A structural analysis of the decline of home-cooked food * Preliminary and incomplete*

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Abstract

The share of home-cooked food in the diet of households has declined considerably over the past few decades across the developed world. We develop and estimate a structural model of food consumption and time use in the UK to understand the key driving forces. We show that the market price of ingredients for home cooking has *declined* relative to the price of ready-to-eat foods. However, once we account for the fact that cooking takes time we find that the opposite is true - the shadow price of home-cooked food has risen relative to ready-to-eat food. This is because there has been an the increase in the market value of time of secondary earners. We show that increased taxes alone would not be sufficient to incentivise households to shift back to home-cooked food, and decrease their consumption of ready to eat food.

Keywords: food, consumption, time use, home production, shadow prices, AIDS.

JEL codes:

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1 Introduction

Households in the developed world have shifted away from home-cooked food towards ready-to-eat food to a substantial extent over the past few decades. In the UK, home-cooked food represented close to two thirds of the food budget in 1980, but less than a third in 2000. This is an enormous change, which has been associated with equally important changes in life-style and time use, and in particular with changes in labour market behaviour of secondary earners. This change in diet has been proposed as one of the likely candidate causes of the growth in obesity and decline in the nutritional quality of diets, and there is considerable interest in understanding what has driven this change in order to help design policies to reverse it.

The increase in the consumption of ready-to-eat foods has been linked to adverse health outcomes, such as obesity, as well as to negative impacts on cognitive outcomes, particularly amongst children, among others by Case et al. (2002), Heckman (2007), Anderson et al. (2003a), Anderson et al. (2003b), Baum and Chou (2011), Cawley (2000), Goldman et al. (2009), Herbst and Tekin (2011), Mackenbach et al. (2008). This has led to calls for policy intervention aimed at changing eating habits, see for example Bhattacharya and Sood (2011), Brunello et al. (2009), Finkelstein and Zuckerman (2008), Gortmaker et al. (2011), Philipson and Posner (2008), Dobbs et al. (2014)), and promote a healthy, balanced diet.

Our contribution in this paper is twofold. First, we document a number of interesting trends. Over the period 1980 to 2000 the price of ingredients for home cooking has actually decreased relative to that of ready-to-eat alternatives (both eaten at home and out). This leads to a puzzle, assuming that both types of food are normal goods, then we would expect their consumption to increase and for the consumption of ingredients to increase by more if food is one good in preferences. We show that there have also been big changes in time use, and in particular in the labour market participation of secondary earners, and a decrease in time spent cooking.

Second, we develop a structural model of food consumption and time use, with home production, which we estimate on UK data. Our model is based on the insight from Becker (1965) that consumption comes from the combination of market goods and time, so that it is the shadow prices of goods (their market price plus the opportunity cost of the time needed to produce them) that determine choices. There is a literature that establishes the importance of non-separabilities between consumption and time use, for example, Browning and Meghir (1991), or Blow et al. (2014) who test for separability between time use and consumption in preferences in the CEX and reject. Our model is in the tradition of Barten (1964), in specifying that household composition acts as price deflators. We follow Deaton and Paxson (1998), with economies of scale in food consumption, and Crossley and Lu (2018), with economies of scale in food preparation. In our model, there is food preparation with heterogenous time costs and two agents contributing time to home cooking. We study the choices households make between ready-to-eat food, requiring no preparation time, and home-cooked food, requiring the combination of time together with ingredients to be produced. The heterogeneity in time costs is extreme, since ready to eat food requires no preparation and home cooked food requires time to be combined with ingredients in fixed proportions to be produced.

On the consumption side, the model incorporates trade offs between purchasing ingredients for cooking or purchasing ready-to-eat food. We allow for potential economies of scale in cooking, which might also have increased the costs of home production, since household size has declined. On the time use side, the model accounts for trade offs between working to earn an income, cooking and leisure. We do not have information about the uses of time when not working. We assume that time spent cooking and ingredients are complements in the production of home-cooked food. We evaluate full income - the sum of expenditures and the imputed cost of time spent not working. To do this we have to impute the value of time, i.e. a potential wage for the individuals that are not working. This, together with the structural model, enables us to recover the elements of the behavioural model.

The model allows us to recover the shadow price of home-cooked food, which incorporates the opportunity cost of time as well as the price of ingredients and returns to scale in food preparation, and to do so both for participants and non participants. This helps to explain the shift from ingredients used for home cooking to ready-to-eat foods, because the rising opportunity cost of time has increased the shadow price of home cooking.

We use the UK Family Expenditure Survey and distinguish labour intensive and non labour intensive food. We are able to track consumption and prices over the period 1980 to 2000. Women's labour force participation and hours worked have increased, as have real wages, thus making time spent cooking more costly in terms of foregone earnings. In addition, household size has decreased, reducing the opportunity to exploit economies of scale generated by cooking for a larger numbers of individuals.

We find that accounting for the opportunity cost of time is important to explain households's food choices. Changes in the labour market affect the market value of time and the relative attractiveness of home production. This means that the shadow price of ingredients differs significantly from the market price; we are able to explain the evolution of the structure of the food budget over the period 1980 to 2000 and explain away the apparent puzzle that is present when conditioning on food prices and incomes.

We estimate the elasticities of demand for home-cooked food to market prices and shadow prices of time and ingredients, which are themselves functions of household size and labour market participation. We use these estimates to assess the importance of changes in labour market conditions (real wage offers and participation opportunities), and in prices and demographics (e.g. changes in household size) to better understand the rise in the consumption of ready-to-eat food over the period.

We use the model to perform counterfactual analysis. We show that the level of tax required to shift households choices away from ready-to-eat food towards ingredients and home-cooked food is not sustainable, because food choices are driven by wages to a much larger extent than by prices.

The availability of ready-to-eat food means it is possible to spend less time cooking, which could be welfare enhancing, for instance if parents spent the time gained with their children. Unless we know how households use the time that is freed up by not having to cook, it is not possible to evaluate the net effect of the increased availability of ready-to-eat food on behaviour and thus welfare more broadly. It would be interesting to know for instance whether parents use the time thus acquired to look after their children, or increase participation and hours of work.

The structure of the paper is as follows. In section 2 we describe trends in the evolution of food consumption, market prices, labour force participation and household size between 1980 and 2000 in the UK. We also present cross section evidence. In section 3 we present a structural model of food consumption and time use with home production. In section 4 we discuss the empirical specification. In section 5, we present the estimates of the structural model, and we present counterfactuals in section 6. A final section concludes.

2 Reduced form evidence

We document a substantial relative decline in home-cooked food and an increase in ready-to-eat foods. We relate these to trends in market prices; labour market participation and time use; wages and household size over the period 1980 to 2000 in the UK. We also show that in the cross-section, expenditure on home-cooked food as a share of the household's total food expenditure is correlated with characteristics, such as female employment and wage, and that time spent on food preparation is correlated with household characteristics. These correlations point to the possibility that improved labour market opportunities for secondary earners (largely females) and a reduction in household size led to a reduction in demand for home-cooked food. This reduced form evidence guides the assumptions we make in developing the structural model in Section 3.

We use data on expenditure, wages, labour force participation and hours of work from the UK Family Expenditure Survey and Expenditure and Food Survey (FES/EFS) for the period 1980-2000. This is a nationally representative repeated cross-section. We focus on households with two adults and any number of dependent children (including zero), where both adults are of working age (25-60), and where the head of household works full-time. We omit households with self-employed individuals (whose hours of work are not recorded in the data), as well as households in which either member is involved in a work-related government training programme. This gives us a sample of 29,753 households.

Selecting on households where the head works full-time allows us to treat the hours of the main earner as exogenous, and simplifies modelling considerably. This is not an unduly restrictive assumption, since labour force participation of male heads of household in the age range 25-60 is very high, and there is very little variation in hours worked (conditional on working full-time). We also assume that there are no frictions on the labour market, so that unemployment is voluntary. In the absence of frictions, the value of time is the wage (or the potential wage).

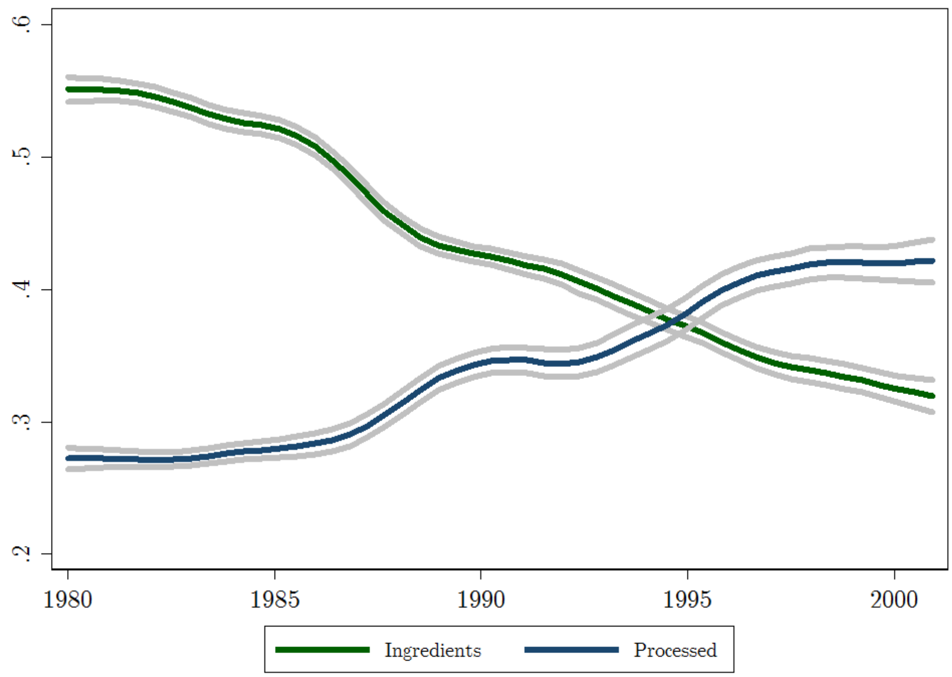
The data give details of expenditure on 367 food categories. We map these into four aggregate categories - home-cooked food, processed food eaten at home, meals out, and take away and snacks. Appendix A.1 shows how foods are aggregated into relevant food groups. We measure prices using the ONS Retail Price Index (RPI) price series. There are about 30 price indices for foods available that we can use (the exact number varies through the period); we construct a price index for each of the aggregated food categories as detailed in Appendix A. Information on time use and time spent on food preparation comes from two cross-sectional surveys: People's Activities and Use of Time (1974-1975) and the 2000 Time Use Survey.

We first describe the evolution of food consumption then market prices, labour force participation and wages, and household size. We then present evidence on time use and cross section evidence on food consumption choices.

2.1 Food consumption

The share of expenditure on ingredients for home-cooked food declined dramatically from 1980 to 2000, see Figure 2.1. In 1980, on average, close to 58% of the food budget was allocated to home-cooked food, with the remaining 42% split between food purchased ready-to-eat at home, meals out and take away and snacks. By 2000 the share of ingredients for cooking at home had halved, from 58% to 28%. The share of pre-prepared food had risen from 26% to 44%, while the share of expenditure on meals out has almost tripled, from 4.7% to 15%. The share of take away and snacks has increased until around 1994, decreased until about 1999 and increased again. The distinction we make between the food aggregate "processed food" and the food aggregate "take away and snacks" is not entirely due to the nature of the foods, but to the collection method. In both processed food and take away and snacks, we have foods that are bought ready to eat, and eaten at home. For pre-prepared food, the data is collected by a diary method; whilst for take away and snacks, the data was collected by a different set of methods, leading to some issues with the data. Over part of the period 1980 to 2000, data on meals out and take away and snacks was collected by asking one individual to recall all expenditures on these foods made by all individuals of the household. This is a particularly unreliable method of data collection and the data is consequently noisy. Subsequently, all household members were provided with diaries and tasked with reporting information on meals out and take away and snacks over a suitably chosen recording period. This led to some improvement over the recall method by one individual, but the quality of this data remains inferior to the quality of the data on expenditures on ingredients and processed foods because of recall issues. Furthermore, what constitutes "Meals out" is a heterogenous aggregate, in terms of the activity it constitutes, and of the time involved, from leisurely eating a meal in a fancy restaurant to picking up a meal in a fast food restaurant. Similarly, what constitutes "Take away and snacks" is even more varied, and changed considerably over the period, thanks to supply side effects and to changes in the survey definitions of the goods.

