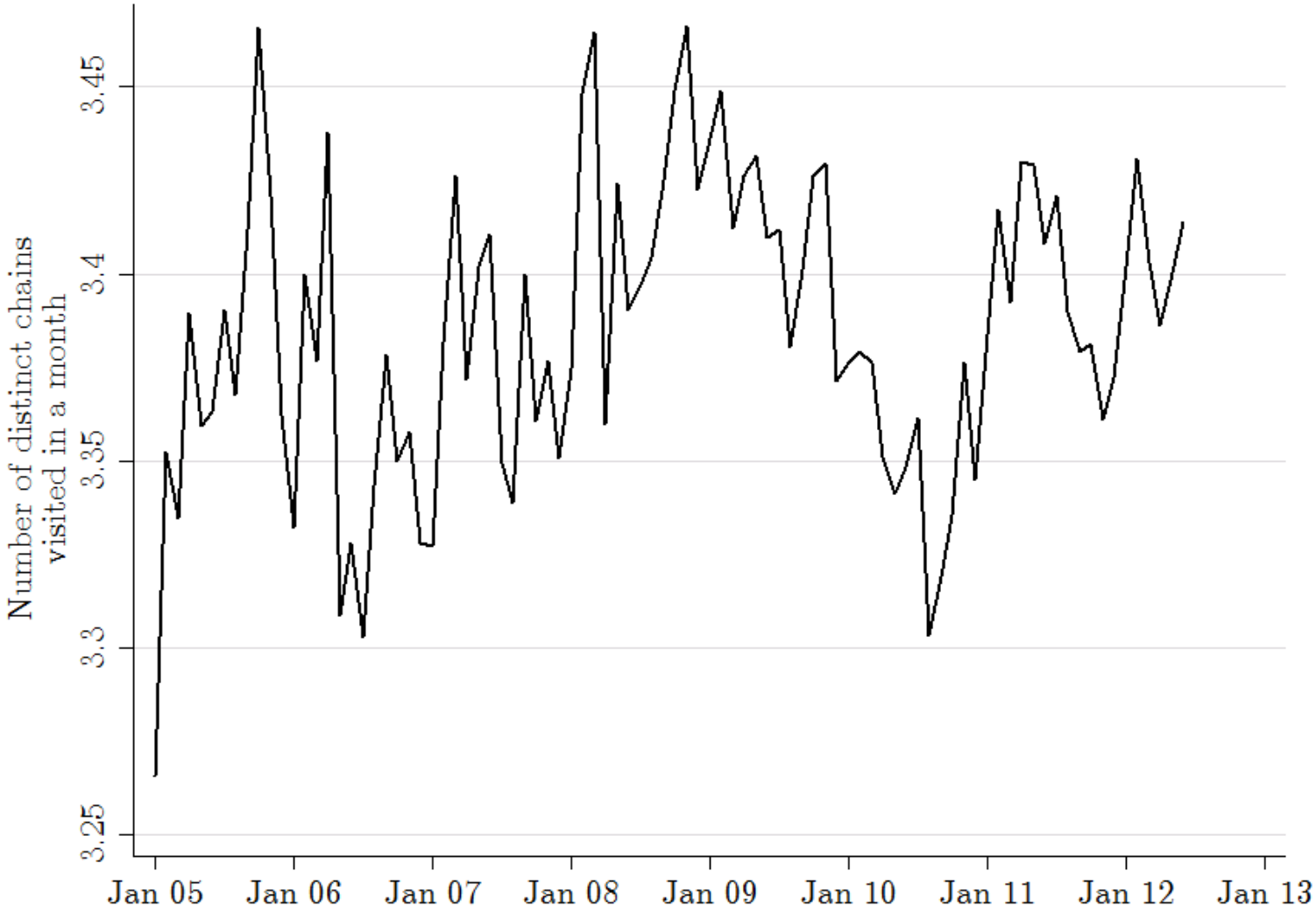
Number of retailer chains visited



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Shopping at a discounter

- Switch the type of store that they visit in order to reduce the price they pay
- Discounter outlets (Aldi, Lidl, Netto) purport to offer lower prices but may be less convenient
- Estimate the savings that a household makes by shopping at a discounter as opposed to a non-discounter outlet

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Estimating savings from shopping at discounters

- Estimate the following regression separately for 205 product categories:

$$\ln p_{isd} = \delta_y^1 d_s * b_{1,i} + \delta_y^2 d_s * b_{2,i} + \delta_y^3 d_s * (1 - b_{1,i} - b_{2,i}) + \zeta_k + \tau_t + \rho_h + e_{hisd} \quad (5)$$

  - $d_s = 1$ if $s \in \{Aldi, Lidl, Netto\}$
  - $b_{1,i} = 1$ if product i is a standard own brand product
  - $b_{2,i} = 1$ if product i is a budget own brand product
  - ζ_k are product specific effects
  - τ_t are year-month dummies
  - ρ_h are a set of region dummies

- Allow the savings offered by discounters to vary across years.

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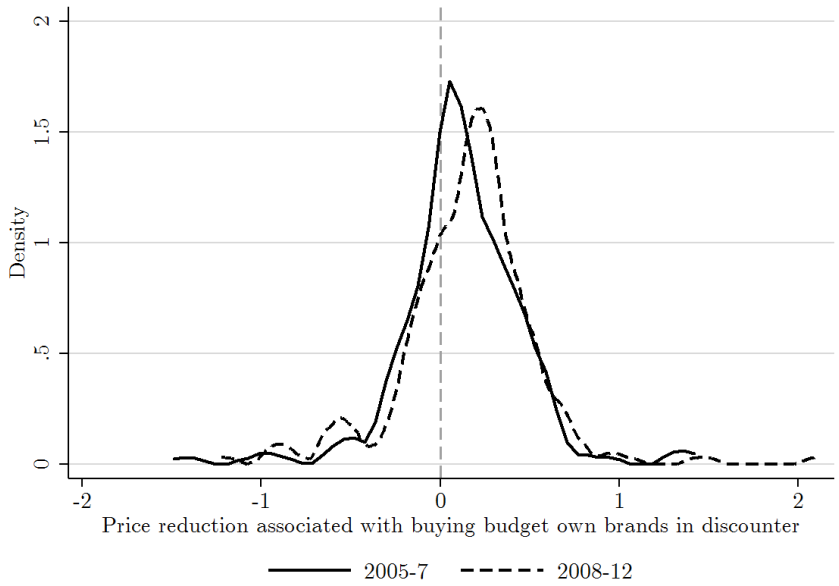
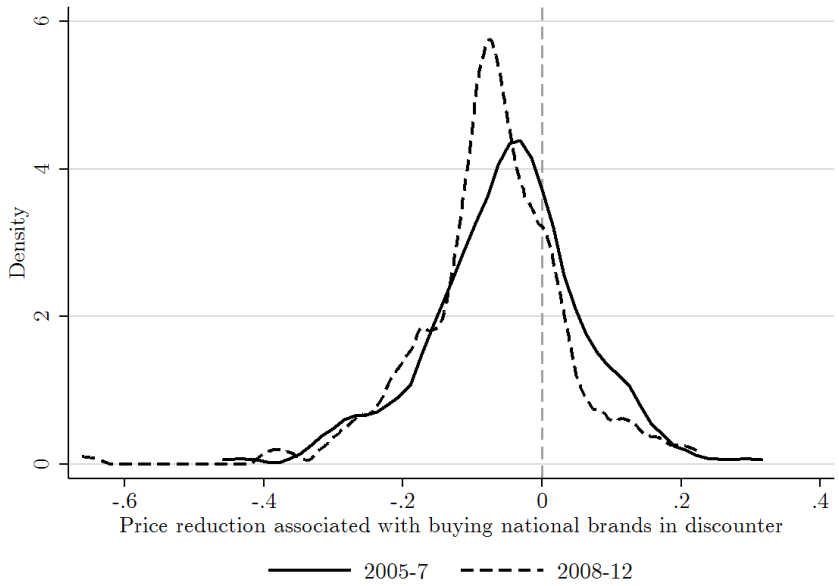
Estimated price differences

