The decline of home cooked food

The decline of home cooked food

Rachel Griffith, Wenchao (Michelle) Jin and Valérie Lechene *

March 22, 2022

Abstract

The share of home-cooked food in the diet of UK households declined from the 1980s. This was contemporaneous with a *decline* in the market price of ingredients for home cooking relative to ready-to-eat foods. We consider a simple model of food consumption and time use which captures the key driving forces behind these apparently conflicting trends. We show that observed behaviour can be rationalised by the fact that the shadow price of home-cooked food, which accounts for the fact that cooking takes time, has risen relative to the price of ready-to-eat food, due to the increase in the market value of time of secondary earners. We discuss the implications for policies that aim to encourage healthier diets.

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

JEL codes: D12, D13, I12

*Griffith is at the University of Manchester and the Institute for Fiscal Studies, rgriffith@ifs.org.uk; Jin is at University College London and the Institute for Fiscal Studies, wenchao_j@ifs.org.uk; Lechene is at University College London and the Institute for Fiscal Studies, v.lechene@ucl.ac.uk. We gratefully acknowledge financial support from the European Research Council (ERC) under ERC-2009-AdG-249529 and ERC-2015-AdG-694822, and the Economic and Social Research Council (ESRC) under the Centre for the Microeconomic Analysis of Public Policy (CPP), grant number RES-544-28-0001. We would like to thank Tom Crossley, who was a coauthor on an earlier version of this work and who helped us all very much, and Zoe Oldfield for her assistance with setting up the data.

1 Introduction

Households in the developed world have shifted away from home-cooked food towards ready-to-eat food. In the UK, home-cooked food represented more than half 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 other non-communicable disease (Adams et al., 2020), and there is considerable interest in understanding what has driven this change in order to help design policies to reverse it.

Our contribution in this paper is twofold. First, we document a number of interesting trends. Both the price of ingredients for home cooking and that of ready-to-eat alternatives (at home) decreased over the period 1980 to 2000, with ingredients decreasing by relatively *more*. Assuming that both types of food are normal goods, then we would expect the consumption of ingredients to increase, both because of the substitution and the income effect. Real income growth in the period would reinforce these effects. However, we show that real consumption of ingredients has fallen.

Our second contribution is to show that an increase in the opportunity cost of time for secondary earners (largely females) helps to explain the shift from ingredients used for home cooking to ready-to-eat foods. Using the insight from Becker (1965), that consumption comes from the combination of market goods and time, a simple model of food demand and time use with home production allows us to recover the shadow price of home-cooked food. This incorporates the opportunity cost of time as well as the price of ingredients and returns to scale in food preparation. We estimate the opportunity cost of time of secondary earners and show that the rising opportunity cost of time has increased the shadow price of home cooking, which helps to explain the shift from ingredients used for home cooking to ready-to-eat foods.

The decline in home-cooked food is contemporaneous with a rise in labour market participation and wages. We show that in the cross section the expenditure share on home-cooked food is negatively correlated with female employment and wages, 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 and a reduction in household size led to a reduction in demand for home-cooked food.

In order to better understand the implications of these trends, we write down a simple model of demand that incorporates home production of food with heterogenous time costs and two adults contributing time to home cooking. We incorporate the trade offs between purchasing ingredients for cooking or purchasing ready-to-eat food. 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.

We use the UK Family Expenditure Survey and distinguish labour intensive and non labour intensive food. We are able to track consumption, prices, wages and labour market participation over the period 1980 to 2000. Women's employment rate and hours worked have increased, as have real wages, making time spent cooking more costly in terms of foregone earnings. To find the shadow price we have to impute the value of time, i.e. a potential wage for the individuals that are not working. We estimate a heckman selection equation to recover wages for women not participating in the labour market. Putting this together with market prices we show that increases in the opportunity cost of time help 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.

Our paper relates closely to the literature that establishes the importance of non-separabilities between consumption and time use (Browning and Meghir, 1991). For example, Blow et al. (2014) reject separability between time use and consumption in preferences using data for the US. 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 (2017), with economies of scale in food preparation.

Our work is motivated by the literature that shows that the increase in the consumption of ready-to-eat or processed foods has been linked to adverse health outcomes, such as obesity, as well as to negative impacts on cognitive outcomes, particularly amongst children.[1] This has led to calls for policy intervention aimed at changing eating habits,[2] and promoting a healthy, balanced diet, most recently in the UK by the establishment of the independent National Food Strategy.[3] It is also motivated by the literature that seeks to understand why obesity has increased, and what role prices have played[4]

The structure of the paper is as follows. In section 2 we describe trends in the evolution of food consumption and market prices. In section 3 we summarise changes in labour market participation,

[1] Adams et al. (2020), 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).

[2] See, amongst others, Bhattacharya and Sood (2011), Brunello et al. (2009), Finkelstein and Zuckerman (2008), Gortmaker et al. (2011), Philipson and Posner (2008), Dobbs et al. (2014))

[3] https://www.nationalfoodstrategy.org/

[4] Bleich et al. (2008), Cutler et al. (2003), Lakdawalla et al. (2005) Lakdawalla and Philipson (2007), Lakdawalla and Philipson (2009), Lu and Goldman (2010), Philipson and Posner (2003), Swinburn et al. (2009), Gomis-Porqueras et al. (2011)

wages, and time use. In section 4 we present a simple model of food consumption and time use with home production and discuss the implications for shadow prices. A final section provides a discussion of the implications.

2 Trends in food consumption and market prices

We use data on expenditure, wages, employment and hours of work for a sample of 27,193 households from the UK Family Expenditure Survey. Details about these data are provided in Appendix A.1.

We restrict our attention to 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 do this because 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. Employment rate of male heads of household in the age range 25-60 in the UK is high, and there is very little variation in hours worked (conditional on working full-time), meaning that the assumption that hours are exogenous is not very restrictive.[5]

Importantly, our analysis does not include single-adult households. It's possible that time spent cooking varies for this group, for example, single-adult households might cook less due to lack of scale. An increase in share of single-adult households could have contributed to the rise of processed food in aggregate, and could have important implications for policy; that is not something we study here.