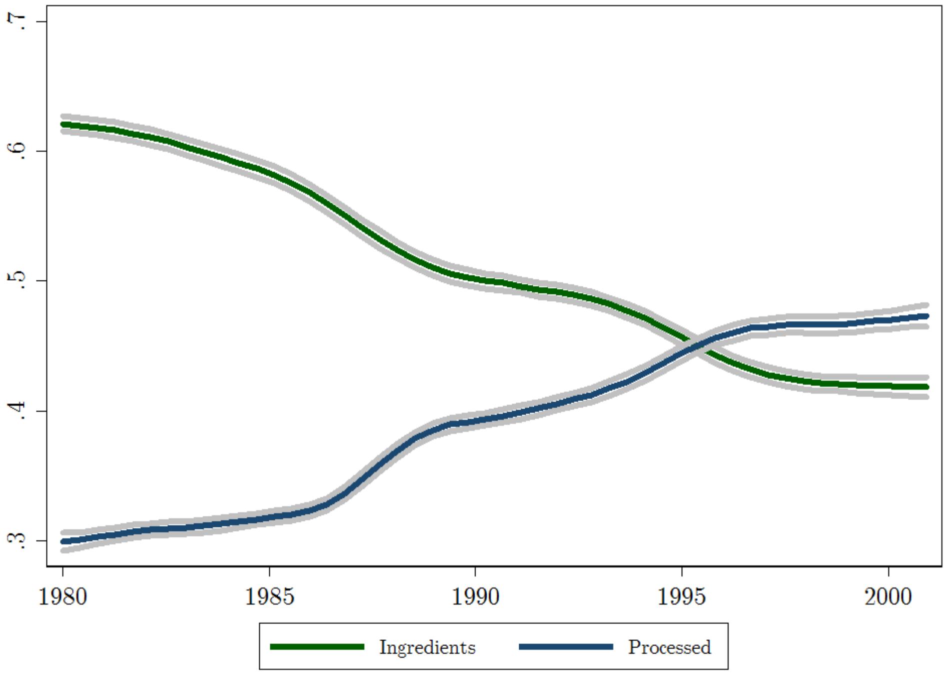
Figure 2.1: *Budget shares*



Note: Sample of 38,291 households with two adults aged 25-60, with any number (including zero) of dependent Children. Solid line is a fitted local polynomial and lighter lines are 95% confidence intervals.

We are ultimately more interested in changes in quantities than in changes in expenditures; changes in budget shares could reflect changes in relative prices as well as changes in quantities. To establish what has happened over time to quantities consumed, figure 2.2 shows budget shares expressed in constant 1980 prices. For ingredients for home cooking and pre-prepared food there is not much difference between the evolution of the budget shares and the evolution of the quantities consumed through time. The quantities of ingredients purchased for cooking at home have decreased dramatically, while the quantities of pre-prepared foods have increased as a mirror image. For meals out and takeaways and snacks, the trends differ. While the increase of the share of expenditure on meals out over the period in current prices is gradual, the increase in constant 1980 prices occurs mostly at the beginning of the period, between 1980 and 1985. In other words, the quantity increased first, followed by prices. Finally, the share of take away and snacks in constant 1980 prices has decreased since 1990, indicating a decrease in quantity consumed of these foods.

Figure 2.2: *Quantity shares (budget shares in constant 1980 prices)*

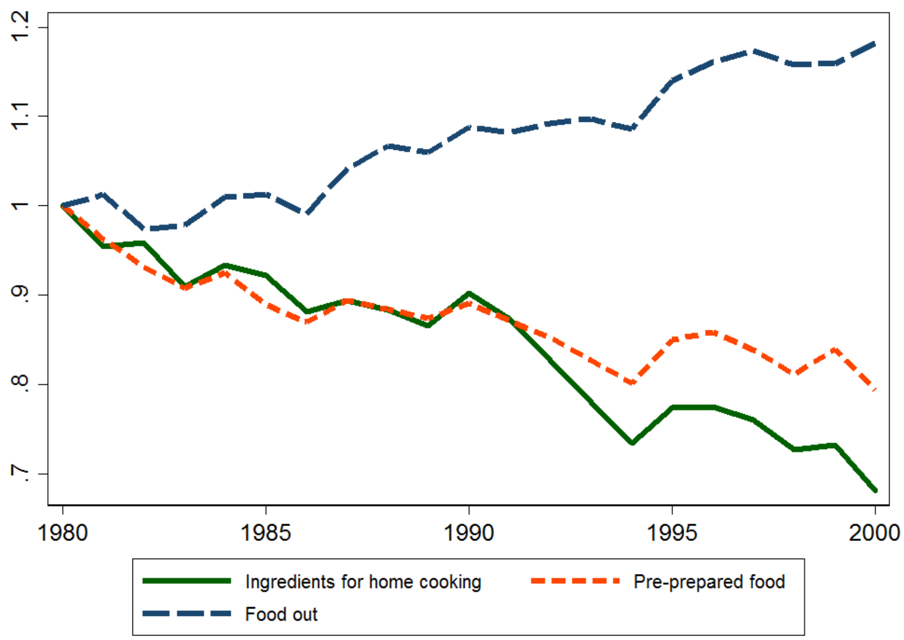


Note: Sample of 38,291 households with two adults aged 25-60, with any number (including zero) of dependent children. Solid line is a fitted local polynomial and lighter lines are 95% confidence intervals.

2.2 Market prices

Market prices for ingredients for home cooking and processed foods fell over the 1980s and 1990s, with the market prices of ingredients falling the most, by close to 35%, and the prices of pre-prepared foods by about 25%. Over the same period, the price of meals out has risen by about 10% and that of take away and snacks by 20%, as shown in Figure 2.3.

Figure 2.3: *Market prices of food aggregates*



Note: Prices of aggregates constructed from ONS price series, relative to the price of the outside good.

This leads to a puzzle. The prices of both ingredients and pre-prepared food decreased from 1980 to 2000, yet the consumption of ingredients has fallen while that of pre-prepared food has increased. From 1990 to 2000 the price of ingredients fell more than that of pre-prepared food, but the consumption of pre-prepared foods continued to increase while that of ingredients for home cooking continued to decrease. It is not possible to rationalise these trends in preferences if food is one good in preferences, or if home cooked food and processed food are substitutes in preferences, or if both are normal goods.

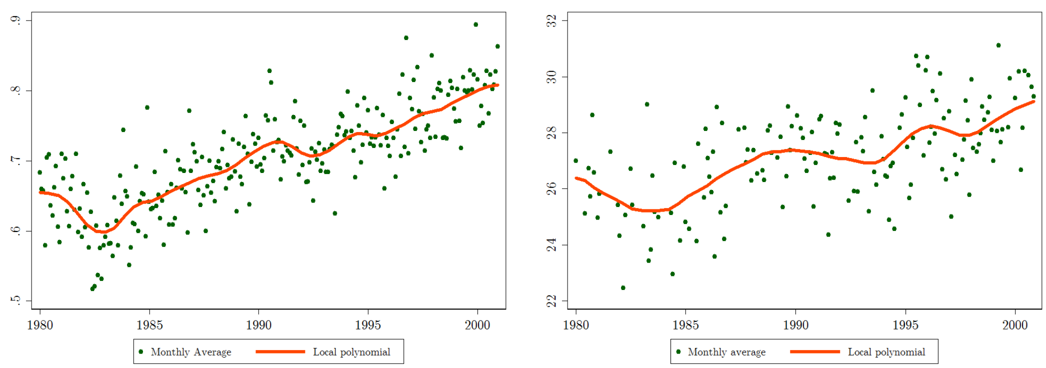
We show that the opportunity cost of time has risen as real wage offers and labour market participation for secondary earners have increased, which means that the shadow price of ingredients has increased.

2.3 Labour force participation and wages

The last three decades have seen changes in the use of time and these have differed for males (usually the main earner in two adult households) and females (usually the secondary earner in two adult households, particular when children are present in the household). Most working age males participate in the labour market, and they mostly work full time. Female labour force participation has increased significantly over this period, with participation rising from about 55% to about 85% (see figure 4(a)) and conditional on working, average weekly hours have increased from about 22 to 33 hours (see figure 4(b)). Altonji and Blank (1999) and Costa (2000) document similar trends in female labour market participation for the US. Meanwhile, the rise in female labour force participation and the narrowing of the gender wage gap have been described and investigated in a large body of literature.

Figure 2.4: *Labour force participation of females*

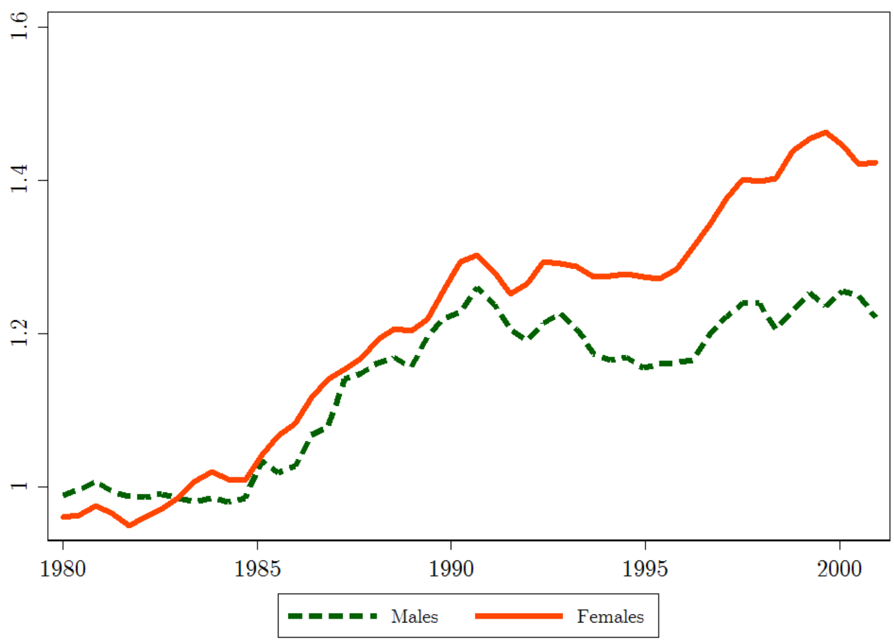
(a) Labour force participation   (b) House worked, conditional on participation



Note:

Real wage have grown for males and more so for females, as shown in Figure 2.5, about 40% for females and 20% for males.

Figure 2.5: *Real wages of head and secondary earners, conditional on participation*



Note: Average real wages relative to January 1980

2.4 Time use

We use the UK Time Use Survey 2000 (TUS [1]) and the People's Activities and Use of Time, 1974-1975 (PAUT) to describe changes in time spent on food preparation.

The TUS is a nationally representative cross-sectional survey of 6,000+ households. All individuals aged 8 or older in the household are asked to complete an individual questionnaire and a diary detailing their main and secondary activity for each 10 minute slot over two pre-selected 24 hours periods. One of the two days is a weekday and the other is a weekend day. We consider time spent on the following activities as food management: "unspecified food management", "food preparation","baking","dish washing","preserving", and "other specified food management". We select couples where both adults are aged 25-59, where the man is employed full time (excluding self-employed), and for both adults we observe their two-day diaries, individual questionnaire and weight. We exclude households with children aged 18 or above. This gives us a sample of 1055 households in the TUS.

[1] Office for National Statistics, Ipsos-RSL, (2003). United Kingdom Time Use Survey, 2000. 3rd Edition. UK Data Service. http://doi.org/10.5255/UKDA-SN-4504-1

The PAUT [2] is a survey of 3000+ individuals aged 5 or older in which individuals record the main and secondary activities for every half-hour slot from 5am to 2am over seven days. The survey was collected in 4 waves between August 1974 and March 1975. In the 2nd wave, the data only has diaries of two workdays instead of all seven days. So we exclude the 2nd wave. For every other wave, we add up all the half-hours spent on activities related to food management across 7 days of the week. The following activities are considered relevant: "cooking", "washing up", "clearing away", "baking", "peeling vegetables". We select the sample of couples where both adults are aged 25-59 and the man works full-time. There are 408 such couples. There is no weighting variable to gross it up to the population.

In 2000, females spent on average 8.3 hours a week on food management as the main activity, while the male average (including zeros) is 3.3 hours (Table 2.1). The gender gap is much bigger in the subsample of couples where the female does not work, than the ones where the female works (Table 2.2). Time spent on food management differs a lot from that in the mid 1970s. In 1974-5, the average female time on food management was higher at 13.3 hours (compared to 8.3 in 2000). The decline in female hours spent on food preparation is observed across the distribution. By contrast, the average hours that males spent on food management increased from 1.3 to 3.3 over the period, a big proportional increase but there remains an overall decline in the total hours spent by the couple on food management.