(a) For budget own brand products



(b) For national brand products



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Savings from shopping at discounters

- Use equation (5) to predict the prices households would have paid had they not visited a discounter, $\tilde{p}_{isd}$.
- Transactions in which the product was not bought at a discounter $\tilde{p}_{isd} = p_{isd}$.
- Fraction of their grocery basket that household h saved (or spent) in period t as:

$$DISCOUNTER_{ht} = \frac{\sum_{i,s,d \in t} (\tilde{p}_{isd} - p_{isd}) w_{hisd}}{\sum_{i,s,d \in t} p_{isd} w_{hisd}} \tag{6}$$

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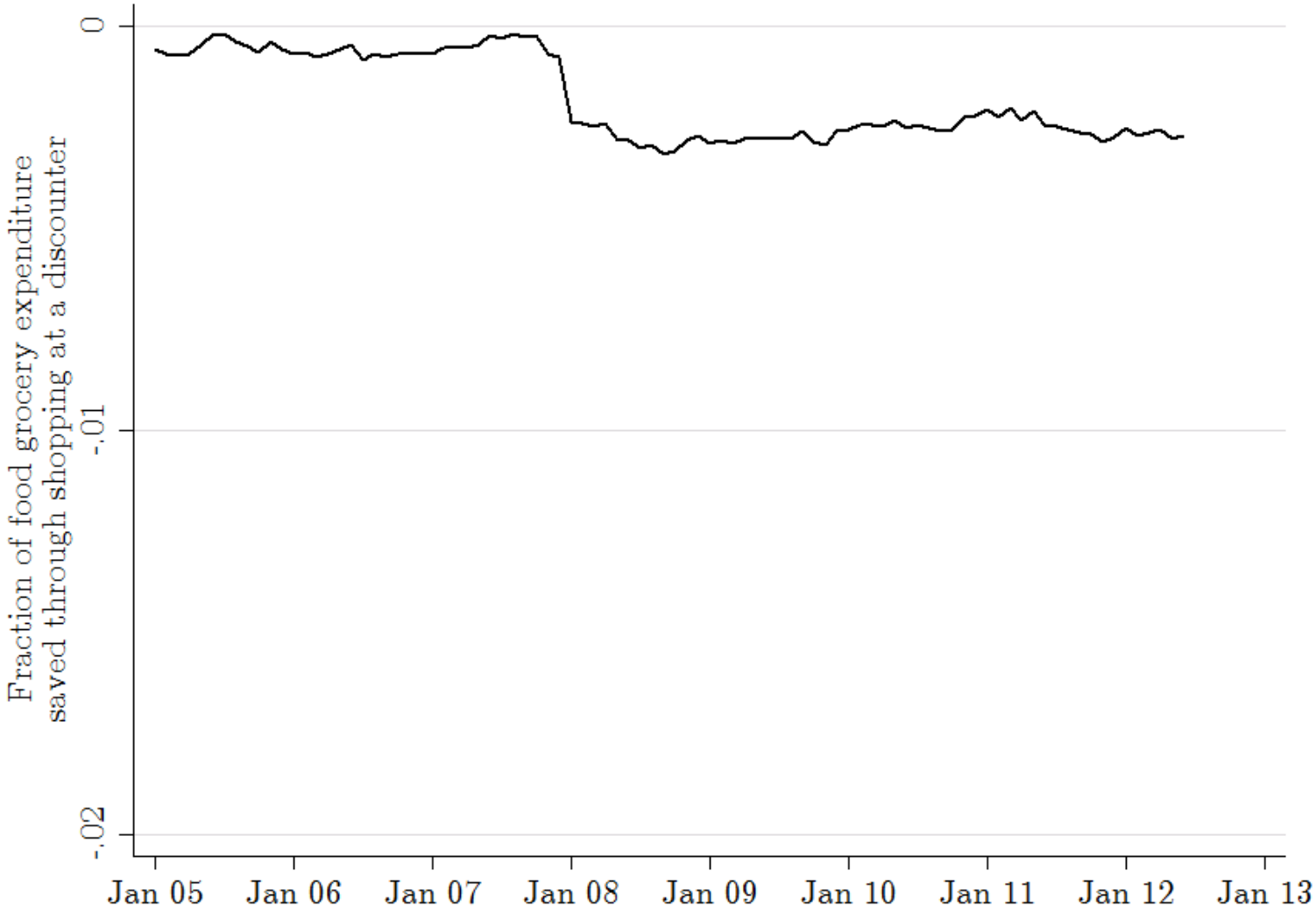
Savings from shopping at discounters 2005-12



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Use of sales

- Increase shopping effort by spending more time searching for lower prices while in store
- Expect that the more effort shoppers put into search:
  - the more of their groceries they are likely to buy on sale
  - and the deeper the discount will be for these sale items