We use data for the period 1980-2000; we stop in 2000 for a number of reasons. First, the main change in labour market participation that we are interested in occured over the 1980s and 1990s, and the shares of ingredients and processed food are relatively stable after 2000. Second, the way the data was collected changes in 2000 making the time series of disaggregated products awkward to compare over this period.

In order to empirically investigate the shift away from home cooking we have to be able to distinguish ingredients for home cooking from processed foods. The distinction that we make in this paper is in terms of time required to prepare food before it can be eaten versus foods which can be eaten with minimal preparation time. To our knowledge this distinction has not been implemented with detailed household level data, and one of the contributions of this paper is to make this empirical distinction. However, the distinction is not a clean one, since some foods can both be eaten raw and

[5] Of men who live in a couple aged 25-60 and are in employment, 96% work full-time over this period. Averaged hours of work for those working full time is 40 on average, 37 at the 10th percentile and 55 at the 90th percentile.

combined with time to make meals. Milk is an obvious example. For our purposes in this paper we have taken the view that a broad categorisation into three categories is sufficient. For other purposes, for example, for estimating a structural model of demand, it is likely that further disaggregation would be necessary.

The FES data records details of expenditure on 367 food categories. We map these into three categories - **ingredients**, which typically can be eaten as they are and do not need to be combined with time to make home-cooked food, **processed** food that is eaten at home, which either can be eaten in their natural state, or which have already been combined with time (by a firm) to make them edible, and so takes minimal time input, and **food out**, which has already been combined with time (by the retailer) to make them edible and is eaten outside of the home (meals out, take aways and snacks). This categorisation is summarised in Table A.2 in Appendix A.

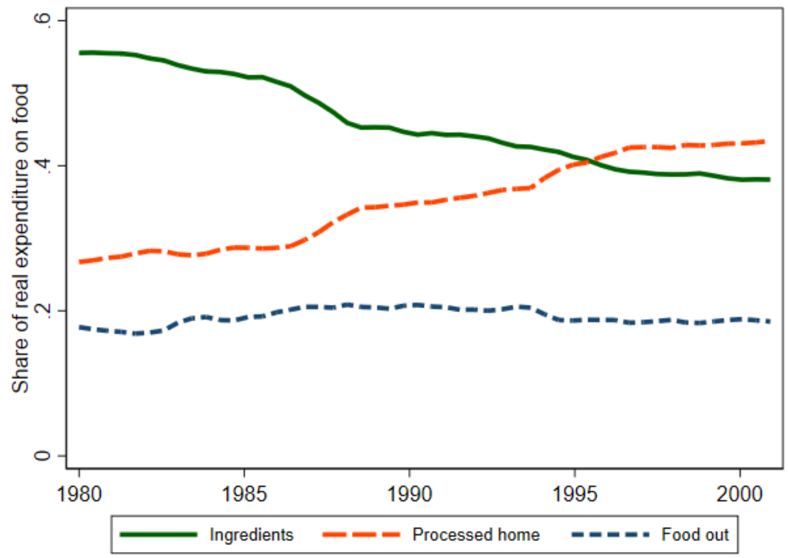
We use the ONS Retail Price Index (RPI) price series to construct a price index for each of the food categories, as indicated in Table A.2. The price data consists in about 30 series of price indices obtained from the ONS.[6]

The share of real expenditure on ingredients for home-cooked food declined dramatically from 1980 to 2000, see Figure 2.1. In 1980, on average, 57% of the food budget was allocated to ingredients for home-cooked food, with the remainder 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 fallen to 35%. The share of processed food for home consumption had risen from 26% to 45% while the share of expenditure on meals out, take away and snacks has remained fairly stable at just under 20%.

Market prices for ingredients for home cooking and processed foods for home consumption fell over the 1980s and 1990s (relative to the price of non-food items). The market prices of ingredients fell by around 30%, and the prices of pre-prepared foods by around 20%. Over the same period, the price of food out increased by close to 20% (more for take aways and snacks than for meals out), as shown in Figure 2.2.

[6]We use RPI prices and RPI weights from the ONS dataset "Consumer price inflation time series (MM23)", at https://www.ons.gov.uk/economy/inflationandpriceindices/datasets/consumerpriceindices. The RPI categories are bread, beef, and so on, as listed in table A.2.

Figure 2.1: *Real food expenditure shares by food category*

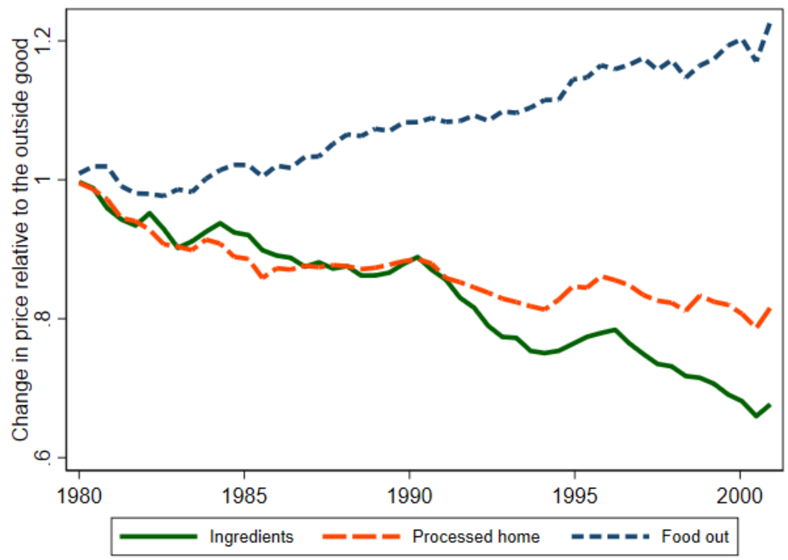


Note: Sample of 27,193 households with two adults aged 25-60, with any number (including zero) of dependent children. Lines are fitted local polynomials. Shares are expenditure shares in constant 1980 prices.