Table 2.1: *Time spent on food management as main or secondary activity*

		% > 0	mean	Hours per week exc. zeros			
			inc.0	mean	25th pct	median	75th pct
Male							
main activity	1974	0.586	1.3	2.2	0.5	1.5	3.0
	2000	0.810	3.3	4.1	1.5	3.2	5.7
secondary activity	1974	0.262	0.3	1.1	0.5	1.0	1.5
	2000	0.117	0.2	1.9	0.7	0.8	2.3
Female							
main activity	1974	0.985	13.3	13.5	9.5	13.0	17.0
	2000	0.971	8.3	8.6	4.3	7.8	12.0
secondary activity	1974	0.733	1.6	2.2	1.0	1.5	3.0
	2000	0.264	0.6	2.1	0.8	1.3	2.7

Note: in those surveys, we select 25-59 year old couples where the male is employed full-time. Sources: UK Time Use Survey 2000 (TUS) and the People's Activities and Use of Time, 1974-1975 (PAUT)

[2] British Broadcasting Corporation, Audience Research Department, 2014, People's Activities and Use of Time, 1974-1975, UK Data Service, Accessed 5 November 2018. SN: 1425, http://doi.org/10.5255/UKDA-SN-1425-1

Table 2.2: *Time spent on food management in 2000, by female labour market status*

	% > 0	mean	Hours per week exc. zeros			
		inc.0	mean	25th pct	median	75th pct
Male						
secondary earner not in work	0.755	2.8	3.7	1.3	2.5	5.7
secondary earner in work	0.827	3.4	4.2	1.7	3.2	5.8
Female						
secondary earner not in work	0.988	11.4	11.6	7.3	11.5	15.3
secondary earner in work	0.966	7.4	7.6	3.8	7.0	10.7

Note: here we consider time spent on food management as the main activity. The sample is the same TUS sample underlying table 2.1. Sources: UK Time Use Survey 2000 (TUS).

These trends are also observed in the US. Bianchi et al. (2000) document a 12.5 hours/week reduction in total female housework hours between 1965 and 1995. About two-thirds of that overall reduction comes from cooking meals and meal clean-up (8.5 hours). Similarly, Smith et al. (2013) documented that between 1965-66 and 2007-08, the amount of time spent in food preparation more than halved for females and nearly doubled for males in the US.

2.5 Household size

There has been a reduction in household size, thus decreasing the scope for households to exploit economies of scale in food preparation. The reduction in household size is primarily due to a reduction in the number of adults, going from 2.2 on average in 1980 to just under 2 in 2000. The number of dependent children in UK households remains around 1.4 on average over the period. We analyse the behaviour of households composed by two adults and any number of children, so economies of scale are not going to play an important role quantitatively in our application.

2.6 Cross section evidence

We expect families with a lower cost of time and a larger number of children to choose more home-cooked food over pre-prepared food. This intuition is confirmed by cross-sectional evidence. First, we see that the share of home-cooked food is negatively correlated with labour supply and real wages of the secondary earner, and positively correlated with the number of children. In Table 2.3, we show the correlation of the share of ingredients in total food expenditure (de-trended) with household characteristics. The number of children is positively correlated with the cross-sectional variation in the share of ingredients, the secondary earner being in employment is negatively correlated, and both the primary and secondary earners' real wages are negatively correlated, but the secondary earner's more so.

Table 2.3: *Cross section correlation between share of ingredients in food expenditure and demographics*

	(1)	(2)	(3)
has one child	0.00839***	0.00699**	0.0173***
	(0.00237)	(0.00269)	(0.00238)
has two children	0.00649**	0.00759**	0.0175***
	(0.00221)	(0.00247)	(0.00222)
has $\geq$ 3 children	0.0115***	0.0150***	0.0254***
	(0.00284)	(0.00346)	(0.00287)
female in work	-0.0392***		
	(0.00173)		
female working hours		0.000385	
		(0.000517)	
male working hours		0.000653	
		(0.001000)	
female log real wage			0.000380
			(0.00330)
male log real wage			-0.0269***
			(0.00218)
Observations	27075	18878	26142
Adjusted R^2	0.070	0.067	0.060

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: OLS regressions; column (1) uses the sample of households in the FES as in previous figures. Columns (2) and (3) restrict the sample to couples where the female is in work and hence has a positive wage observation. In all cases, the dependent variable is the nominal share of ingredients in the household's food expenditure minus the mean share in that year-month. For the number of dependent children, the reference group is having none. All the regressions also condition on the female's age, age squared and years of education.

Cross-sectional correlations in the 2000 Time Use Survey paint the same picture. Table 2.4 shows a set of regressions of individuals weekly hours on food management on employment, hours and wages. Conditional on basic demographics, women in work spend about 3 fewer hours per week on food management. Among two-earner couples, an additional hour of the woman at work is associated with a 0.1 hour reduction in her time on food management. And individual's time spent on food management is negatively correlated with their own wage, more significantly so for women. Table 2.4 also shows that woman's time on food management is significantly positively correlated with the number of children. Compared to the case of zero children, those with 2 children spend 2.5 more hours per week. Interestingly, man's time on food management is not strongly correlated with the number of children. All these correlations are robust to the inclusion of self-reports of how much they enjoy cooking.

Table 2.4: *Tobit regressions of weekly hours on food management on weekly working hours*

	(1) her	(2) her	(3) her	(4) his	(5) his	(6) his
model						
female employed	-3.438***			0.807*		
	(0.384)			(0.316)		
female self-employed	-3.008***			-0.327		
	(0.872)			(0.722)		
has one child	1.706***	0.798	1.390**	0.163	0.258	0.247
	(0.438)	(0.460)	(0.516)	(0.357)	(0.432)	(0.471)
has two children	2.510***	1.535**	2.549***	0.348	0.698	0.868
	(0.449)	(0.490)	(0.545)	(0.367)	(0.461)	(0.497)
has $\geq$ 3 children	4.171***	3.180***	4.256***	-0.555	-0.0129	0.0267
	(0.616)	(0.743)	(0.854)	(0.508)	(0.704)	(0.784)
his weekly working hours		0.0257			-0.0441**	
		(0.0173)			(0.0165)	
her weekly working hours		-0.0989***			0.00602	
		(0.0152)			(0.0144)	
his log hourly pay			-0.0726			-0.752
			(0.449)			(0.409)
her log hourly pay			-1.149**			-0.156
			(0.437)			(0.397)
Observations	1055	766	530	1055	766	530
Adjusted R^2						

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: The sample is working-age couples with any number of dependent children where the male is full-time employed and both adults working hours are reported (including zero for the female). The dependent variable is the female's weekly hours on food management as main activity for the first three columns, and the male's for the next three columns. Columns (1) and (4) use the same TUS sample as used for the summary statistics. Columns (2) and (5) condition on the woman being in work and both adults' hours are observed. Columns (3) and (6) further restrict the sample to those where we observe the hourly wage for both adults. Wage is constructed from weeklized last take-home pay divided by usual hours per week. To deal with outliers, we replace wages above the 99th percentile by the 99th percentile, and wages below the 1st percentile by the 1st percentile. In addition to the shown coefficients, all columns include age and age squared and education of both adults. We have tried adding each adult's reported taste of cooking (in five bands) on the RHS and the key estimates are not sensitive.

3 Structural model

3.1 The model

We present a model of consumption and time use, with home production of food. Households consist of two adults with any number K of children (including none). Utility is derived from consuming food f, which is assumed to be private; a non-food non-durable composite good x, which exhibits some degree of publicness; and leisure l. We follow Barten (1964), Deaton and Paxson (1998) and Crossley and Lu (2018) in allowing for demographic composition to enter as price deflators. We specify a utility function corresponding to a unitary model with fixed weights:

$$\max_{f,x,l} nU(\frac{f}{n}, \frac{x}{n^\theta}, \frac{l}{n}), \tag{3.1}$$

Household size n is equal to $2+K$, since we only consider households with 2 adults; and $\theta \in [0,1]$ captures the returns to scale in the non food good x. If $\theta = 0$, x is entirely public, and if $\theta = 1$, there are no returns to scale in x. Leisure enters preferences as the sum of the leisure times of both adult household members, $l = l_1 + l_2$. Leisure times of both household members are assumed to be perfect substitutes in preferences because of the assumption that men working hours are constrained, so that the opportunity cost of leisure time for men is the wage of the women, and non working time is the sum of leisure time and cooking time.

Food can be cooked at home, by combining time and market bought ingredients, or purchased ready to eat, in which case it requires no processing time. Home cooked food and ready to eat food are not assumed to be perfect substitutes in preferences:

$$\frac{f}{n} = \tilde{f}(\frac{r}{n}, \frac{c}{n}) \tag{3.2}$$

where c is home cooked food and r is ready to eat food.

We follow Hamermesh (2008) in assuming that ingredients i and time spent cooking t are complements, so that home cooked food c is produced according to:

$$\frac{c}{n} = min[\frac{i}{n}, \frac{Bt}{n^\gamma}] \tag{3.3}$$

We assume that the production technology is linear homogenous in time and ingredients, but not in household size, so as to capture that a home-cooked meal for two takes less than twice the time required to prepare a meal for one. In other words, there are returns to scale in cooking which are represented by $\gamma \in [0,1]$. If $\gamma = 0$, it takes the same time to cook a given quantity of food per capita, whatever the total quantity of food cooked, while if $\gamma = 1$, there are no returns to scale in cooking, so that it takes twice the time to cook for 2 as it takes to cook for 1. The time inputs of the adults are perfect substitutes in the production of home cooked food, $t = t_1 + t_2$. The parameter B transforms quantities into time.

Adults allocate time between market work h_s, the production of home-cooked food t_s and leisure l_s, with $s = 1, 2$ for the adult members of the household. The time constraints for both individuals are:

$$t_s + l_s + h_s = T \qquad\qquad s = 1, 2. \tag{3.4}$$

Working hours for the main earner are assumed to be constrained:

$$T - l_1 - t_1 = \overline{h}_1.$$

This assumption is justified by empirical evidence. Indeed, the elasticity of hours of work of males is low, which is usually interpreted as due to a constraint on male hours Non market time is the time not spent working for a wage, it is the sum of the time spent cooking and of leisure. Leisure is all the time which is not spent sleeping, cooking or working for a wage. Since food can be produced at home, by combining time and ingredients, there is no separability between food and time, or between food and other non-durable goods, which is why we have to model the demand for a non food non durable good (henceforth the outside good [3]).

Households purchase ready to eat food r, ingredients i and non food x, which they fund with market work and non labour income:

$$p_r r + p_i i + p_x x = y_0 + w_1 \overline{h_1} + w_2 h_2, \tag{3.5}$$

where p_k is the market price of good k, y_0 is unearned income, and w_s, $s = 1, 2$ is hourly wage for the main and the secondary earner. Households chose how much ready to eat food and home cooked food to eat, how to use time, and how much to spend on the non food good. We have written the model in terms of goods purchased: ready to eat food r, ingredients i and non food good x. We now rewrite it in terms of the objects of choice: ready to eat food r, home cooked food c, non food x and time spent cooking, t and leisure l. From the production function, we obtain the relationship between home cooked food c and ingredients i and between home cooked food c and time spent cooking t. The Leontieff assumption yields:

$$\frac{c}{n} = \frac{i}{n} = \frac{Bt}{n^\gamma} \tag{3.6}$$

so that:

$$i = c \qquad \text{and} \qquad t = \frac{c}{Bn^{1-\gamma}} \tag{3.7}$$

We can substitute for ingredients i and time spent cooking t in the budget constraint, expressed in terms of individual consumption. Because of the assumption that the time inputs of both household

[3] The outside good includes personal goods and services as well as leisure services and leisure goods. It is assumed to have some degree of publicness.

members are perfect substitutes in the production of home cooked food, there is one price for the time input t. The relevant price for the time input t is the opportunity cost of the time of the household member who is not constrained on the labour market, ie it is w_2, the wage of the woman, or secondary earner. Indeed, if the constrained individual reallocates time from cooking to leisure, for a given amount of home cooked food, then the unconstrained individual reallocates time to cooking, away from either market work or leisure. In other words, the price of the time input is the opportunity cost of time of the unconstrained individual, w_2. The budget constraint in terms of full time income, and individual consumption, where the time of the primary earner is valued at the wage of the secondary earner, is:

$$\left(p_i + \frac{w_2}{Bn^{1-\gamma}}\right)\frac{c}{n} + p_r\frac{r}{n} + \frac{p_x}{n^{1-\theta}}\frac{x}{n^{\theta}} + w_2\frac{l}{n} = \frac{1}{n}\left(y_0 + w_1\overline{h_1} + w_2T + w_2(T - h_1)\right), \tag{3.8}$$

Let k^* and p_k^* respectively denote the individual quantity demanded for good k and its shadow price. Substitute food in preferences, so that:

$$\begin{aligned} U\left(\frac{f}{n}, \frac{x}{n^{\theta}}, \frac{l}{n}\right) &= U\left(\tilde{f}\left(\frac{c}{n}, \frac{r}{n}\right), \frac{x}{n^{\theta}}, \frac{l}{n}\right) &(3.9)\\ &= \tilde{U}\left(\frac{c}{n}, \frac{r}{n}, \frac{x}{n^{\theta}}, \frac{l}{n}\right) &(3.10)\end{aligned}$$

The household's problem can be re-written, in terms of individual quantities demanded and shadow prices, as:

$$\begin{cases} \max_{c^*,r^*,x^*,l^*} \; n\tilde{U}(c^*, r^*, x^*, l^*), \\ \text{s.t } p_c^*c^* + p_r^*r^* + p_x^*x^* + p_l^*l^* = \\ \qquad \frac{1}{n}(y_0 + w_1\overline{h_1} + w_2T + w_2(T - \overline{h_1})) \end{cases}$$

where

$$\begin{aligned} p_c^* &= p_i + \tfrac{w_2}{Bn^{1-\gamma}} & c^* &= \tfrac{c}{n} \\ p_r^* &= p_r & r^* &= \tfrac{r}{n} \\ p_x^* &= \tfrac{p_x}{n^{1-\theta}} & x^* &= \tfrac{x}{n^{\theta}} \\ p_l^* &= w_2 & l^* &= \tfrac{l}{n} \end{aligned}$$

3.2 Discussion of the model

The RHS of equation (3.8) is the full income of the household. Because of the constraint on hours worked by agent 1, the non market time of agent 1 is valued at the wage of agent 2. Even though the primary earner can adjust their use of time between leisure and cooking, the relevant opportunity cost for them is not their own wage, since they are constrained on the labour market. Indeed, in this model, a marginal increase in leisure of the primary earner, for a given level of ingredients and leisure of the secondary earner leads to a reduction in cooking time by the primary earner, an increase in cooking time by the secondary earner and a reduction in working hours of the secondary earner. In a sense, there is a tradeoff between leisure of the primary earner and working hours of the secondary earner, because the two adults can substitute their cooking times. This leads to both the shadow price of leisure of the primary earner, and the shadow price of home cooked food to depend on the wage of the secondary earner. It is worth noting also that the shadow price of home cooked food does not depend on hours worked by either adult members of the household.