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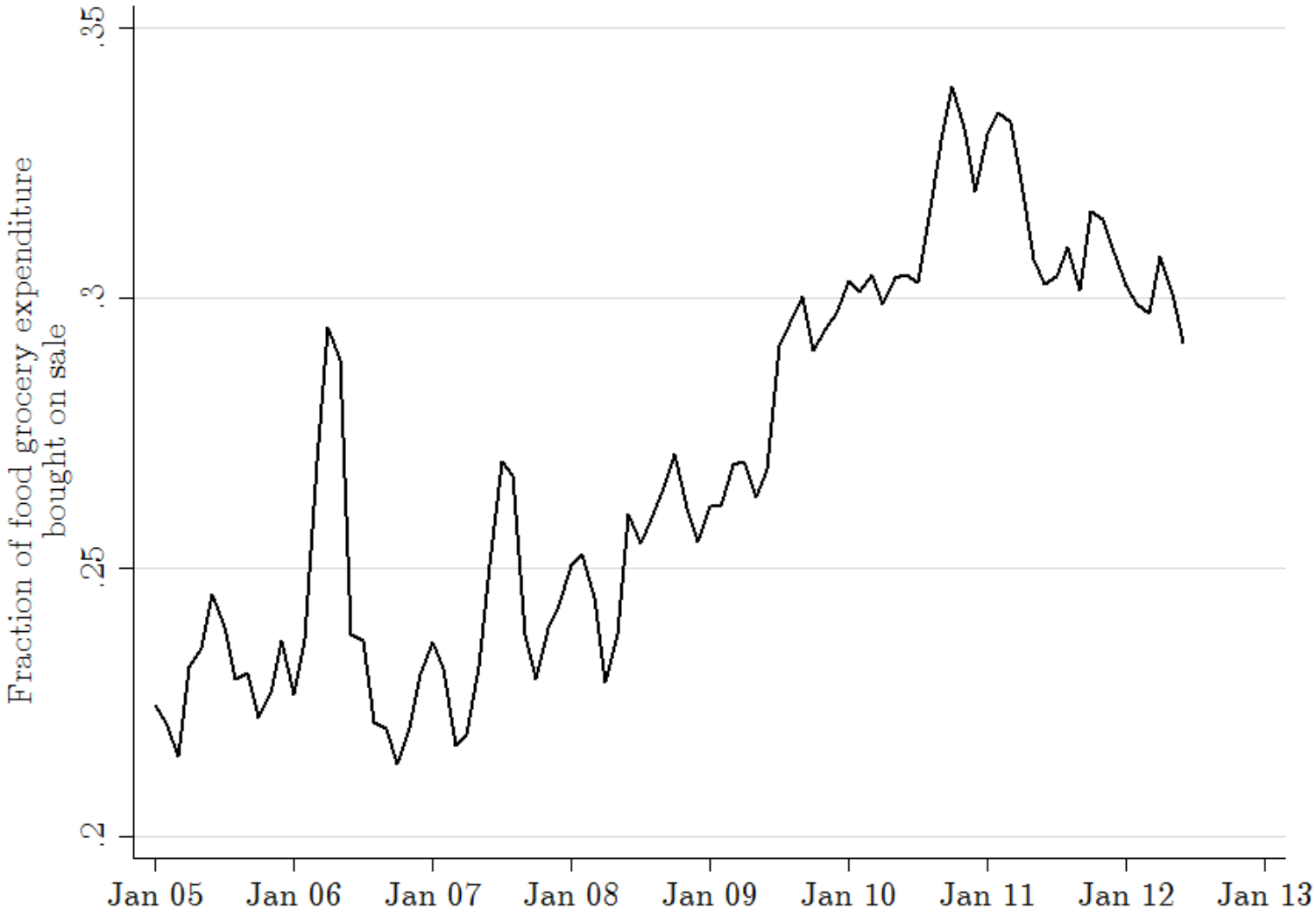
Quantity of food bought on sale 2005-12



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Estimating price reductions associated with sales

- Estimate the following separately for 205 product categories:

$$\ln p_{isd} = \sigma_y^1 r_{1,isd} + \sigma_y^2 r_{2,isd} + \zeta_i + \tau_t + \rho_h + e_{hisd} \tag{7}$$

  - $r_{1,isd} = 1$ if the product had ticket price reduction
  - $r_{2,isd} = 1$ if the product was on a multi-buy offer
  - ζ_i are product specific effects
  - τ_t are year-month dummies
  - ρ_h are a set of region dummies

- Allow the effect of the ticket price reductions and multi buy offers to vary across years.

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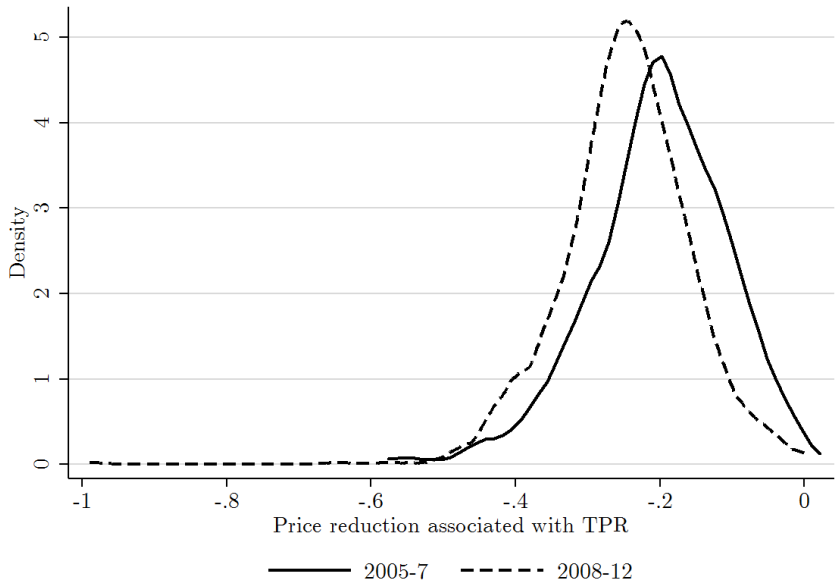
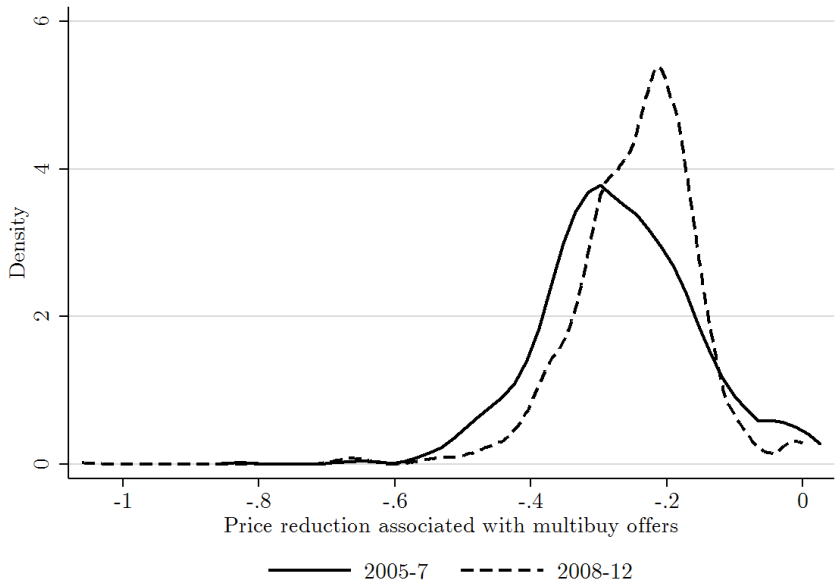
Estimated price differences