In real terms, the average expenditure on ingredients shrank by 19% over the period, while that of processed food increased by 89% (see Figure A.1 in Appendix A.1). This leads to a puzzle. The prices of both ingredients and pre-prepared food declined from 1980 to 2000, yet the consumption of ingredients has fallen while that of pre-prepared food has increased. It is not possible to rationalise these trends with standard models of demand, where food is typically either modelled as one composite good in preferences, or home cooked food and processed food are substitutes in preferences. The relative decline in price should cause a substitution from pre-prepared food towards ingredients. Assuming that both are normal goods, then income growth over the period should also lead to increases in the real quantities consumed.[7] Thus, the decline in the real consumption of ingredients is particularly puzzling.

[7]The income effect could be smaller on ingredients than on processed food, if processed food is more of a luxury food and ingredients more of a necessity.

Figure 2.2: *Change in market prices of foods*



Note: Lines are the expenditure weighted aggregated price indices for the relevant categories shown in Table A.2. The outside good includes all non-durable non-food consumption, including alcohol, tobacco, household services, personal goods and services, and leisure goods and services.

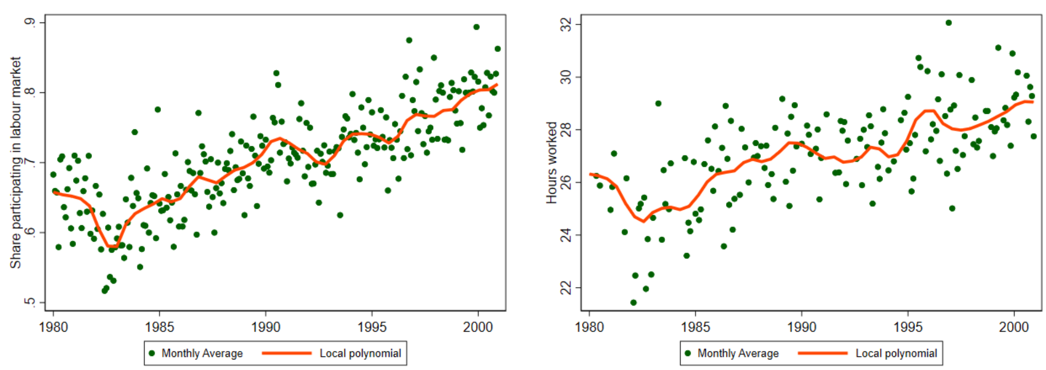
One important difference in these goods is that ingredients require time for preparation, while processed foods are pre-prepared and require no time (or at least much less time than ingredients). Therefore changes in the opportunity cost of time are an obvious candidate to help explain these trends. Another possibility is that the quality and variety of processed food may have improved a lot more than ingredients. This could be interpreted either as the observed price increase in processed food overstates the truth, or as a reason for preferences to shift towards processed food. If the true quality-adjusted price of processed food has fallen by more than 10% below the official measure, then in theory, the substitution effect could lead to a shift from ingredients to processed food. However, it would take a much bigger measurement error and a large substitution elasticity to cause the huge shift we observe in Figure 2.1. Meanwhile, we don't have a strong reason or evidence base to think the ONS's own attempt at quality adjustment in constructing their price indices are severely inadequate. Similarly, it's hard to find evidence for how preferences have shifted. One could even make the opposite conjecture that preferences have shifted towards home-cooked food as consumers become more health conscious. Therefore, we take the neutral stance of assuming stable preferences and using official measures of prices.

3 Trends in employment, wages and time use

The 80s and 90s saw subsantial changes in women's uses of time. Across all females the employment rate was relatively low to start with (57% in 1975) and increased substantially to close to 75% around the mid-and-late 2000s (Roantree and Vira, 2018). In our sample the female employment rate was around 55%, but has increased significantly over this period to about 80% in 2000, see figure 1(a). Conditional on working, average weekly hours for women have increased from about 22 to 33 hours, see figure 1(b). Altonji and Blank (1999) and Costa (2000) document similar trends in female labour market participation for the US. Most working age males in the UK worked in the labour market over this period, and most worked full-time.

Figure 3.1: *Labour market participation of females*

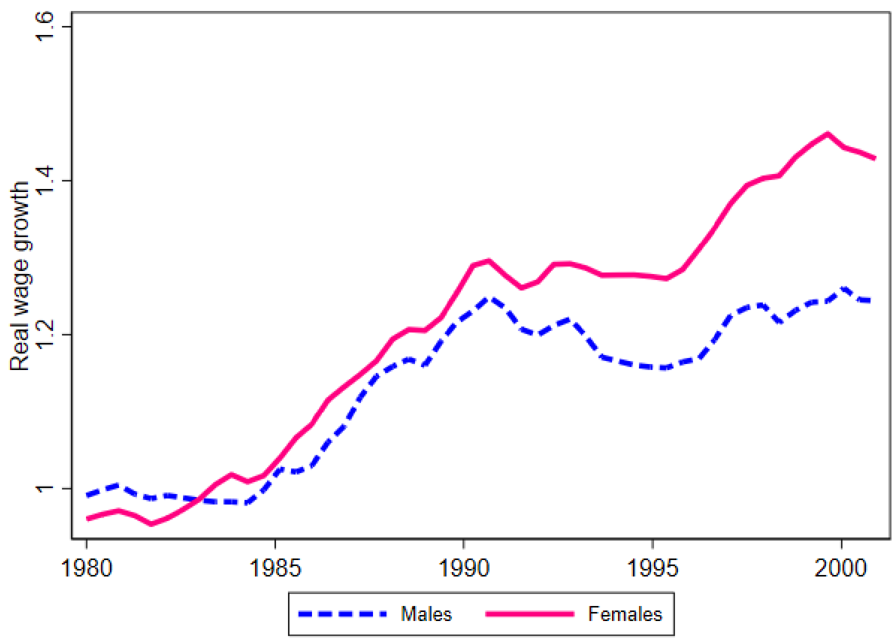
(a) Employment rate (b) Hours worked, conditional on working



Note: the dots in the left-hand graph shows the proportion of women who were working each month, and the line is a local polynomial fit. In the right-hand graph, the dots are the weekly working hours of women conditional on working, averaged for each month, and the line is a local polynomial fit.