We see from the expressions of the shadow prices that demands for home cooked food and for the non food good depend on household size through prices. If cooking is more efficient in larger households, the shadow price of home-cooked food will be lower for larger households. Home-cooked food is also more expensive with higher market wages for the secondary earner. There have been significant changes over time in household size and in wages, and so these will have altered the relative shadow prices for home-cooked and ready to eat foods. These changes are a candidate explanation for movements over time in the composition of household food budgets.

The model predicts that when household size increases, the shadow price of home cooked food and shadow price of the non food good decrease. The substitution effect leads to an increase in the consumption of home cooked food, and of the non food good, and a decrease in the consumption of ready to eat food. The income effect goes in the same direction as the substitution effect for home cooked food and the non food good, and in the opposite direction for ready to eat food. We should see that for a given level of full time income per capita, as household size increases, the consumption of home cooked food per capita increases, the consumption of the non food good per capita increases and the consumption of ready to eat food per capita might increase or decrease. The effects of changes in wages are as follows. An increase in the wage of the secondary earner corresponds to an increase in the shadow price of home cooked food. There is a decrease in the demand for home cooked food, and an increase in the demand for ready to eat food, as per the substitution effect. The income effect goes in the same direction as the substitution effect for home cooked food and in the opposite direction for ready to eat food. There are also endowment effects, so that an increase in the wage is an increase in full time income, hence, an increase in the demand for home cooked food and ready to eat food per capita. Altogether, increases in wages may lead to increases or decreases in the demand for both home cooked food per capita and ready to eat food per capita, for a given level of full time income per capita, depending on the relative strengths of the substitution, income and endowment effects.

Note that in the presentation of the model, there are two foods entering utility: ready-to-eat food and home-cooked food. Ready-to-eat food is further divided in the empirical implementation, where we consider the choice between three types of ready to eat foods: firstly, processed food, which is bought to be eaten at home, and requires no processing time; secondly, restaurant meals, and finally, take-aways and snacks. If we wanted to be entirely precise we would allow for the fact that food eaten in restaurants takes time, and we would allow for a different production function to that of food produced at home. Abstracting from this introduces a mis-specification in the model, however, we think this will be small. The share of restaurants is small compared to those of ingredients for home cooking and of processed foods, and the time spent in restaurants could also be considered as leisure, which brings yet another level of complexity to the modelling of choices. The price of a restaurant meal also includes the opportunity cost of time of the employees of the restaurant. We chose to abstract from these refinements in the specifications, which we think are likely to be second order importance. We are also guided by data considerations: as we have mentioned, while the data on expenditure on ingredients and processed food is of sufficient quality, that on meals taken out of the home is of lesser quality.

4 Empirical implementation

We take the structural model to data for the UK from 1980 to 2000. We use data from the UK Family Expenditure Survey (FES), which is a nationally-representative, repeated cross section. The FES contains detailed information on expenditure, socio-demographic information, labour supply (participation and hours worked) and incomes. We use data on households with two adults, a working head of household between 25 and 64 years old and with any number of children (including zero). Our sample includes 27,193 observations on between 51 and 159 households per month. See Appendix A for further details on the data.

We specify a functional form for the demand system, which requires us to group foods, calculate full time income and construct price indices. We group foods by time use and construct a price index for each commodity aggregate. We use prices from the ONS RPI series.

For households with both adults in employment, we can calculate full income, and shadow prices from observed data. The shadow price of home cooked food depends on the returns to scale parameter γ, which is calibrated. For households in which the second earner is not in employment, we do not observe the wage, and so cannot construct full income or shadow prices. In order to calculate full time income we estimate a participation model that allows us to correct for selection in the estimation of the demand system. We then estimate the demand system on the sample of two-earner households, including the selection correction.

4.1 Functional form for the demand system

We assume the demand system takes the form of Almost Ideal demand system (Deaton and Muellbauer (1980)) with six goods - home cooked food, processed food, meals out, snacks, a non-food non-durable good and leisure. See Appendix A.1 for details.

The (shadow) share of good j in full income is a linear function of log shadow prices of all five goods and log real full income.

$$\begin{aligned} w_j^* =& \alpha_j + \delta_{jc} \ln p_c^* + \delta_{jr} \ln p_r^* + \delta_{jm} \ln p_m^* + \delta_{js} \ln p_s^* + \delta_{jx} \ln p_x^* + \delta_{jl} \ln p_l^* + \beta_j ln(\frac{Y}{P}) \\ & j \in \{c, r, m, s, x, l\} \end{aligned} \tag{4.1}$$

where

- subscripts $\{c, r, m, s, x, l\}$ stand for home cooked food, processed food, meals out, snacks, a non-food non-durable good and leisure.
- w_j^* is the expenditure share of good j in full income and note that for home cooked food the expenditure share includes the time cost as well the ingredients $w_c^* = p^* c^* / Y$
- P is the usual AIDS deflator (which depends on parameters)
- for each j, α_j includes a constant and linear controls of: age of the woman, her age squared, her years of education, whether there are children, age of the youngest child, and monthly dummies.

Returns to scale in cooking are represented by the parameter γ, which we set to 0.8.

Full income Y is total resources available for spending on non-durables as well as leisure. Note that, because we assume that the market hours of the primary earner are constrained and that the household production function for home-cooked food is Leontieff in the sum of the times spent cooking and the ingredients, full income equals $y_0 + w_1\overline{h_1} + w_2(2T - \overline{h_1})$. In principle we could use this expression to measure full income, however, we do not have good data on unearned income, y_0. Unearned income is often negative in the FES, and we have not incorporated saving or borrowing in this model. Instead we measure full time income using total weekly expenditure on all items (food plus non food x) plus the imputed cost of time spent cooking and on leisure $w_2(2T - \overline{h_1} - h_2)$.

When taking (4.1) to the data, we correct for selection (as explained in the subsection 4.2). Because the shares necessarily add up to 1, we estimate the share equations for the food categories and leisure only. We do not impose symmetry. Symmetry is generally rejected for households of more than one person (see for instance Browning and Chiappori, 1998). We impose homogeneity. We calculate the usual elasticities according to the equations in the appendix B

4.2 Labour Market Participation and Wages of the Secondary Earner

We observe the wage of all primary earners. For secondary earners some participate in the labour market, in which case we observe their wage, and others do not participate. We use data on all secondary earners to estimate participation status and a wage equation. This allows us to compute an inverse Mills ratio for all secondary earners. The inverse Mills ratio is used to correct for selection in the estimation of the structural model of demand and time use.

Each individual has a potential wage, W_i^p, if they participate in the labour market, that is given by:

$$\ln W_i^p = X_i\theta + Q_i\delta + u_i, \tag{4.2}$$

and a reservation wage, W_i^r, that dictates whether they participate, given by:

$$\ln W_i^r = X_i\alpha + Zi\beta + \varepsilon_i, \tag{4.3}$$

where

$$\begin{pmatrix} u \\ \varepsilon \end{pmatrix} \sim N\left[\begin{pmatrix} 0 \\ 0 \end{pmatrix}, \begin{pmatrix} \sigma_u^2 & \rho\sigma_u\sigma_\varepsilon \\ \rho\sigma_u\sigma_\varepsilon & \sigma_\epsilon^2 \end{pmatrix}\right].$$

X_{it} includes the woman's age, age squared, age cubic, the woman's education in 7 bands and year dummies. Q_{it} includes 11 dummies for region of residence and interactions between year dummies and 4 broader regions, so as to control for local labour market conditions. Z_{it} contains whether there are children present in the household, the number of children, 5th order polynomial of the age of the youngest child, the household's unearned income, income from benefits, and the husband's wage, age, education, hours of work and occupation, market prices of the goods in our model, housing tenure, and interaction between year dummies and the presence of children.

The secondary earner chooses to participate in the labour market if their potential wage is greater than their reservation wage:

$$X_i(\theta - \alpha) + Q_i\delta - Zi\beta. + u_i - \varepsilon_i > 0$$

We observe the wage, W_i, which is given by

$$W_i = \begin{cases} W_i^p & \text{if} \quad X_i(\theta - \alpha) + Q_i\delta - Zi\beta + u_i - \varepsilon_i > 0 \\ 0 & otherwise \end{cases}$$

Table 4.1: *Heckman wage equation*

	heck		
	lws	select	mills
	b/se	b/se	b/se
rr2	-0.004	-0.084	
	(0.014)	(0.052)	
rr3	0.021	-0.010	
	(0.013)	(0.051)	
rr4	0.008	-0.035	
	(0.033)	(0.115)	
rr5	0.008	-0.094	
	(0.033)	(0.114)	
rr6	-0.021	-0.096	
	(0.034)	(0.119)	
rr7	0.132	-0.044	
	(0.030)	(0.106)	
rr8	0.030	-0.112	
	(0.030)	(0.104)	
rr9	-0.023	-0.125	
	(0.037)	(0.131)	
rr10	-0.034	-0.166	
	(0.038)	(0.133)	
rr11	-0.020	0.064	
	(0.039)	(0.140)	
rr12	-0.037	0.095	
	(0.043)	(0.154)	
yy1981N	0.014	-0.012	
	(0.043)	(0.150)	
yy1982N	0.005	-0.177	
	(0.046)	(0.154)	
yy1983N	-0.000	-0.061	
	(0.046)	(0.158)	
yy1984N	0.016	0.087	
	(0.045)	(0.153)	
yy1985N	-0.026	-0.078	
	(0.045)	(0.158)	
yy1986N	0.078	0.210	
	(0.045)	(0.158)	
yy1987N	0.025	0.100	
	(0.045)	(0.157)	
yy1988N	0.009	0.087	
	(0.044)	(0.156)	
yy1989N	-0.064	0.002	
	(0.044)	(0.156)	
yy1990N	-0.006	-0.032	
	(0.044)	(0.163)	
yy1991N	-0.041	0.081	
	(0.047)	(0.175)	
yy1992N	-0.045	0.282	
	(0.048)	(0.176)	
yy1993N	0.044	-0.051	
	(0.049)	(0.181)	
yy1994N	0.034	0.096	
	(0.048)	(0.180)	
yy1995N	-0.040	0.081	
	(0.048)	(0.178)	
yy1996N	0.011	0.233	
	(0.047)	(0.184)	
yy1997N	0.023	0.181	
	(0.048)	(0.186)	
yy1998N	0.039	-0.117	
	(0.049)	(0.198)	
yy1999N	0.022	0.131	
	(0.048)	(0.193)	
yy2000N	0.002	-0.184	
	(0.048)	(0.196)	
yy1981SNI	0.021	-0.143	
	(0.057)	(0.192)	
yy1982SNI	0.009	-0.213	
	(0.063)	(0.212)	
yy1983SNI	0.048	0.069	
	(0.058)	(0.202)	
yy1984SNI	0.019	-0.091	
	(0.057)	(0.196)	

We estimate the model with Heckman two-step estimation and report the results in Table 4.1. The selection equation results are not surprising: the probability to participate is increasing in the education of the secondary earnerd, decreasing in unearned incomes, and decreasing in the male's wage and hours of work. It is also lower for females who have children and increasing in the age of the youngest child. The potential wage is increasing in the education of the secondary earner, the age of the secondary earner until about 50 years of age and decreasing afterwards.