(c) For ticket price reductions



(d) For multibuy offers



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Estimating savings from sales

- Use equation (7) to predict prices in the absence of any sales, $\tilde{p}_{isd}$
- Transactions in which the product was not on sale $\tilde{p}_{isd} = p_{isd}$.
- Fraction of their grocery basket that household h saved in period t from buying on sale:

$$SALES_{ht} = \frac{\sum_{i,s,d \in t} (\tilde{p}_{isd} - p_{isd}) w_{hisd}}{\sum_{i,s,d \in t} p_{isd} w_{hisd}} \tag{8}$$

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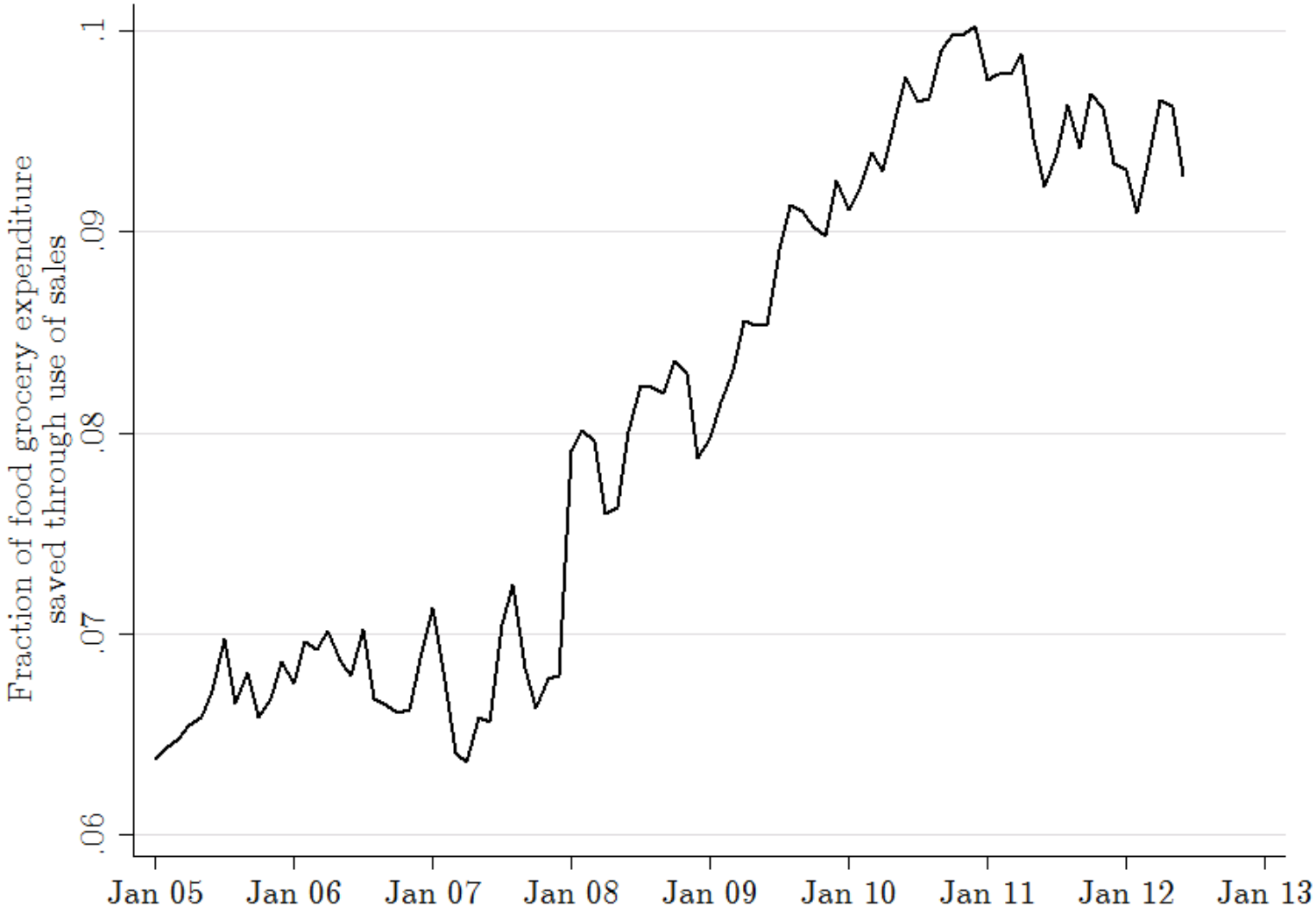
Savings from sales 2005-12



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Storage requirement of shopping basket

- Storage is costly, but buying larger pack sizes allows households to take advantage of non-linearities in price
- Measure the share of a household's shopping basket that they buy from bigger than average pack sizes