Real wages have grown for both males and females, but more so for females, as shown in Figure 3.2. Wage growth over this period has been around 40% for females and 20% for males.

Figure 3.2: *Real wages of head and secondary earners, conditional on participation*



Note: Local polynomial fit of wages deflated by the price of the outside good, and normalized to 1 in January 1980.

3.1 Time use

On average, time spent on home preparation of food has declined. To describe this we use the UK Time Use Survey 2000 (TUS, Office for National Statistics (2003)) and the People's Activities and Use of Time, 1974-1975 (PAUT, BBC (2014)). Details about these data are provided in Appendix **??**.

From the TUS we have a measure of time spent on food management by a sample of 1,005 males and females living in couples where both adults are aged 25-60, where the man is employed full time (excluding self-employed). From the PAUT we have a sample of 408 couples where both adults are aged 25-60 and the man works full-time.

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, see Table A.3. The gender gap is much bigger in the subsample of couples where the female does not work, than the ones where the female works.

In 1974-5, the average female time on food management was higher at 13.3 hours (compared to 8.3 in 2000). In Appendix **??** we show that this decline in female hours spent on food preparation is observed across the distribution, not only at the mean. 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 3.1: *Time spent on food management*

	Female		Male	
	1974	2000	1974	2000
As main activity	13.3	8.3	1.3	3.3
As secondary activity	1.6	0.6	0.3	0.2
Female not in work	-	11.4	-	2.8
Female in work	-	7.4	-	3.4

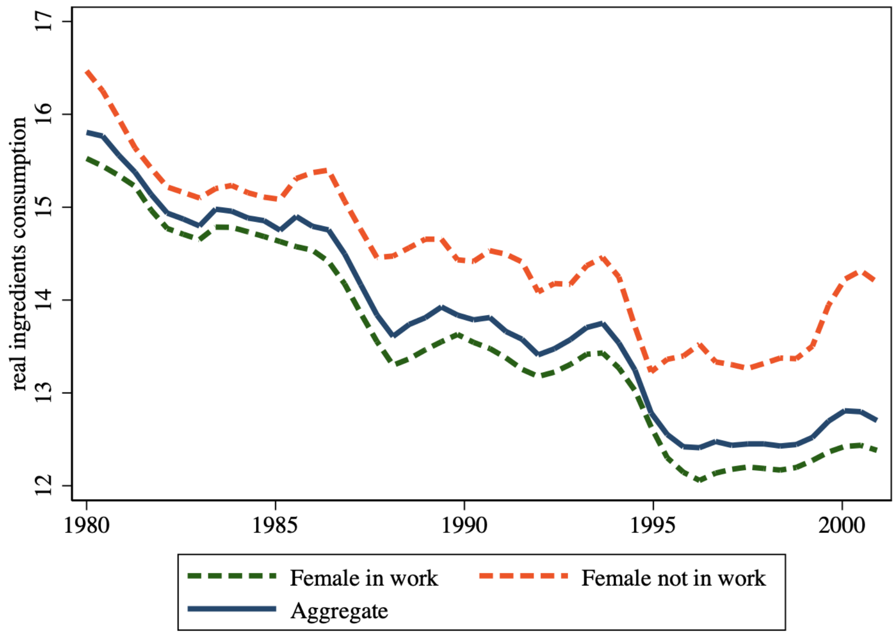
Note: Sample of 25-60 year old couples where the male is employed full-time. Sources: UK Time Use Survey 2000 (TUS) and the People's Activities and Use of Time, 1974-1975 (PAUT)

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.

3.2 The correlation between home cooking and household characteristics

Table A.3 shows that women in work spend less time cooking on average than women not in work. Therefore, the increasing share of women in work would in itself reduce the average level of ingredients consumption. We also see that real consumption of ingredients has fallen for both groups, but is lower and has fallen by more for households where the female works, see figure 3.3.

Figure 3.3: *Real household consumption of ingredients, by female employment*



Note: Local polynomial fit of real consumption of ingredients, in January 1980 prices.

We expect families with a lower cost of time and a larger number of children to choose more home-cooked food. This intuition is confirmed by cross-sectional correlations in both expenditure data and time use data.

In Table 3.2 we report conditional correlations between the share of ingredients in food consumption and household characteristics. We see that the share of ingredients (home-cooked food) is positively correlated with the number of children, negatively correlated with female employment, her hours (if working), and both his and her wages (proxies for the cost of time).

Table 3.2: *Cross section correlation between share of ingredients in food expenditure and demographics*

	(1)	(2)	(3)	(4)
has one child	0.0153***			
	(0.0024)			
has two children	0.0143***			
	(0.0022)			
has $\geq$ 3 children	0.0229***			
	(0.0028)			
female in work		-0.0400***		
		(0.0017)		
female working hours			-0.0010***	
			(0.0001)	
male working hours			-0.0002	
			(0.0001)	
female log real wage				-0.0165***
				(0.0027)
male log real wage				-0.0289***
				(0.0027)
Observations	27075	27075	18878	18878
Adjusted R^2	0.227	0.241	0.236	0.237

Standard errors in parentheses

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

Note: Dependent variable is the share of ingredients in the household's real food expenditure. Reported estimates are from 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. All the regressions include female age, age squared, years of education, year and month dummies.

Cross-sectional correlations in the 2000 Time Use Survey paint the same picture; details are provided in Appendix A.2. 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. Women's time spent on food management is negatively correlated with her own wage, and positively correlated with the number of children. Interestingly, men's time on food management is not strongly correlated with the number of children.

4 A simple model

In order to investigate these correlations further we write down a simple model that allows us to recover the shadow price of cooking and to see how it has changed over time.