We estimate the wage equation to obtain the estimate coefficients $\widehat{\theta}$, $\widehat{\delta}$, and $\widehat{\rho\sigma_u}$. In a Probit, the scale of the parameters is not identified: we obtain $\widehat{k(\theta-\alpha)}$, $\widehat{k\delta}$, and $\widehat{k\beta}$, where $k = 1/\sigma_{u-\varepsilon}$ is unknown.

In theory $\widehat{\delta}$ and $\widehat{k\delta}$ are two estimates of the same vector δ, except for the scale transformation k. We can use them to retrieve $\widehat{k}$ and another (better) estimate of δ. Specifically, we can solve the following problem

$$\min_{k,\delta} \left((\widehat{\delta}-\delta)', (\widehat{k\delta}-k\delta)' \right) \sum{}^{-1} \begin{pmatrix} \widehat{\delta}-\delta \\ \widehat{k\delta}-k\delta \end{pmatrix} \tag{4.4}$$

where $\sum$ is the covariance matrix of $\begin{pmatrix} \widehat{\delta}-\delta \\ \widehat{k\delta}-k\delta \end{pmatrix}$ and it's proxied by the estimated variance covariance matrix corresponding to $\widehat{\delta}$ and $\widehat{k\delta}$.

If we do (4.5), we would get k just below 1 and the inverse of $\hat{k}$ is $\widehat{\sigma_{u-e}}$, which would be 1.1. Michelle thinks this is unreasonably big, and it is the reason that $E[\ln W^r|X, Z, P = 0]$ is so much bigger than $E[\ln W^r|X, Z]$.

So, now we impose $\sigma_e = 0.5$, and we use the ρ estimated in the Heckman model to compute σ_{u-e} and get a value of 0.58, thereby $k = 1.73$. We solve the following problem :

$$\min_{\delta} \left((\widehat{\delta}-\delta)', (\widehat{k\delta}-k\delta)' \right) \sum{}^{-1} \begin{pmatrix} \widehat{\delta}-\delta \\ \widehat{k\delta}-k\delta \end{pmatrix} \tag{4.5}$$

where k takes the calibrated value and $\sum$ is proxied in the same way as above.

This distance minimization gives us a new estimate of δ and let's denote it $\tilde{\delta}$. We obtain $\widehat{\beta}$ as $\widehat{k\beta}/k$ and $\widehat{\alpha}$ as $\widehat{\theta} - \widehat{k(\theta-\alpha)}/k$, assuming k takes the calibrated value .

We compute $\widehat{\zeta_i} = X_i(\theta-\alpha) + Q_i\delta - Zi\beta$. The probability of participation for each individual as $\Phi(\widehat{\zeta_i}/\widehat{\sigma_{u-e}})$.

The Inverse Mills Ratio is $[\phi(\widehat{\zeta}_i/\widehat{\sigma_{u-e}})/\Phi(\widehat{\zeta}_i/\widehat{\sigma_{u-e}})]$, where $\widehat{\sigma_{u-e}}$ is imposed to 0.582. The IMR goes on the RHS in our AIDS estimation, so the choice of $\widehat{\sigma_{u-e}}$ can potentially affect our results in this aspect. We can do some robustness checks later.

We compute the unconditional market wage as $E(\ln W_i^p) = X_i\widehat{\theta} + Q_i\widetilde{\delta}$. Market wages conditional on partipation status are:

$$E[\widehat{\ln W_i}|P_i = 1] = X_i\widehat{\theta} + Q_i\widetilde{\delta} + \widehat{\rho\sigma_u}\frac{\phi(\widehat{\zeta}_i/\widehat{\sigma_{u-\varepsilon})}}{\Phi(\widehat{\zeta}_i/\widehat{\sigma_{u-\varepsilon})}} \tag{4.6}$$

$$E[\widehat{\ln W_i}|P_i = 0] = X_i\widehat{\theta} + Q_i\widetilde{\delta} - \widehat{\rho\sigma_u}\frac{\phi(\widehat{\zeta}_i/\widehat{\sigma_{u-\varepsilon})}}{\Phi(-\widehat{\zeta}_i/\widehat{\sigma_{u-\varepsilon})}} \tag{4.7}$$

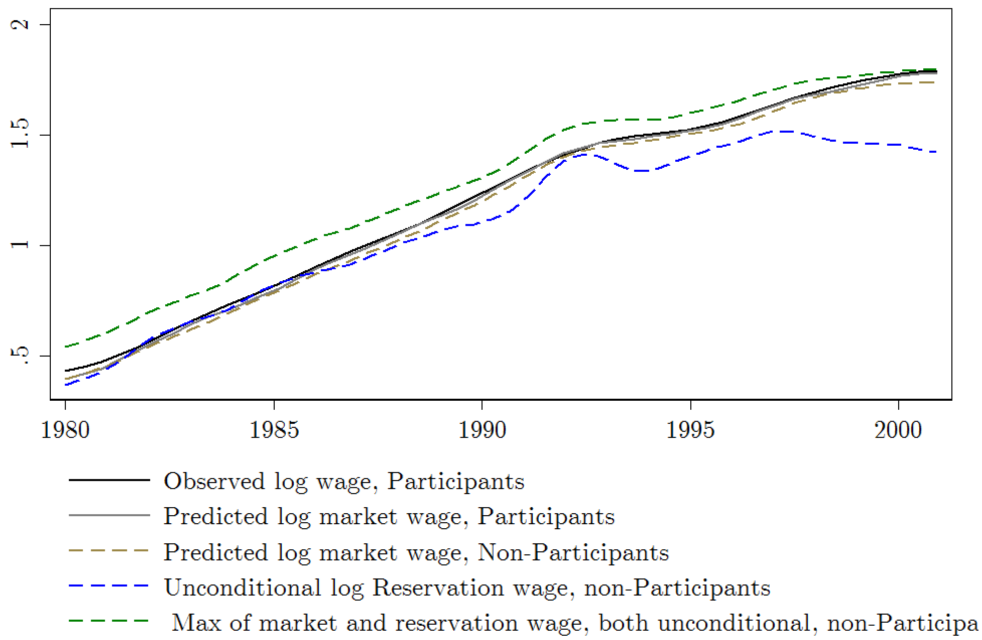
We compute the unconditional reservation wage as $E[\ln W_i^r] = X_i\hat{\alpha} + Z_i\hat{\beta}$. Reservation wage conditional on participation status are

$$E[\widehat{\ln W_i^r}|P_i = 1] = X_i\hat{\alpha} + Z_i\hat{\beta} + (\widehat{\rho\sigma_u} - \sigma_{u-\varepsilon})\frac{\phi(\widehat{\zeta}_i/\widehat{\sigma_{u-\varepsilon})}}{\Phi(\widehat{\zeta}_i/\widehat{\sigma_{u-\varepsilon})}} \tag{4.8}$$

$$E[\widehat{\ln W_i^r}|P_i = 0] = X_i\hat{\alpha} + Z_i\hat{\beta} - (\widehat{\rho\sigma_u} - \sigma_{u-\varepsilon})\frac{\phi(\widehat{\zeta}_i/\widehat{\sigma_{u-\varepsilon})}}{\Phi(\widehat{-\zeta_i}/\widehat{\sigma_{u-\varepsilon})}} \tag{4.9}$$

Figure 4.1 shows the predicted log wage against the actual log wage through time for participants and non-participants. We see that we are able to reproduce the time paths of the wages between 1980 and 2000 for the participants. For the non-participants, the predicted log market wage follows that of participants closely, at a slightly lower level. The mean predicted log reservation wage lags behind the market wage substantially in the last 5 years of our sample period. This is not driven by a fewer outliers in the later years, we find $E[\ln W_i^r] < E[\ln W_i^p]$ for a substantial proportion of non-participants every year. Since their value of time must be greater than their potential wage if they choose not to work, we will use the max of the two log wages as their log value of time in counterfactual analysis. This choice is only relevant to the counterfactual analysis for non-participants; for participants, we simply use their observed wages in counterfactual analysis. And it doesn't affect our estimation of the demand system, since it is estimated on the sample of participants.

Figure 4.1: *Actual and predicted ln wage of secondary earner*



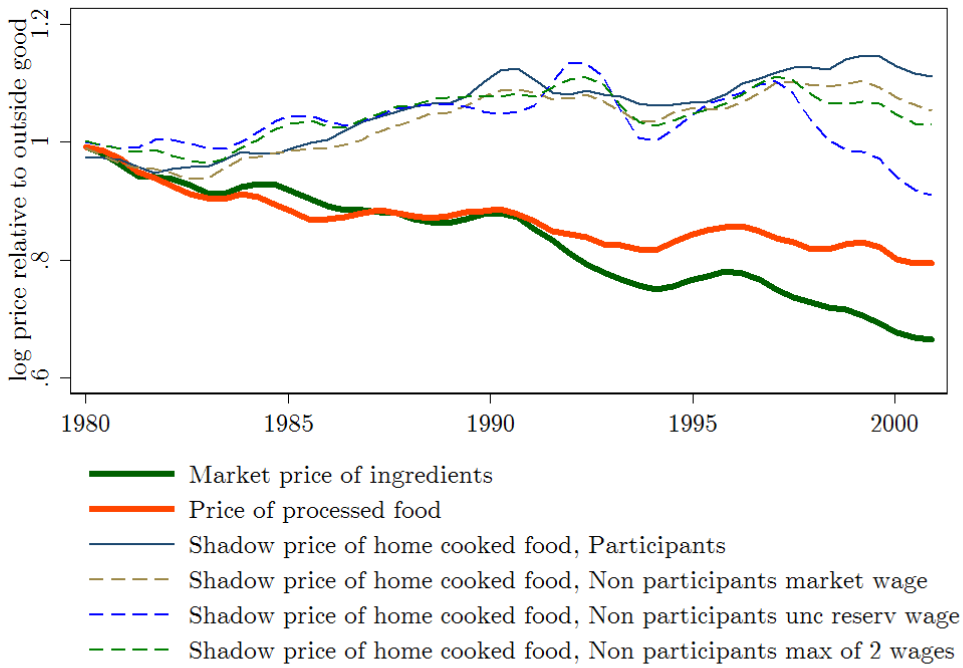
the predicted market wages are unconditional on actual participation status

4.3 Shadow price of home-cooked food

The shadow price of home cooked food is given by $p_r^* = p_i + \frac{w_2}{Bn^{1-\gamma}}$. We set $\gamma = 0.8$ and $B = 0.88$ so that the average observed expenditure on ingredients almost exactly match the average reported time on food management, separately for households with 0 and 2 children.[4] We construct the shadow price of home cooked food and show its time path in figure 4.2, together with those of the prices of ingredients and of processed foods.

[4]The 2 most common values of K is 0 and 2 in our sample, each accounting for about a third of the sample. We obtain the mean of weekly time on food management as main activity from the Time Use Survey 2000, counting both spouses: it's 10.8 for those without children and 12.5 for those with 2.We also have the mean weekly expenditure on ingredients for the two groups in 2000. Based on $\gamma = 0.8$ and $B = 0.88$ and equation (3.7), the implied weekly hours would be 10.9 for those without kids and 12.6 for those with 2.

Figure 4.2: *Prices of ingredients and processed food, and shadow price of home-cooked food*



Note:All relative to the price of the outside good.

Wages have grown whilst the prices of foods have decreased, and since cooking takes time, the shadow price of home-cooked food, which incorporates the opportunity cost of time, has in fact increased over the period, as is shown in solid lines in figure 4.2. For non-participants, the value of time has grown as well, so their shadow price of home-cooked food has grown faster than the price of processed food, regardless of which we measure the value of time .

5 Estimates and fit of the model

We estimate the model; coefficients are reported in Table 5.1.

Table 5.1: *Estimated coefficients from structural demand model*

	Ingredients	Processed food	Restaurant	Snacks	Leisure
	.				
	cat1	cat2	cat3	cat4	cat6
	b/se	b/se	b/se	b/se	b/se
P* ingred	0.1034***	0.0647***	-0.0183**	0.0339***	0.0084
	(0.0189)	(0.0055)	(0.0058)	(0.0040)	(0.0298)
P proc	0.0952***	-0.0430***	-0.0141*	-0.0473***	-0.0746*
	(0.0202)	(0.0059)	(0.0062)	(0.0043)	(0.0318)
P rest	-0.0939*	0.0994***	0.0181	0.0827***	-0.2534***
	(0.0373)	(0.0109)	(0.0114)	(0.0080)	(0.0587)
P snack	-0.1038**	0.0520***	-0.0028	-0.0589***	0.0658
	(0.0341)	(0.0099)	(0.0104)	(0.0073)	(0.0537)
P leis	-0.0565***	-0.0707***	0.0062	-0.0313***	0.1469***
	(0.0127)	(0.0037)	(0.0039)	(0.0027)	(0.0199)
ln(rY)	-0.0963***	-0.0256***	0.0099***	-0.0106***	-0.1982***
	(0.0029)	(0.0008)	(0.0009)	(0.0006)	(0.0046)
o.cons	0.0000	0.0000	0.0000	0.0000	0.0000
	(.)	(.)	(.)	(.)	(.)
N	16912				

Notes: All regressions include ln(AK), IMR age spouse, age spouse squared, age youngest child, any children, age spouse completed education and month dummies.