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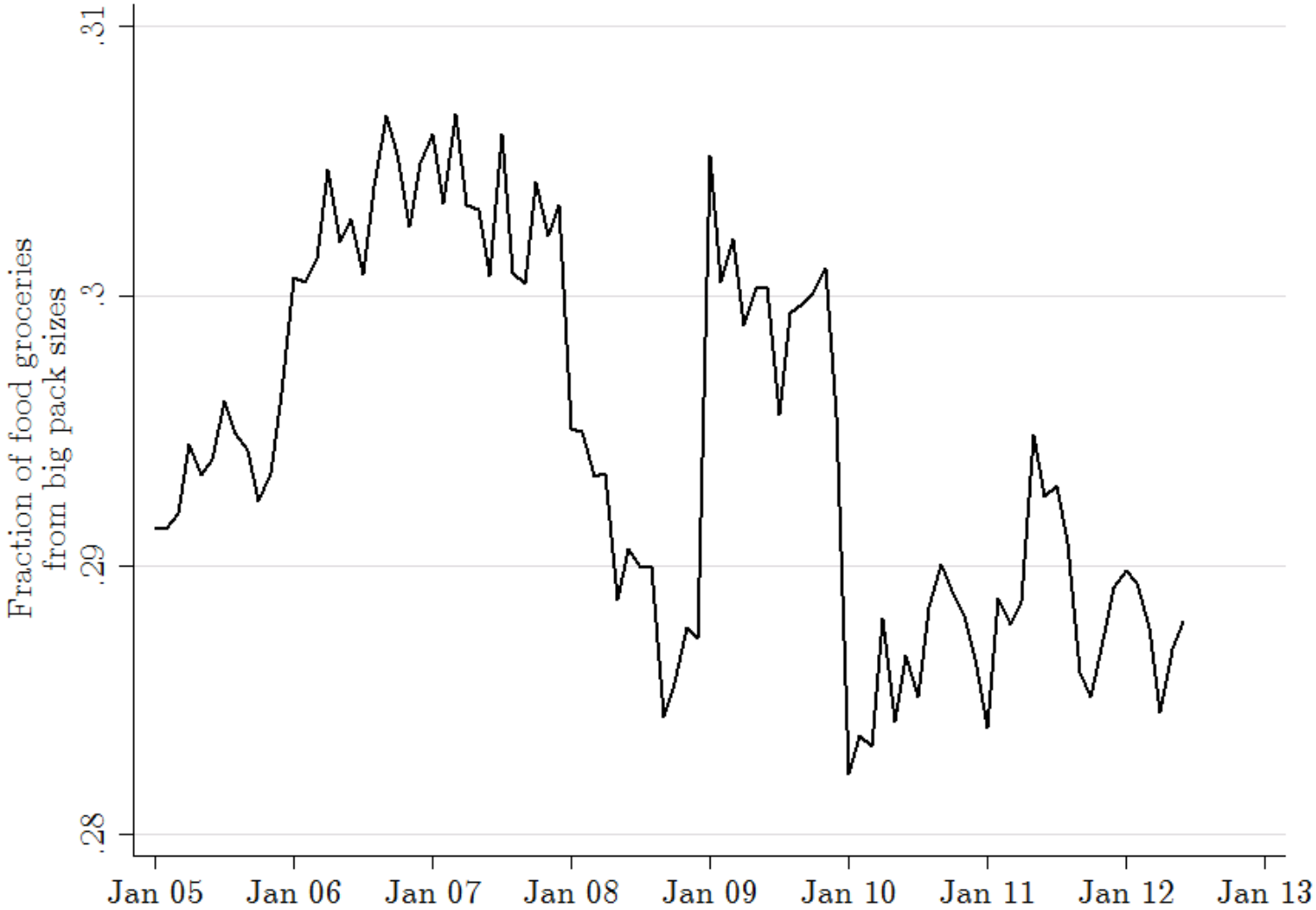
Storage requirement 2005-12



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Total groceries purchased

- Number of calories purchased may affect the price paid per calorie:
  - may be economies of scale with respect to calorie purchases
  - alternative: conditional on shopping effort, buying more calories may lead to high grocery prices as search is spread more thinly
- Measure total number of calories bought by household h in period t as sum over all transactions:

$$C_{ht} = \sum_{i,s,d \in t} c_{hisd} \tag{9}$$

- Scale C_{ht} so calories per household per day

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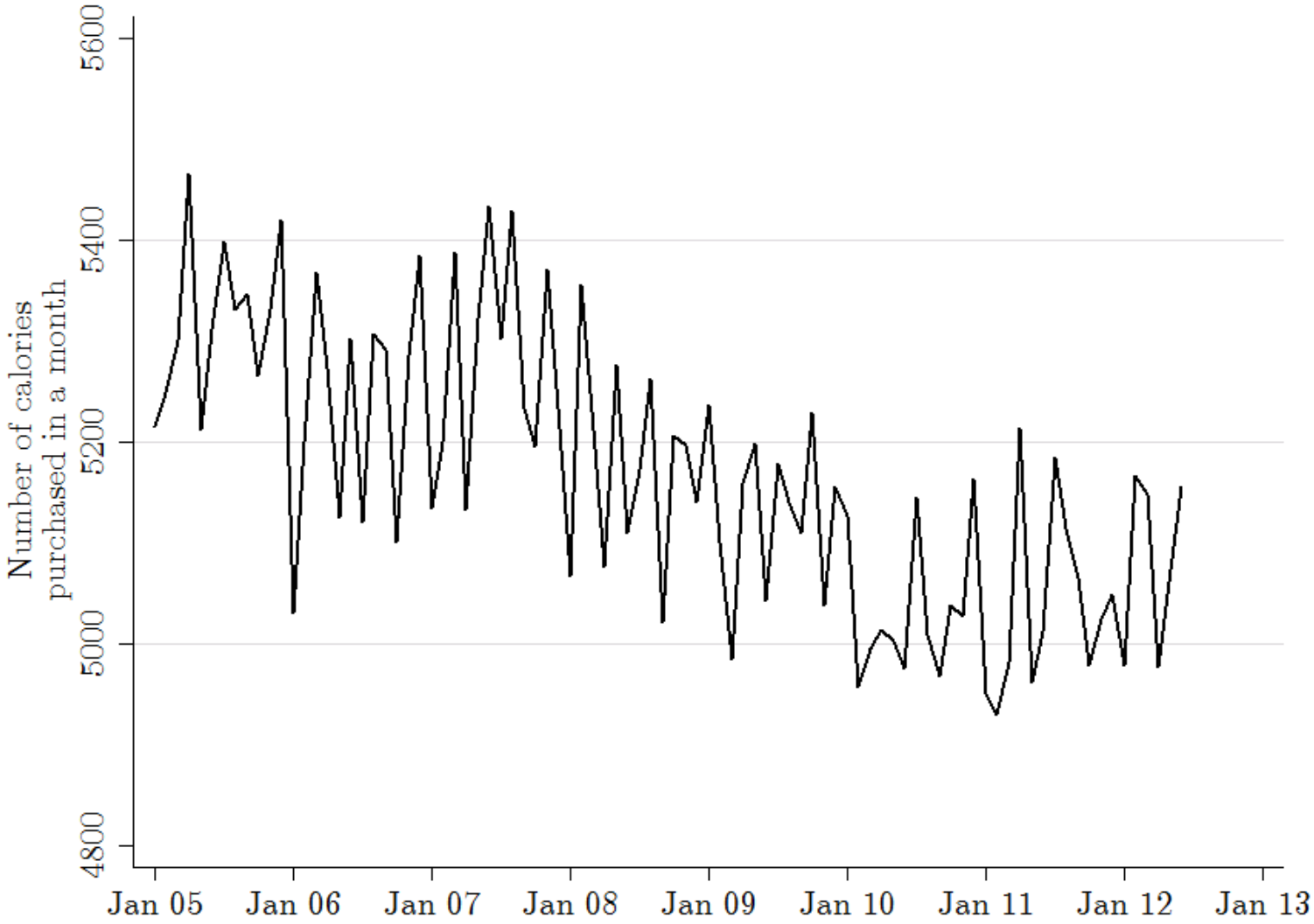
Total calories purchased 2005-12