We model consumption and time use, with home production of food. Households consist of n people, equal to two adults with any number K of children (including none). Utility is derived from household food consumption f (which is private); a non-food non-durable composite good x, which exhibits some degree of publicness; and leisure l. We allow for heterogeneity by allowing demographic composition to enter as price deflators following Barten (1964), Deaton and Paxson (1998), Crossley and Lu (2017) and Lewbel and Pendakur (2017).

We specify a utility function that corresponds to a unitary model of the household:

$$\max_{f,x,l} U(f, \frac{x}{n^{\theta-1}}, l), \tag{4.1}$$

$\theta \in [0, 1]$ captures potential 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 are assumed to be perfect substitutes in preferences. We assume that male 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:

$$f = f(r, c), \tag{4.2}$$

where c is home cooked food and r is ready to eat food, both at the household level.

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:

$$c = min[i, \frac{Bt}{n^{\gamma-1}}]. \tag{4.3}$$

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 number of people catered for, 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:

$$t_s + l_s + h_s = T \qquad s = 1, 2. \tag{4.4}$$

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.

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

$$p_r r + p_i i + p_x x = y_0 + w_1 \overline{h_1} + w_2 h_2, \tag{4.5}$$

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. Prices and wages are assumed to be exogenously determined.

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:

$$c = i = \frac{Bt}{n^{\gamma - 1}} \tag{4.6}$$

so that:

$$i = c \qquad \text{and} \qquad t = \frac{c}{Bn^{1-\gamma}}. \tag{4.7}$$

We can substitute for ingredients i and time spent cooking t in the budget constraint. Because of the assumption that the time inputs of both household 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, it is w_2, the wage of the woman, or secondary earner. The budget constraint in terms of full time income, and final consumption, where the time of the primary earner is valued at the wage of the secondary earner, is therefore:

$$\left(p_i + \frac{w_2}{Bn^{1-\gamma}}\right) c + p_r r + \left(\frac{p_x}{n^{1-\theta}}\right)\left(\frac{x}{n^{\theta-1}}\right) + w_2 l = y_0 + w_1 \overline{h_1} + w_2 T + w_2(T - \overline{h}_1), \tag{4.8}$$

Let k^* and p_k^* respectively denote the quantity demanded for final good consumed k and its shadow price. The household's problem can be re-written, in terms of quantities of final goods consumed and shadow prices, as:

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

where the shadow prices are related to the market prices as:

$$p_c^* = p_i + \tfrac{w_2}{Bn^{1-\gamma}} \qquad c^* = c$$

$$p_r^* = p_r \qquad r^* = r$$

$$p_x^* = \tfrac{p_x}{n^{1-\theta}} \qquad x^* = \tfrac{x}{n^{\theta-1}}$$

$$p_l^* = w_2 \qquad l^* = l$$

Our object of interest, the shadow price of home cooked food, is $p_c^* = p_i + \frac{w_2}{Bn^{1-\gamma}}$. Home cooked food results from the combination of ingredients and time, so the shadow price of home cooked food involves the market price of ingredients and the opportunity cost of time for the household, the wage of the unconstrained individual (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). The shadow price of home cooked food is increasing in the price of ingredients, in the wage of the unconstrained individual and decreasing in household size. It does not depend on the woman's hours worked; instead, the latter is an endogenous outcome of the model and is likely to be correlated with wages and prices.[8]

[8]Female's non-working hours $= (t_1 + t_2) + (l_1 + l_2) - (l_1 + t_1)$. The last term is constrained. The first two terms are likely to be decreasing in female wage.

The model does not yield any prediction on how leisure or cooking time is split within the household. The model only has implications for $t_1 + t_2, l_1 + l_2$, and since $l_1 + t_1$ is constrained by the man's work, any marginal change in t_1 is compatible with the same change in l_2 and the opposite change in l_1, t_2. We have chosen to abstract from intra-household allocation of time since our main motivation is to the explain the decline in home-cooked food consumption, regardless of who does the cooking within the household.

An increase in the wage of the secondary earner corresponds to an increase in the shadow price of home cooked food. This leads to 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.

As well as increasing in the opportunity cost of time, the shadow price of home cooked food is decreasing in the number of people in the household. If cooking is more efficient in larger households, the shadow price of home-cooked food will be lower for larger households. While there has been a reduction in household size in the UK overall, this is largely due to an increase in single person households. Since we analyse the behaviour of households composed of two adults and any number of children, economies of scale did not play an important role quantitatively for these types of households.

The shadow price of home cooked foods is also reducing in cooking technology. We hold this constant as we do not have any information to suggest that this has changed substantially over this period.

4.1 Wages

One challenge we face in calculating the shadow price of ingredients is that we do not observe wages for secondary earners who are not currently in the labour market. Which secondary earners choose to participate in the labour market and which do not may be endogenous (i.e. related to demand or preference shocks). To get around this problem we use data on all households to estimate a wage equation controlling for selection by estimating participation status. This allows us to compute wages for all secondary earners.

Details of how we do this are provided in Appendix B, we provide a brief description of our approach here.

We estimate wages using the Heckman two-step estimation. Each individual has a potential wage, W_i^p, if they participate in the labour market, and a reservation wage, W_i^r, that dictates whether they participate. Variables that shift both participation and reservation wage include the woman's age, age squared, age cubic, the woman's education in seven bands and year dummies. Variables that shift only the participation wages include dummies for eleven regions of the UK based on where the household resides and interactions between year dummies and four broader region dummies, so as to control for local labour market conditions. Variables that shift only the reservation wage include a dummy for whether there are children present in the household, the number of children, a 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.

Our estimated selection equation results are as expected: the probability to participate is increasing in the education of the secondary earner, 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.