We first present income and price elasticities constructed from the demand estimates, then Engel curves and we compare the actual and predicted time trends of the food shares. The coefficient estimates of the structural model are shown in Appendix C. We also examine the performance of the labour force participation and wages part of the model. Finally, we discuss the shadow price of home cooked food as a function of predicted wages.

5.1 Price and income elasticities

We compute income and price elasticities without imposing symmetry. Price elasticities are computed with respect to the shadow prices of the goods, and also with respect to the price of ingredients. The formula can be found in Appendix B.

Starting with the income elasticities, home cooked food, processed food and snacks are necessities, and their income elasticities are very similar, at around 0.5. Restaurant meals are a luxury, with an income elasticity of 1.67. Food altogether is usually found to be a necessity and this would be the case here.

Turning to the price responses, our analysis focusses mainly on the relationship between home cooked food and processed food eaten at home, rather than on the relationship between the four different types of food we introduce in the model, although we discuss those as well.

There are several reasons for this focus. The price responses involving restaurants and take away and snacks are possibly less reliable than those involving home cooked food and processed food. Data collection for the former foods mean that expenditure on restaurant and on take away and snacks may not be recorded with sufficient accuracy to allow robust analysis of price responses. Furthermore, the composition of the aggregate take away and snacks has changed over the period. Both restaurants and take away and snacks have high levels of infrequency of purchase, which is not accounted for in our model. Regarding restaurant meals, no information is collected concerning the time spent eating in restaurant so that the model is misspecified in this respect, since we don't model restaurant as combining time and goods. There are also more fundamental reasons to have less focus on restaurants and take away and snacks. We expect foods for which there is no time cost and no leisure element of the activity (such as we can presume to exist for restaurant meals) to be substitutes in preferences. But eating in restaurants takes time, which we don't model, and it might also be a leisure activity in itself, which could mean that it is not substitutable for home cooked food or processed food eaten at home, or take away and snacks. Similarly, the choice to eat take away and snacks might be linked to work and use of time. Lunch eaten at home, whether home cooked or processed, is probably not in the choice set of many working individuals. We will discuss the elasticities linked to restaurant meals and take away and snacks, while keeping in mind these reservations.

Starting with Marshallian own price elasticities; these are negative and significant for home cooked food, processed food and snacks, with snacks and processed food the most price elastic, and home cooked food the least price elastic. The own price elasticity of restaurants is positive, which is not surprising, if you go back to the evolution of the budget share of restaurant meals, which has increased over the period (cf figure 2.1) and the evolution of the price of restaurant meals (cd figure 2.3), which have also increased over the period. This does not mean that restaurant meals are a Giffen good. Indeed, a Giffen good is an inferior good for which the income effect dominates the substitution effect, so that demand increases when its price increases. Here, restaurant meals are a luxury, with an income elasticity of 1.62 and yet their demand increases with their price. In the cross section, however, depending on the years, the own price elasticity of restaurant is negative or positive and often not significantly different from zero. The positive elasticity we find here combines cross sectional effects, which go in the expected direction and time series effects. The latter show changes which happened over the period 1980-2000 in the supply of restaurants and probably also in preferences for restaurant meals in British society. It is quite interesting that we can capture this, even though the model is misspecified.

The own price elasticity of take away and snacks is suspiciously high, at -3.9.

The Hicksian own price elasticities of processed foods and take away and snacks are negative and significant; the own price elasticity of home cooked food is negative but not significant and the elasticity of restaurant meals is positive.

Altogether, home cooked food is not very responsive to its own price, as both Marshallian and Hicksian own price responses for home cooked food are small. Looking at the overall effect (the Marshallian elasticities) home cooked food is also not responsive to the price of leisure. The price elasticity of home cooked food with respect to the price of leisur is 0.14.

At constant utility, when the price of time increases, households consume less home cooked food and restaurant meals and more processed food and snacks. The elasticities of the demand for processed food with respect to the price of time and to ingredients also go in the right direction: when time or ingredients are more expensive, consumption of processed food increases.

Cross price elasticities are often difficult to estimate, particularly when they concern goods for which there is limited relative price variation. Here, all the Marshallian cross price elasticities between foods are significantly different from zero, apart from the elasticity of the demand for restaurant with respect to the prices of processed food and snacks. Most of the Hicksian cross price elasticities are significantly different from zero, apart from the price elasticities of the demand for restaurant. This indicates an absence of substitutions between restaurant meals and the other foods of the demand system.

The cross price elasticities indicate that home cooked food and processed food eaten at home are substitutes, which is what we expect. An increase of 1% in the price of processed food leads to an increase of 0.6% in the demand for home cooked food, and an increase of 1% in the price of home cooked food leads to an increase of 1.1% in the demand for processed food.

The results indicate that home cooked food and restaurant meals are complements, which is not what we would have anticipated. But in fact, since the substitution effect dominates the income effect, it suggests that it might be an effect of the opportunity cost of time: when time is more expensive, there is less time to either cook or go to restaurants. It is plausible that there is not much substituability between leisure and food.

The relationship between home cooked food and snacks is not clear. When the price of home cooked food increases, the demand for snacks increases. But on the other hand, when the price of snacks increases, the demand for home cooked food decreases, which we can interpret by the same argument about the opportunity cost of time as we invoked regarding restaurants and home cooked food.

The marshallian and hicksian cross price elasticities for all the goods with respect to the price of restaurants are almost equal. This indicates that the response of all goods to changes in the price of restaurants is driven by substitution effects rather than by income effects. This is because the budget share of restaurant is so small that there is virtually no income effect associated to marginal changes in the price of restaurant meals. The same remarks apply regarding responses to changes in the price of snacks.

The non food non durable aggregate is constituted of expenditures on a heterogenous group of goods, including tobacco, alcohol, expenditure on leisure goods. The heterogenous nature of the composite means that the elasticities cannot be easily interpreted.

We present results obtained without imposing symmetry. Symmetry is rejected. The rejection could be due to a number of sources of misspecification. An obvious source is the fact that the model is unitary, and it has been shown that symmetry does not hold for households with more than one decision maker. Other sources of misspecification come from the manner in which the different foods are assumed to be produced. We specify that restaurant meals don't require time, which is obviously wrong, but inevitable given the data at hand. We also adopt a rather specific form for the production of home cooked food, again partially dictacted by the data constraints. The fact that symmetry is rejected indicates that the model is misspecified in some respect, but the test is an omnibus specification test, since there are several potential sources of misspecification.

Table 5.2: *Marshallian elasticities*

Goods	Share	Inc.elast.	Home cook.	Processed	Restaurant	Snacks	Non-food	Time	Ingr.
			Prices						
Home cooked	0.18	0.46	-0.28	0.58	-0.47	-0.46	0.23	0.14	-0.10
	0.00	0.02	(0.11)	(0.12)	(0.22)	(0.19)	(0.17)	(0.01)	(0.04)
Processed	0.05	0.51	1.07	-1.55	1.95	1.22	-2.23	0.28	0.38
	0.00	0.02	(0.14)	(0.12)	(0.22)	(0.21)	(0.17)	(0.01)	(0.05)
Restaurant	0.02	1.67	-1.04	-0.49	0.45	-0.17	-0.32	0.64	-0.37
	0.00	0.09	(0.39)	(0.44)	(0.76)	(0.67)	(0.60)	(0.04)	(0.14)
Snacks	0.02	0.54	1.54	-2.12	3.82	-3.91	1.26	0.49	0.55
	0.00	0.06	(0.24)	(0.25)	(0.47)	(0.41)	(0.33)	(0.02)	(0.08)
Non-food	0.21	2.55	-1.06	0.09	1.03	-0.11	-1.62	0.66	-0.38
	0.00	0.03	(0.11)	(0.13)	(0.22)	(0.22)	(0.18)	(0.01)	(0.04)
Leisure	0.53	0.63	0.03	-0.08	-0.60	0.21	0.33	0.09	0.01
	0.00	0.01	(0.06)	(0.07)	(0.11)	(0.11)	(0.09)	(0.01)	(0.02)

Note: the columns refer to the prices. The price of 'Home cook.' is the shadow price p_c^*. Elasticities with regard to the price of 'Time' is the elasticity wrt to the price of leisure, holding the shadow price p_c^* constant.

Table 5.3: *Hicksian elasticities*

Goods	Share	Inc.elast.	Home cooked	Processed	Restaurant	Snacks	Non food	Time	Ingr.
			Prices						
Home cooked	0.18	0.46	-0.20	0.60	-0.46	-0.45	0.33	-0.04	-0.01
	0.00	0.02	(0.11)	(0.12)	(0.22)	(0.19)	(0.17)	(0.01)	(0.01)
Processed	0.05	0.51	1.16	-1.53	1.96	1.23	-2.12	0.09	0.17
	0.00	0.02	(0.14)	(0.12)	(0.22)	(0.21)	(0.16)	(0.01)	(0.02)
Restaurant	0.02	1.67	-0.74	-0.41	0.48	-0.13	0.02	0.00	-0.02
	0.00	0.09	(0.38)	(0.45)	(0.76)	(0.67)	(0.60)	(0.06)	(0.05)
Snacks	0.02	0.54	1.64	-2.10	3.83	-3.90	1.37	0.29	0.23
	0.00	0.06	(0.23)	(0.25)	(0.47)	(0.41)	(0.32)	(0.02)	(0.03)
Non-food	0.21	2.55	-0.60	0.21	1.06	-0.06	-1.11	-0.31	0.03
	0.00	0.03	(0.11)	(0.13)	(0.22)	(0.22)	(0.18)	(0.02)	(0.01)
Leisure	0.53	0.63	0.15	-0.05	-0.60	0.22	0.45	-0.15	0.04
	0.00	0.01	(0.06)	(0.07)	(0.11)	(0.11)	(0.09)	(0.01)	(0.01)

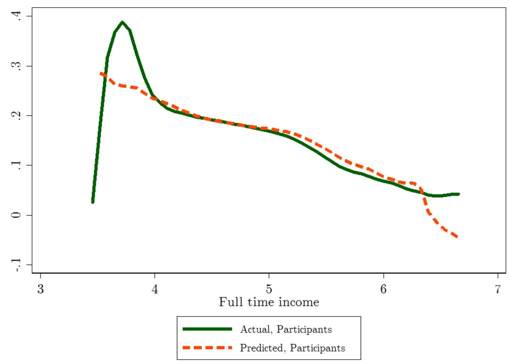
Note: same notes as table 5.2

5.2 Fit of the structural model

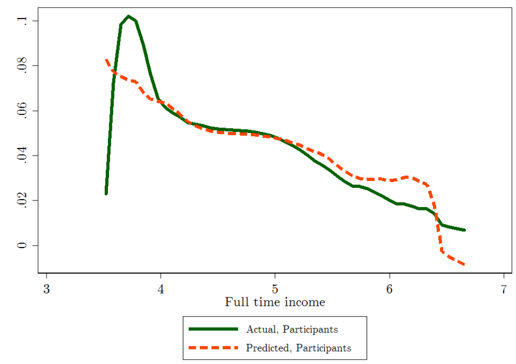
In figure 5.1, we show the Engel curve derived from the structural model, together with the relationship between the shares and full time income. For ingredients, processed food and take away and snacks, the Engel curves confirm the conclusions drawn from the income elasticities: all three foods are necessities. Restaurant meals only become a luxury at high level of full time income.