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Characteristics: generic produce

- Two types of own brand: standard and budget:
  - standard own brands similar to national brands - advertised by the supermarket, comparably priced and generally quality equivalent
  - budget own brands (generic products) are seldom advertised, typically sold in plain packaging and sold for substantially lower prices
- All else equal, likely that consumers will value generic products less than branded (national and standard own) products
- Measure the share of groceries bought from generic products

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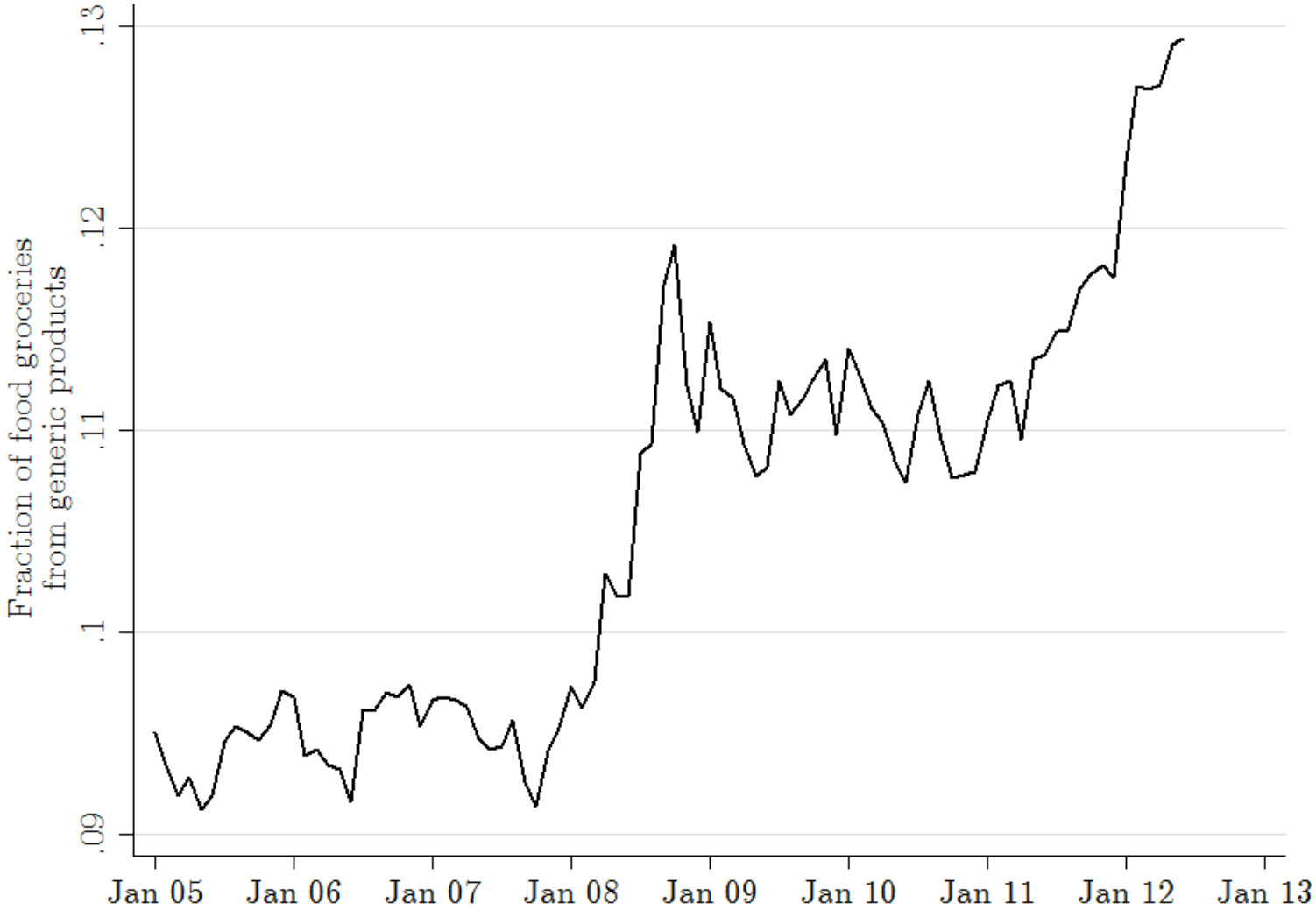
Share of groceries from generic products 2005-12



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Characteristics: calories per kg

- Measure the number of calories per kg in household's shopping basket
- Captures differences in the relative impact of number of calories versus the unit weight of the shopping basket on its price