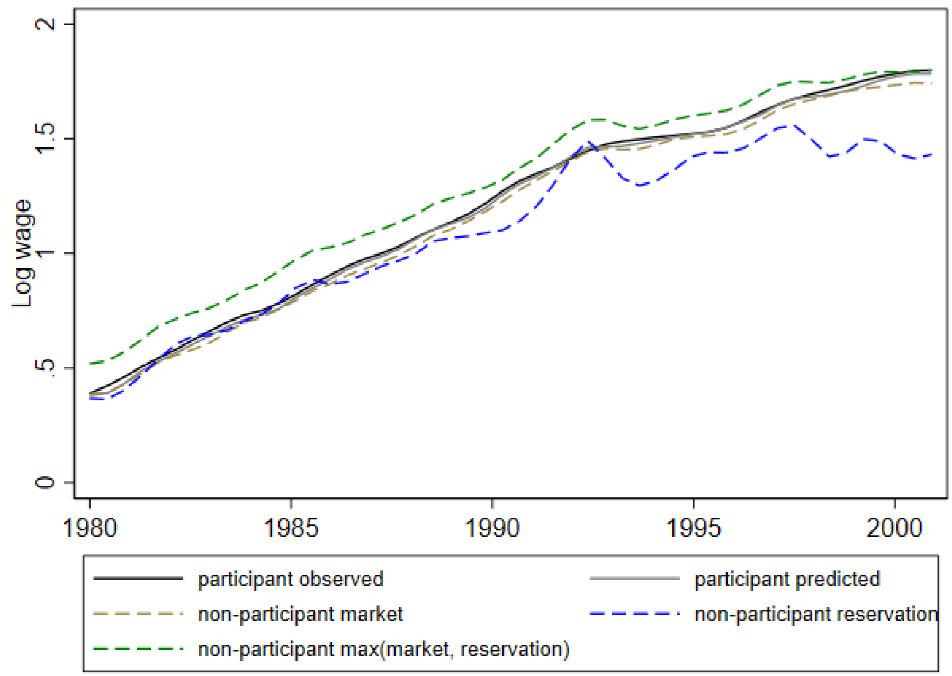
We use the estimated coefficients from the wage equation, along with estimates of the scale parameter, to predict market wages and reservation wages.

Figure 4.1 shows the predicted log wage from our model for participants and non-participants and the actual log wage for participants through time. 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.[9]

In our analysis below when we construct the shadow price of ingredients we use the predicted wage. For non-participants we use the maximum of the predicted wage and predicted reservation wage, since their value of time must be greater than their potential wage if they choose not to work.

[9] The mean predicted log reservation wage lags behind the market wage substantially in the last 5 years of our sample period. We check that this is not driven by outliers.

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



Note: Market and reservation wages as defined by equations B.4 and B.5.

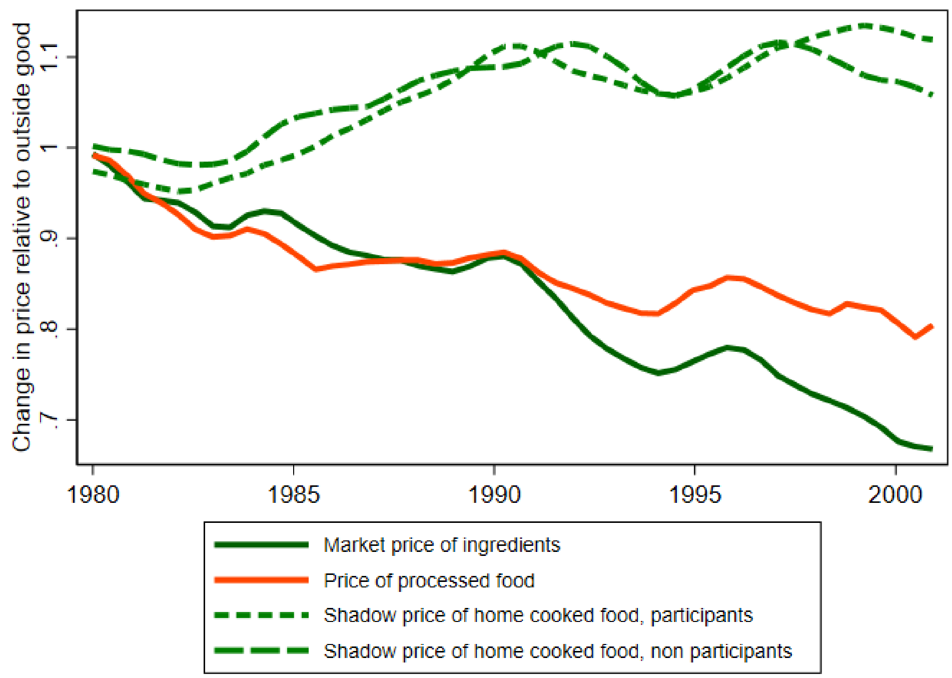
4.2 Shadow price of home-cooked food

We use the estimates from the wage equation to calculate the shadow price of home cooked food to see how this has change over the period. The shadow price of home cooked food is given by $p_c^* = n(p_i + \frac{w_2}{Bn^{1-\gamma}})$. We calibrate the returns to scale parameter $\gamma = 0.8$ 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.[10] When computing the shadow price of home cooked food, we use the observed wage for the participants and the maximum of the market wage and reservation wage for non-participants. We show their time path in figure 4.2, together with the market prices of ingredients and of processed foods. We express all these prices relative to the price of outside good. The outside good includes all non-durable non-food consumption, including alcohol, tobacco, household services, personal goods and services, and leisure goods and services. For

[10]The 2 most common values of K are 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 (4.7), the implied weekly hours would be 10.9 for those without kids and 12.6 for those with 2.

participants on average, the cost of time constituted 57% of the shadow price in 1980, rising to 73% in 2000. For non-participants, the share of time cost in shadow price increased from 62% to 75% over the same period.

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



Note: All prices are relative to the price of the outside good, and assume the outside good is private.

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 the dashed lines in figure 4.2. The increase is 14% for labour market participants and 5% for non-participants. Thus, overall, the true cost of home-cooked food has increased in the UK over the sample period.

There are a number of caveats we should make to this result. Our estimate of the shadow price of home-cooked food could be mismeasured for a number of reasons. In our view it is unlikely that these are large enough to reverse our claim that the shadow price has increased over time, but we not able to show that conclusively in this paper.