Figure 5.1: *Engel curves from structural model*

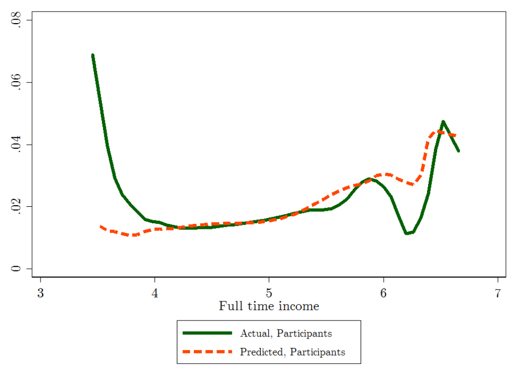
(a) Ingredients



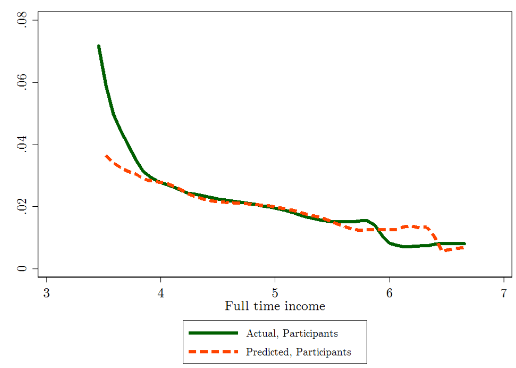
(b) Processed



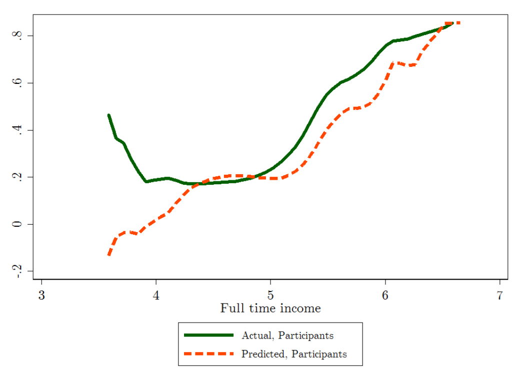
(c) Food Out



(d) Non-food



(e) Leisure

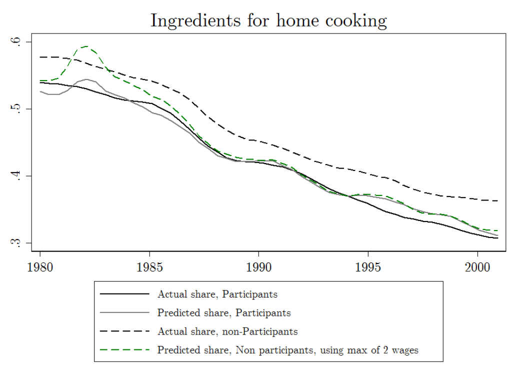


Note: among Participants only

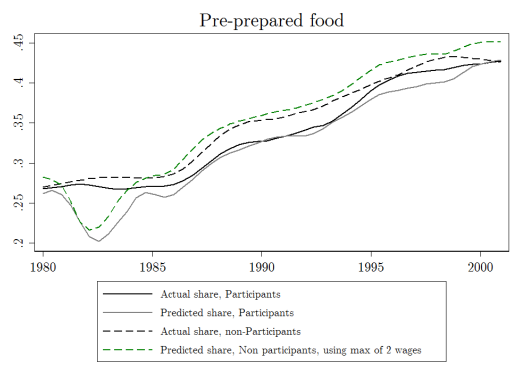
We also assess the fit of the structural model by comparing the actual and predicted shares of foods over the period 1980 to 2000, shown in figure 5.2. The model is estimated in terms of shares out of full income, and the predictions are then re-scaled to be out of food expenditure. The model does very well in terms of capturing the trends of expenditures on the different food aggregates, particularly ingredients and pre-prepared food. For reasons we explained above regarding the collection of data on take away and snacks and meals out, the quality of the data on these foods is lower. Because of these issues, the raw time trend of the budget share for ”Take away and snacks” is probably mostly due to data collection issues, and unsurprisingly, not only is there not much of a trend in the share of this good, but the model does quite poorly in predicting the evolution of the share of expenditure on this composite food.

Figure 5.2: *Actual and predicted shares of food*

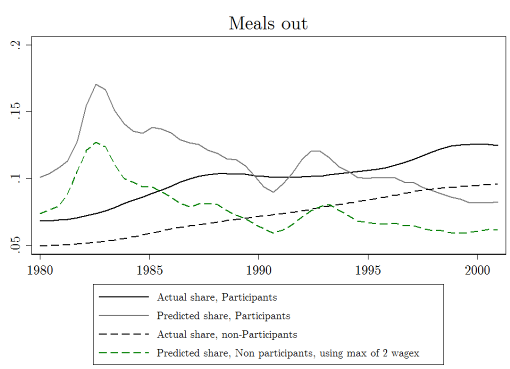
(a) Ingredients for home cooking



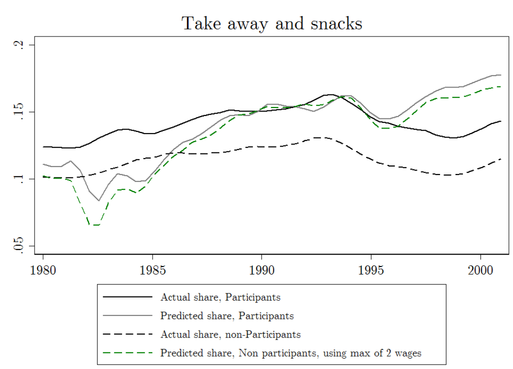
(b) Pre-prepared food



(c) Food out



(d) Snacks



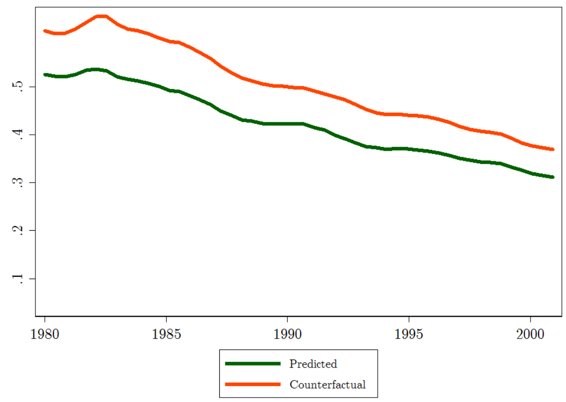
6 Effect of a counterfactual tax on processed food

We run a price counterfactuals where the price of processed foods is 20% high than the observed.

We do not run a wage counterfactual. Our model is static, and a wage counterfactual would require a dynamic model. Indeed, it has been documented that when real wages decrease, people dont change their labour supply. This is because there is a wealth effect which operates along the substitution effect. Another reason to consider the effect of a tax on food rather than of a tax on time is that price is a more plausible policy lever than wages.

Figure 6.1: *Effect of a 20% tax on ingredients' share in food expenditure*

(a) Participants



(b) Non-participants

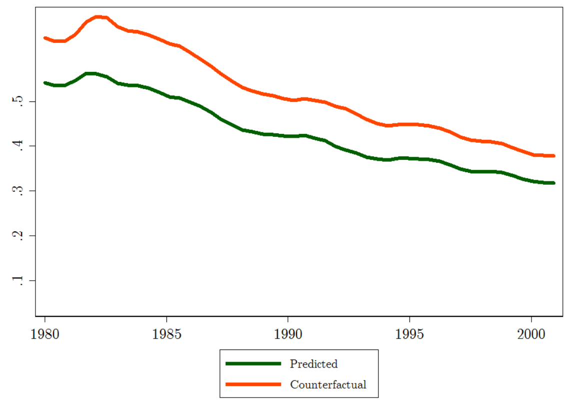
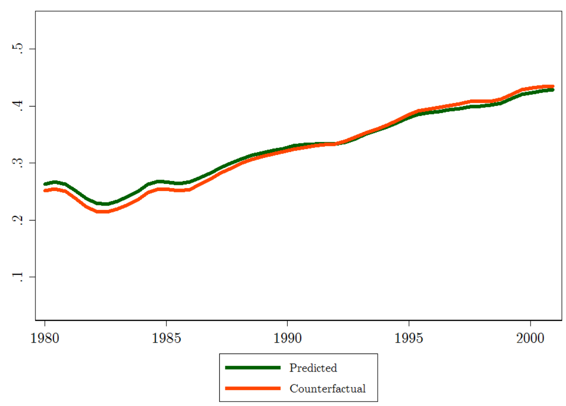
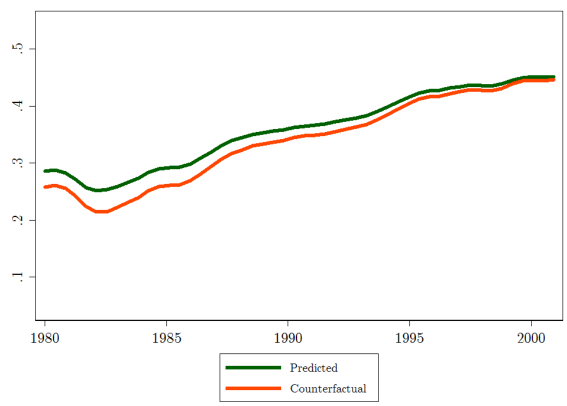


Figure 6.2: *Effect of a 20% tax on processed food's share in food expenditure*

(a) Participants



(b) Non-participants



In both the counterfactual and baseline predictions, a small proportion of households have non-positive predicted shares. We exclude such households (1.2% of the sample) when comparing the counterfactual and baseline predictions in figures 6.1-6.2. We find that a tax on processed food leads to households substituting home cooking for processed food. The share of ingredients in total food expenditure is about 10% higher in the counterfactual of a 20% tax than in the baseline prediction (Figure 6.1). This is true for both participants and non-participants. The effect on the share of processed food in food expenditure is close to zero for participants; it's negative for non-participants but also quite small. This is because total food expenditure falls in response to a tax, by a similar proportion as the fall in expenditure of processed food.

7 Conclusions

There has been a significant decline in the share of ingredients in UK households' food expenditure in the past thirty years. This has happened despite a long-term fall in the price of ingredients relative to processed food. The key to understanding this phenomenon is to recognize that the true cost of ingredients includes the opportunity cost of cooking time. which has increased rapidly due to wage growth.

We have developed a theoretical consumption model that explicitly allows time cost in the home production of food. We estimate a set of expenditure share equations that are derived directly from the model. This approach gives predictions of time trends that are similar to the observed. We found that the fall in the price of processed food relative to non-food is important in explaining the long-term shift of consumption away from ingredients and towards processed food. Our analysis shows that, as the shadow price of home cooked food depends so much on the wage, taxes on market prices unlikely to provide incentives for households to switch away from ready to eat food and consume more home cooked food. This discussion has been largely missing from the policy debates around these questions. There are other relevant aspects of the choices of use of time and food. For instance, what do parents do when they are not cooking? How much of the time saved by not cooking is allocated to investment in the human capital of their children?

A Data

The data used in this publication were made available through the ESRC Data Archive. Data from the Family Expenditure Survey, Expenditure and Food Survey and Living Costs and Food Survey is Crown Copyright and reproduced with the permission of the Controller of HMSO and the Queen's Printer for Scotland. Neither the original collectors of the data nor the Archive bear any responsibility for the analyses or interpretations presented here.

The references for these datasets are:

- Family Expenditure Survey; Department of Employment. (1993). Family Expenditure Survey, 1980. [data collection]. UK Data Service. SN: 3057, http://dx.doi.org/10.5255/UKDA-SN-3057-1; and all following years until 2000.

- Expenditure and Food Survey; Office for National Statistics, Department for Environment, Food and Rural Affairs. (2007). Expenditure and Food Survey, 2001-2002. [data collection]. 3rd Edition. UK Data Service. SN: 4697, http://dx.doi.org/10.5255/UKDA-SN-4697-1; and all following years until 2007.

- Living Costs and Food Survey; Office for National Statistics and Department for Environment, Food and Rural Affairs, Living Costs and Food Survey, 2008 [computer file]. Colchester, Essex: UK Data Archive [distributor], March 2010. SN: 6385.http://dx.doi.org/10.5255/UKDA-SN-6385-1; and all following years until 2013.

Apart from the prices, the data is a series of repeated cross sections of the UK Family Expenditure Survey, from 1980 to 2000. We extract a sample of households with or without children in which the head of household is between 25 and 64 years old. There are approximately 200 households per month, giving us a total of 45000 observations. The survey contains detailed information on expenditure on food and non-food non-durable expenditures, as well as socio-demographic information. There is also information on labour supply (participation and hours worked) and incomes.

The price data consists in about 30 series of price indices obtained from the ONS.

A.1 Food groups

Category	Description	Price index (RPI categories)
1. Ingredients		
Ingredients for cooking	Meat, eggs, fish, vegetables, butter, margarine, pasta, rice, legumes, oil, flour	beef, lamb, pork, bacon, poultry, oth_meat, fish, butter, oil_fats, eggs, pots, oth_vegs
Ingredients (also ready-to-eat)	Bread, cheese, cold and cooked meats cream, milk, yoghurt, fruit, juice, prepared fish	bread, cheese, fruit, milkprod, milkfres beef, lamb, pork, bacon, poultry, oth_meat, fish
2. Processed		
Drinks	Carbonated drinks, coffee, tea, hot choc, fruit juice, squash, bottled water	softdrin, tea, coffee
Ready meals	Ready meals, packaged and canned foods, breakfast cereals, pickles, sauces, soup, baby food	oth_food, cereals
3. Food out		
Takeway (eaten at home)	Take-away meals, sandwiches	takeaway
Meals out	Meals out, inc hot, cold and canteen, snacks eaten out, workplace meals	canteen, restaur
Sweets, snacks	Confectionary, ice cream, biscuits, cakes	biscuits, sug_pres, swe_choc
4. Non-food non-durables	Alcohol, tobacco, household services, personal goods and services, leisure goods and services	Alcohol, tobacco, household services, personal goods and services, leisure goods and services

A.2 Price indices

The shadow price of home-cooked food is the price per unit of home-cooked food. For clarity of exposition, let us call this unit a meal. The cost of a meal is thus the sum of the cost of the ingredients used to cook the meal and the cost of the time spent cooking the meal. The cost of the ingredients is the product of the quantity of ingredients by the price per unit of ingredient. Because we are talking about a composite good, ingredients, the price of this good is an index. The cost of the time spent cooking a meal is much more straightforward, it is the product of the time spent cooking by the wage.