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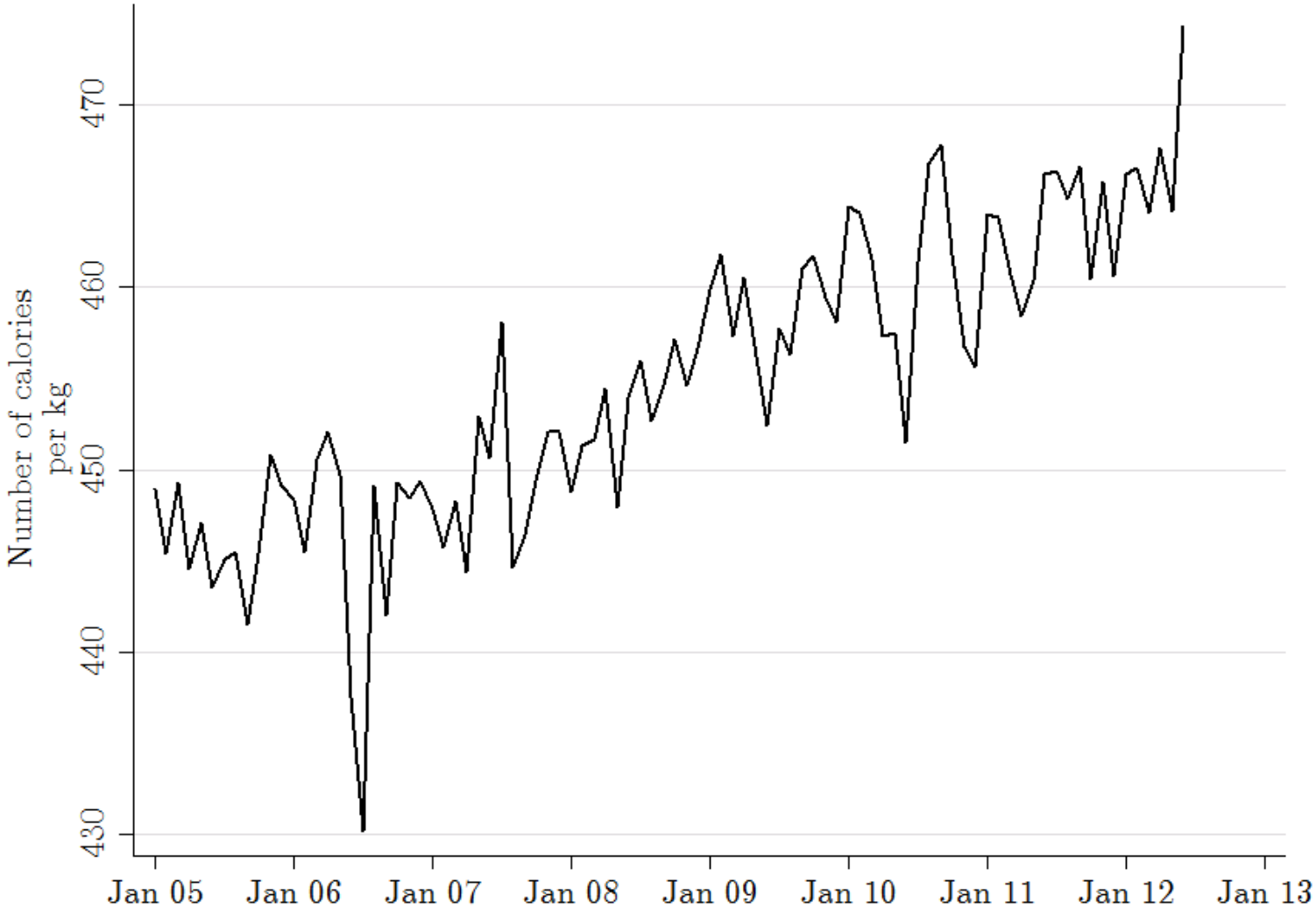
Calories per kg 2005-12



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Characteristics: nutritional composition

- Households choose nutritional composition of shopping basket:
  - households may prefer different nutrients
  - marginal price likely to vary across nutrients
- Let n_{id} denote the amount of nutrient n product i contains at date d:
  - macronutrients (protein, saturated fat, unsaturated fat, sugar, non-sugar carbohydrates) - n_{id} is share of calories from the macronutrient
  - micronutrients (fibre and sodium) - n_{id} is amount of nutrient per 100g
- Total nutrient:

$$N_{ht} = \sum_{i,s,d \in t} n_{id} w_{hisd}$$

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Nutritional composition of shopping basket 2005-12

	2005-2007	2010-2012	Difference
Share of kcals from protein	15.04	15.04	-0.00
Share of kcals from saturated fat	14.92	14.45	-0.48
Share of kcals from unsaturated fat	23.50	23.94	0.44
Share of kcals from sugar	23.18	22.76	-0.42
Share of kcals from non-sugar carbs	23.35	23.81	0.46
Fibre (g per 100g)	1.07	1.14	0.08
Sodium (g per 100g)	0.18	0.17	-0.01

Notes: the numbers are mean of each variable in 2005-7 and 2010-12 and the mean difference, controlling for fixed differences across households.

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Estimates of price function

- Estimate the price function:

$$\ln P_{ht} = \alpha \ln e_{ht} + \beta \ln C_{ht} + \gamma \ln \mathbf{z_{ht}} + \theta \ln s + \tau_t + \mu_h + \epsilon_{ht}$$

- Estimate two specifications: with and without fixed effects
- Compare the change in the actual price paid, P_{ht}, with the counterfactual price paid in the absence of behaviour changes, τ_t: how effect of changes in behaviour contributed to changes in P_{ht}

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Results

	No fixed effects			Fixed effects		
	Coeff	Change	Cont	Coeff	Change	Cont
Total			-8.50			-5.20

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	Coeff	Change	Cont	Coeff	Change	Cont
Total			-8.50			-5.20
Shopping effort:						
Number of shopping trips	-0.03	-0.039	0.12	0.03	-0.073	-0.22
Number of chains visited	0.05	0.025	0.13	0.01	-0.013	-0.02
Savings from discounter	-1.98	-0.002	0.37	-0.32	-0.002	0.06
Savings from sales	-1.88	0.028	-5.17	-0.86	0.026	-2.19
Total			-4.55			-2.37

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Total			-4.55			-2.37
Storage:						
Share of groceries from big pack sizes	-0.86	-0.008	0.71	-0.42	-0.010	0.43
Total groceries:						
Total calories	-0.03	-0.024	0.07	-0.05	-0.058	0.31
Non-nutrient characteristics:						
Share of groceries from generic produce	-1.29	0.020	-2.56	-0.70	0.017	-1.16
Calories per kg	-0.76	0.029	-2.21	-0.61	0.031	-1.93
Total			-4.77			-3.09
Nutrient characteristics:						
Protein	2.23	-0.000	-0.02	1.46	-0.000	-0.01
Saturated fat	1.14	-0.005	-0.56	0.56	-0.004	-0.23
Unsaturated fat	0.49	0.004	0.20	-0.04	0.004	-0.02
Sugar	0.29	-0.005	-0.13	0.11	-0.003	-0.04
Fibre	0.03	0.066	0.17	-0.03	0.069	-0.19
Sodium	-0.05	-0.077	0.39	-0.00	-0.074	0.01
Total			0.04			-0.49