One issue is that fertility choices are endogenous and likely correlated with female labour supply decisions. This introduces a negative correlation between female work and economies of scale in cooking, and may bias our estimates of the shadow cost of home-cooking, due to differential wages between part-time and full-time work. This is a limitation of our analysis that could potentially be addressed by modelling differential female wages in part-time and full-time work. We leave that analysis for future work.

A second issue is that it is generally difficult to predict the cost of time for non-working women. Conceptually, the marginal cost of time for an individual who has chosen not to work might even be lower than their market wage, due to fixed costs of working. In addition, there could be unobserved cross-sectional differences in preferences, which means the finding that working women cook less is not necessarily inconsistent with them having higher or lower cost of time.

The fact that we find an increasing shadow price for working women and declining ingredients consumption among them provides some support for our interpretation. In addition, our imputed wages for non-working women are likely to over-estimate their marginal cost of time. We use the maximum of the market wage and reservation wage for non-participants. Due to fixed costs of working, once they have decided not to work, their marginal cost of time might be lower than both their market wage and their reservation wage. The proportion of non-working women decreases over time, so the extent of over-estimation of the mean shadow price for this reason would decreases over time, and so the true mean shadow price would increase more than in our calculation.

These are interesting issues that merit further investigation, but are beyond the scope of this paper. While there may be systematic errors in the imputed time cost for non-participants, we believe that it is unlikely to affect our main conclusion in this paper.

5 Summary and final comments

There has been a significant decline in UK households' consumption of ingredients in the past thirty years, both in real quantities terms and relative to the total food consumption. 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 written down a simple model of consumption that explicitly incorporates the time cost involved in the home production of food, this allows us to derive the shadow price and show that this has risen. Thus, our analysis offers an intuitive and data-based explanation to the real decline in ingredients consumption, without resorting to unobserved shifts in preferences or quality.

These facts have implications for policy that aims to encourage healthier diets. Our analysis shows that the shadow price of home cooked food depends as much on the wage as on the market price. Taxes or subsidies to market prices would have to be large to provide incentives for households to switch away from ready to eat food all together and to consume more home cooked food, unless they were accompanied by changes in time use. These wouldn't have to be a reduction in labour market participation by secondary earners, but could instead be driven by changes in preferences for leisure activities (for example, substituting cooking for other leisure activities).

These results also suggest that policies that led to improvements in the nutritional characteristics of processed foods, for example, by encouraging firms to reformulate, might be more effective than policies that focus only on increasing home cooking. In terms of future avenues of work, there are many unanswered questions on the relationship between time use and consumption that could fruitfully be explored.

References

Adams, J., K. Hofman, J.-C. Moubarac, and A. M. Thow (2020, June). Public health response to ultra-processed food and drinks. *BMJ 369*, m2391.

Altonji, J. G. and R. M. Blank (1999). Chapter 48 Race and gender in the labor market. In *Handbook of Labor Economics*, Volume 3, pp. 3143–3259. Elsevier.

Anderson, P., K. Butcher, and P. Levine (2003a, January). Economic Perspectives on Childhood Obesity. *Economics Faculty Scholarship*.

Anderson, P. M., K. F. Butcher, and P. B. Levine (2003b). Maternal employment and overweight children. *Journal of Health Economics 22*(3), 477–504.

Barten, A. P. (1964). Consumer Demand Functions under Conditions of Almost Additive Preferences. *Econometrica 32*(1/2), 1–38.

Baum, C. L. and S. Y. Chou (2011). The Socio-economic Causes of Obesity. *NBER Working Paper*, 1–47.

BBC (2014). People's Activities and Use of Time, 1974-1975, SN 1425. http://doi.org/10.5255/UKDA-SN-1425-1.

Becker, G. S. (1965). A Theory of the Allocation of Time. *Economic Journal 75*, 493–517.

Bhattacharya, J. and N. Sood (2011). Who pays for obesity? *Journal of Economic Perspectives 25*(1), 139–158.

Bianchi, S., M. Milkie, L. Sayer, and J. Robinson (2000, September). Is Anyone Doing the Housework? Trends in the Gender Division of Household Labor. *Social Forces 79*(1), 191–228.

Bleich, S., D. Clutler, C. Murray, and A. Adams (2008). Why is the developed world so obese? *Annual Review of Public Health 29*, 273–295.

Blow, L., V. Lechene, and P. Levell (2014, July). Using the CE to Model Household Demand. *NBER*, 141–178.

Browning, M. and C. Meghir (1991, July). The Effects of Male and Female Labor Supply on Commodity Demands. *Econometrica 59*(4), 925.

Brunello, G., P. C. Michaud, and A. Sanz-de-Galdeano (2009). The rise of obesity in Europe: An economic perspective. *Economic Policy 24*(59), 553–596.

Case, A., D. Lubotsky, and C. Paxson (2002). Economic status and health in childhood: The origins of the gradient. *The American Economic Review 92*(5), 1308–1334.

Cawley, J. (2000, August). Body Weight and Women's Labor Market Outcomes. Working Paper 7841, National Bureau of Economic Research.

Costa, D. L. (2000, December). From Mill Town to Board Room: The Rise of Women's Paid Labor. *Journal of Economic Perspectives 14*(4), 101–122.

Crossley, T. F. and Y. Lu (2017). Returns to scale in food preparation and the Deaton–Paxson puzzle. *Review of Economics of the Household*, 1–15.

Cutler, D. M., E. L. Glaeser, and J. M. Shapiro (2003). Why Have Americans Become More Obese? *Journal of Economic Perspectives 17*(3), 93–118.

Deaton, A. and C. Paxson (1998, October). Economies of Scale, Household Size, and the Demand for Food. *Journal of Political Economy 106*(5), 897–930.

Dobbs, R., S. Sawers, F. Thompson, J. Manyika, J. Woetzel, P. Child, S. McKenna, and A. Spatharou (2014). Overcoming obesity: An initial economic analysis.

Finkelstein, E. and L. Zuckerman (2008, January). *Wiley: The Fattening of America: How The Economy Makes Us Fat, If It Matters, and What To Do About It - Eric A. Finkelstein, Laurie Zuckerman.* Wiley, New York.