B Elasticities

In this model, the Marshallian demands $f_j(p^*, Y)$ for the $j = c, r, m, s, x, l$ goods, home cooked food c, ready to eat food r, meals out m, take away and snacks s, outside good x and leisure l depend on the shadow prices of the goods p^* and on full income Y.

B.1 Shadow price of home cooked food

The shadow price of home cooked food is given by:

$$p_c^* = p_i + \frac{w_2}{Bn^{-\gamma}} \tag{B.1}$$

The derivative of the shadow price of home cooked food with respect to the price of ingredients is:

$$\frac{\partial \ln p_c^*}{\partial \ln p_i} = \frac{p_i}{p_c^*} \tag{B.2}$$

The derivative of the shadow price of home cooked food with respect to the price of time is:

$$\frac{\partial \ln p_c^*}{\partial \ln w_2} = \frac{1}{Bn^{1-\gamma}} \frac{w_2}{p_c^*} \tag{B.3}$$

B.2 Stone price index

The Stone price index is given by:

$$\ln P = \sum_k w_k^* \ln p_{k^*} \qquad for \quad k = c, r, m, s, x, l. \tag{B.4}$$

The derivatives of the Stone price index with respect to the prices of home cooked food, ready to eat food, meals out, snacks and the outside good, $(k = c, r, m, s, x)$, are given by:

$$\frac{\partial \ln P}{\partial \ln p_{k^*}} = w_k^* \tag{B.5}$$

The derivative of the Stone price index with respect to the price of time is:

$$\frac{\partial \ln P}{\partial \ln w_2} = w_c^* \frac{\partial \ln p_c^*}{\partial \ln w_2} + w_l^* \tag{B.6}$$

The derivative of the Stone price index with respect to the price of ingredients is:

$$\frac{\partial \ln P}{\partial \ln p_i} = w_c^* \frac{\partial \ln p_c^*}{\partial \ln p_i} \tag{B.7}$$

B.3 Full income

Full income is given by:

$$Y = y_0 + w_1\overline{h_1} + w_2(2T - \overline{h_1}) \tag{B.8}$$

The only good for which the derivative of full income with respect to its price is not zero is time, for which:

$$\frac{\partial \ln Y}{\partial \ln w_2} = \frac{w_2\left(2T - \overline{h_1}\right)}{Y} \tag{B.9}$$

B.3.1 Budget shares

The derivatives of the budget shares of goods $k = c, r, m, s, x, l$ with respct to the prices of goods $j = c, r, m, s, x$ are given by:

$$\frac{\partial w_k^*}{\partial \ln p_j^*} = \delta_{kj} - \beta_k \frac{\partial \ln P}{\partial \ln p_j^*} \tag{B.10}$$

For all goods $(k = c, r, m, s, x, l)$, the derivatives of the budget shares with respect to the price of time are given by:

$$\frac{\partial w_k^*}{\partial \ln w_2} = \delta_{kc}\frac{\partial \ln p_c^*}{\partial \ln w_2} + \delta_{kl} + \beta_k\left(\frac{\partial \ln Y}{\partial \ln w_2} - \frac{\partial \ln P}{\partial \ln w_2}\right) \tag{B.11}$$

The derivatives of the budget shares with respect to the price of ingredients are:

$$\frac{\partial w_k^*}{\partial \ln p_i} = \delta_{kc}\frac{\partial \ln p_c^*}{\partial \ln p_i} - \beta_k\frac{\partial \ln P}{\partial \ln p_i} \tag{B.12}$$

$$= \left(\delta_{kc} - \beta_k w_c^*\right)\frac{\partial \ln p_c^*}{\partial \ln p_i} \tag{B.13}$$

B.4 Income elasticities

For all goods, the income elasticities are given by:

$$\eta_j = \frac{1}{w_j^*}\frac{\partial w_j^*}{\partial \ln Y} + 1 \tag{B.14}$$

B.5 Marshallian elasticities

For all goods and their prices, the Marshallian elasticities are given by:

$$\eta_{jk}^M = \frac{1}{w_j^*}\frac{\partial w_j^*}{\partial \ln p_k^*} + \frac{\partial \ln Y}{\partial \ln p_k^*} - \epsilon_{jk} \tag{B.15}$$

where $\epsilon_{jk} = 1$ if $j = k$ and 0 otherwise.

The Marshallian elasticity of the demand for home cooked food with respect to the price of ingredients is given by:

$$\eta_{ci}^{M} = \frac{1}{w_c^*}\frac{\partial w_c^*}{\partial \ln p_i} - \frac{\partial \ln p_c^*}{\partial \ln p_i} \tag{B.16}$$

The Marshallian elasticities of the demands for ready to eat food, restaurant meals, snacks, the outside good and leisure with respect to the price of ingredients are given by, for $k = r, m, s, x, l$:

$$\eta_{ki}^{M} = \frac{1}{w_k^*}\frac{\partial w_k^*}{\partial \ln p_i} \tag{B.17}$$

B.6 Hicksian elasticities

The Hicksian elasticities of all the goods with respect to the prices of the goods for which the household does not have an endowment, are linked to the Marshallian elasticities by the standard formula:

$$\eta_{jk}^{H} = \eta_{jk}^{M} + \eta_j w_k^* \tag{B.18}$$

where $j = c, r, m, s, x, l$ and $k = c, r, m, s, x$.

The Hicksian elasticities of all the goods with respect to the price of ingredients are given by:

$$\eta_{ji}^{H} = \eta_{jc}^{H} * \frac{\partial \ln p_c^*}{\partial \ln p_i} \tag{B.19}$$

where $j = c, r, m, s, x, l$ and p_i is the price of ingredients.

The Hicksian elasticities of ready to eat food, the non food non durable good and leisure with respect to the price of leisure, for which the household has an endowment of time, are given by:

$$\eta_{jl}^{H} = \eta_{jl}^{M} + \eta_j \frac{w_2\left(l - 2T + \overline{h_1}\right)}{Y} \tag{B.20}$$

where η_{jl}^{H} and η_{jl}^{M} are respectively the Hicksian and Marshallian elasticities of the demand for good j with respect to the price of leisure, η_j is the income elasticity of the demand for good j, for $j = c, r, x, l$. The last term in the equation above is the budget share of the net quantity of leisure demanded by the household. Finally, the Hicksian elasticity of home cooked food with respect to the price of leisure is:

$$\eta_{jl}^{H} = \left(\eta_{jl}^{M} + \eta_j \frac{w_2\left(l - 2T + \overline{h_1}\right)}{Y}\right)\frac{\partial p_c^*}{\partial w_2} \tag{B.21}$$

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C Coefficient Estimates

Table C.1: *Estimated coefficients from standard demand model*

Ingredients	Processed	Food out	Snacks	Non-food

Notes: All regressions include month dummies.

Table C.2: *Estimated coefficients from standard demand model*

	Ingredients	Processed	Food out	Snacks	Non-food	Leisure
lrshadowp1	0.1126	0.0476	-0.0137	0.0300	-0.1592	-0.0174
	(.0201106)	(.0067941)	(.0056983)	(.0047343)	(.0223337)	(.0334686)
lrpcat2	0.1002	-0.0279	-0.0069	-0.0442	0.0330	-0.0542
	(.0208459)	(.0056157)	(.0066488)	(.0051451)	(.0268523)	(.0346552)
lrpcat3	-0.0853	0.0943	0.0218	0.0786	0.2139	-0.3233
	(.0388777)	(.0104881)	(.0113201)	(.0095313)	(.0444622)	(.0607007)
lrpcat4	-0.0847	0.0587	-0.0023	-0.0602	-0.0167	0.1051
	(.0350025)	(.0099769)	(.0100017)	(.0083382)	(.0439797)	(.0573507)
lrwagespouse	-0.0645	-0.0595	0.0037	-0.0283	-0.0098	0.1584
	(.0132541)	(.0046816)	(.003804)	(.0033317)	(.0147034)	(.021953)
lAK	0.0761	0.0378	-0.0082	0.0175	-0.1022	-0.0211
	(.005111)	(.0014647)	(.0014421)	(.0009954)	(.0050802)	(.00688)
lrY	-0.0972	-0.0240	0.0101	-0.0095	0.3151	-0.1944
	(.0036259)	(.0010159)	(.0013466)	(.0012203)	(.0054502)	(.0058299)
IMR	0.0142	0.0007	0.0077	0.0021	0.0442	-0.0688
	(.0026885)	(.0009059)	(.0011622)	(.0008058)	(.0044979)	(.0054243)
agecedspouse	0.0017	0.0001	0.0005	-0.0001	0.0043	-0.0065
	(.0003618)	(.0000906)	(.0000988)	(.0000643)	(.0004316)	(.0005499)
anykid	-0.0368	-0.0113	-0.0125	-0.0110	-0.0759	0.1475
	(.0040621)	(.001186)	(.0012923)	(.0008745)	(.0052502)	(.0068162)
ageynghh	0.0023	0.0007	0.0008	0.0009	0.0051	-0.0098
	(.0002232)	(.0000688)	(.0000873)	(.0000551)	(.000303)	(.0003918)
agespouse	0.0071	0.0007	0.0004	-0.0010	0.0057	-0.0128
	(.0008082)	(.0001832)	(.0002042)	(.000152)	(.0008607)	(.0011047)
age2spouse	-0.0001	-0.0000	-0.0000	0.0000	-0.0001	0.0002
	(.0000101)	(2.25e-06)	(2.58e-06)	(1.91e-06)	(.0000108)	(.0000137)
cons	0.0000	0.0000	0.0000	0.0000	1.0000	0.0000
	(0)	(0)	(0)	(0)	(0)	(0)
MONTH2	-0.0023	0.0018	0.0019	0.0014	-0.0017	-0.0011
	(.0027775)	(.0007959)	(.0008361)	(.0006494)	(.0027587)	(.0038772)
MONTH3	-0.0039	0.0041	0.0018	0.0016	-0.0013	-0.0023
	(.0025767)	(.0008938)	(.0008597)	(.0007307)	(.0030786)	(.0039653)
MONTH4	-0.0036	0.0051	0.0020	-0.0008	0.0014	-0.0041
	(.0029105)	(.0008451)	(.0009064)	(.0005758)	(.003085)	(.0043421)
MONTH5	-0.0030	0.0023	0.0017	0.0010	0.0025	-0.0045
	(.0029428)	(.0007828)	(.0008293)	(.0005903)	(.0030642)	(.004144)
MONTH6	-0.0027	0.0034	0.0012	0.0009	0.0044	-0.0071
	(.0028478)	(.0007864)	(.0007573)	(.0005472)	(.0028595)	(.0041125)
MONTH7	-0.0097	0.0027	0.0036	0.0014	0.0092	-0.0071
	(.0031232)	(.0008508)	(.0009225)	(.0006498)	(.0035178)	(.0046744)
MONTH8	-0.0114	0.0020	0.0043	-0.0002	0.0074	-0.0021
	(.003036)	(.0008278)	(.0009414)	(.0005532)	(.0032)	(.0046455)
MONTH9	-0.0100	0.0009	0.0015	0.0009	0.0040	0.0028
	(.0028444)	(.0007198)	(.0008679)	(.0005304)	(.0032366)	(.0039434)
MONTH10	-0.0056	0.0023	0.0016	0.0013	0.0017	-0.0014
	(.0026295)	(.0008371)	(.0008054)	(.0005824)	(.0027704)	(.0037946)
MONTH11	-0.0050	0.0049	0.0017	0.0011	0.0123	-0.0150
	(.0025835)	(.0008432)	(.0007438)	(.0005933)	(.003232)	(.0042647)
MONTH12	0.0104	0.0086	0.0044	-0.0018	0.0174	-0.0391
	(.0033585)	(.0009135)	(.0008844)	(.0005686)	(.0036024)	(.0048455)

Notes: All regressions include month dummies.

Table C.3: *Description of shares*

stat	Ingredients	Processed	Food out	Snacks	Non-food	Leisure
min	0	0	0	0	.0089619	-.1093647
mean	.0009747	.0005714	.232111	.018183	0	0
p50	.1341526	.0451121	.0057212	.0167039	.1856752	.5733541
max	.7869169	.3799926	.3908245	.6592084	.9409735	.9735584
mean	.1425077	.0494175	.0149349	.021043	.2086792	.5634177