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Saturated fat	1.14	-0.005	-0.56	0.56	-0.004	-0.23
Unsaturated fat	0.49	0.004	0.20	-0.04	0.004	-0.02
Sugar	0.29	-0.005	-0.13	0.11	-0.003	-0.04
Fibre	0.03	0.066	0.17	-0.03	0.069	-0.19
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Total groceries:						
Total calories	-0.03	-0.024	0.07	-0.05	-0.058	0.31
Non-nutrient characteristics:						
Share of groceries from generic produce	-1.29	0.020	-2.56	-0.70	0.017	-1.16
Calories per kg	-0.76	0.029	-2.21	-0.61	0.031	-1.93
Total			-4.77			-3.09
Nutrient characteristics:						
Protein	2.23	-0.000	-0.02	1.46	-0.000	-0.01
Saturated fat	1.14	-0.005	-0.56	0.56	-0.004	-0.23
Unsaturated fat	0.49	0.004	0.20	-0.04	0.004	-0.02
Sugar	0.29	-0.005	-0.13	0.11	-0.003	-0.04
Fibre	0.03	0.066	0.17	-0.03	0.069	-0.19
Sodium	-0.05	-0.077	0.39	-0.00	-0.074	0.01
Total			0.04			-0.49

Results

	No fixed effects			Fixed effects		
	Coeff	Change	Cont	Coeff	Change	Cont
Total			-8.50			-5.20
Shopping effort:						
Number of shopping trips	-0.03	-0.039	0.12	0.03	-0.073	-0.22
Number of chains visited	0.05	0.025	0.13	0.01	-0.013	-0.02
Savings from discounter	-1.98	-0.002	0.37	-0.32	-0.002	0.06
Savings from sales	-1.88	0.028	-5.17	-0.86	0.026	-2.19
Total			-4.55			-2.37
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Total			0.04			-0.49

Summary of results

- The average price paid per calorie rose by 5.2% less than it would have done in the absence of behavioural change
- Increased use of sales and a switch to generic products contributed more than half of this reduction
- Changes in the nutritional composition of the shopping basket were small and had little effect on the change in price paid per calorie

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Implied opportunity cost of time

- Using the price function and the optimality conditions, can pin down the implied opportunity cost of time:

$$\eta_{ht} = -\alpha \frac{P_{ht} C_{ht}}{e_{ht}}.$$

- Need a scalar measure of effort
- The most important measure of shopping effort is the amount that households save by shopping on sales
- Use this to proxy e_{ht}

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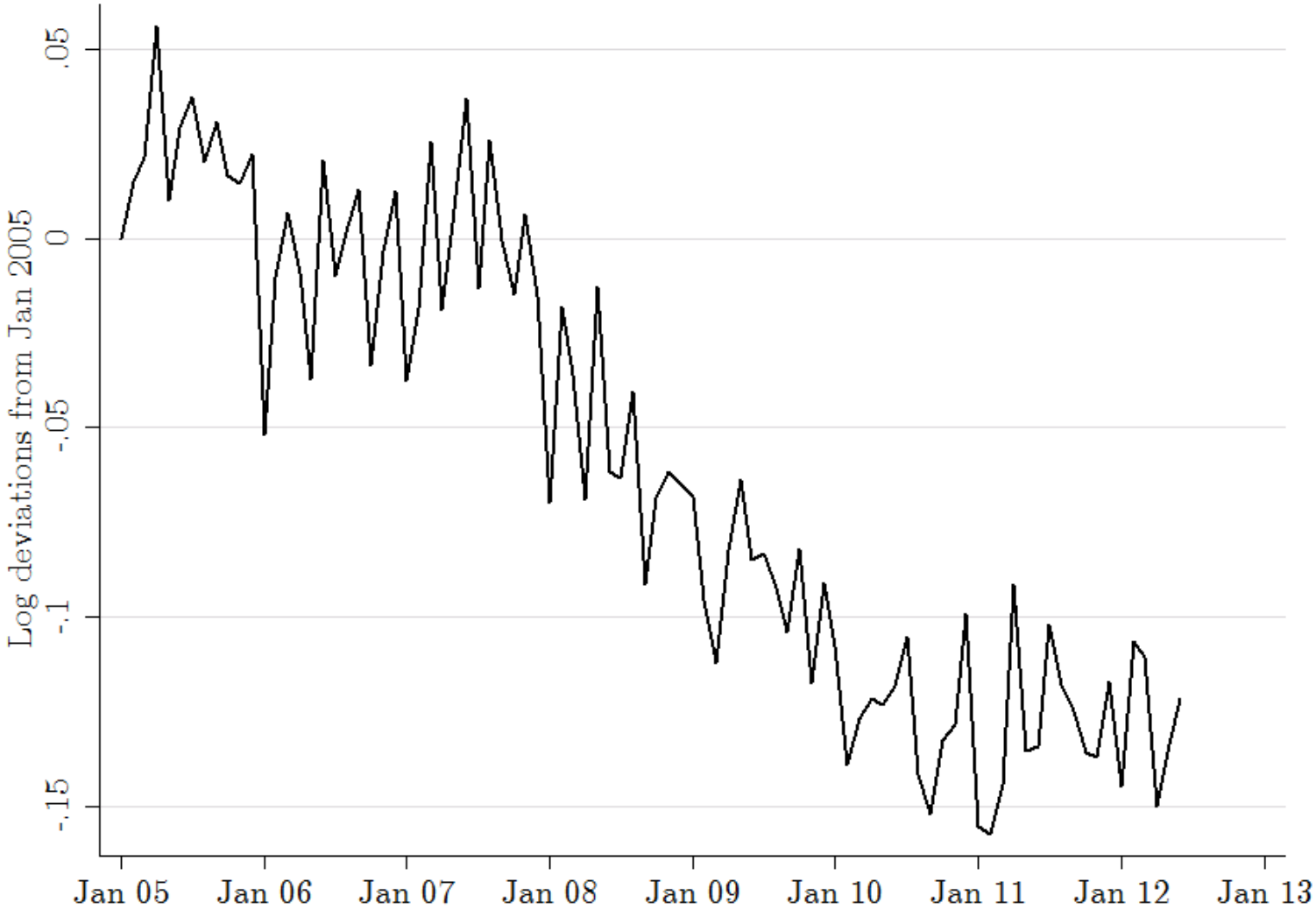
Implied opportunity cost of time 2005-12



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Summary

- Households can adjust their behaviour in a number of ways in response to shocks to their economic environment
- Outline a simple model of consumer shopping behaviour
- Estimate the price function to quantify the extent to which households used different mechanisms to reduce per calorie spend over the recession:
  - increased use of sales and switch to generic products contributed to well over half the reduction
  - changes in nutritional composition of food were small and had little impact on the change in price per calorie
- Use the model to show that the implied opportunity cost of time fell over the recession

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Next steps

- Robustness checks
- Heterogeneity across households:
  - are some households better able than others to use different mechanisms?
  - does the cost of storage vary across households?
  - or the returns to effort?

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