Goldman, D., D. Lakdawalla, and Y. Zheng (2009). Food prices and the dynamics of body weight. Technical report, National Bureau of Economic Research.

Gomis-Porqueras, P., O. Mitnik, A. Peralta-Alva, and M. D. Schmeiser (2011, October). The Effects of Female Labor Force Participation on Obesity. *IZA Discussion Paper 6071*.

Gortmaker, S. L., B. A. Swinburn, D. Levy, R. Carter, P. L. Mabry, D. T. Finegood, T. Huang, T. Marsh, and M. L. Moodie (2011). Changing the future of obesity: Science, policy, and action. *The Lancet 378*(9793), 838–847.

Hamermesh, D. S. (2008). Direct estimates of household production. *Economics Letters 98*(1), 31–34.

Heckman, J. J. (2007). The economics, technology, and neuroscience of human capability formation. *Proceedings of the National Academy of Sciences of the United States of America 104*(33), 13250–13255.

Herbst, C. and E. Tekin (2011). Child care subsidies and childhood obesity. *Review of Economics of the Household 9*(3), 349–378.

Lakdawalla, D. and T. Philipson (2007). Labor Supply and Weight. *The Journal of Human Resources 42*(1), 85–116.

Lakdawalla, D. and T. Philipson (2009, December). The growth of obesity and technological change. *Economics & Human Biology 7*(3), 283–293.

Lakdawalla, D., T. Philipson, and J. Bhattacharya (2005). Welfare-enhancing thenological change and the growth of obesity. *American Economic Review 95*, 253–257.

Lewbel, A. and K. Pendakur (2017). Unobserved Preference Heterogeneity in Demand Using Generalized Random Coefficients. *Journal of Political Economy*.

Lu, Y. and D. Goldman (2010, February). The Effects of Relative Food Prices on Obesity – Evidence from China: 1991-2006. Working Paper 15720, National Bureau of Economic Research.

Mackenbach, J. P., I. Stirbu, A.-J. R. Roskam, M. M. Schaap, G. Menvielle, M. Leinsalu, and A. E. Kunst (2008, June). Socioeconomic Inequalities in Health in 22 European Countries. *New England Journal of Medicine 358*(23), 2468–2481.

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

Philipson, T. and R. Posner (2008). Is the Obesity Epidemic a Public Health Problem ? a Decade of. *NBER Working Paper* (May).

Philipson, T. J. and R. A. Posner (2003, July). The Long-Run Growth in Obesity as a Function of Technological Change. *Perspectives in Biology and Medicine 46*(3), S87–S107.

Roantree, B. and K. Vira (2018). The rise and rise of women's employment in the uk. *IFS Briefing Note*.

Smith, L. P., S. W. Ng, and B. M. Popkin (2013, April). Trends in US home food preparation and consumption: Analysis of national nutrition surveys and time use studies from 1965-1966 to 2007-2008. *Nutrition Journal 12*, 45.

Swinburn, B., G. Sacks, and E. Ravussin (2009, December). Increased food energy supply is more than sufficient to explain the US epidemic of obesity. *The American Journal of Clinical Nutrition*, ajcn.28595.

A Data

A.1 Expenditure data

The UK Family Expenditure Survey is a nationally representative repeated cross-section. It is available through the ESRC Data Archive and are 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 reference is 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.

We exclude a small number of households for their unusual circumstances. 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. Of couples in this age range 99% are identified as a male head of house and a female spouse; we therefore exclude the 1% of households that are same sex couples or where the female is identified as the head of house for simplicity. This gives us a sample of 27,193 households.

Table A.1 shows some descriptive statistics on the key variables of interest.

Table A.2: *Food categories*

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, workplace meals	canteen, restaur
Sweets, snacks	Confectionary, ice cream, biscuits, cakes , snacks eaten out	biscuits, sug_pres, swe_choc

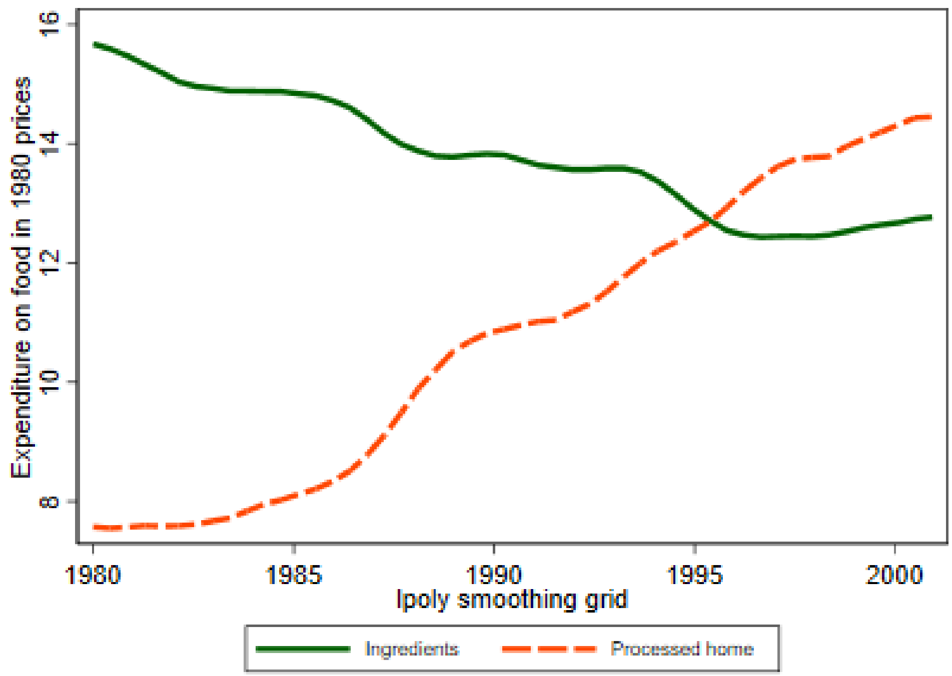
** Drinks included in category 2 do not include those purchased as part of a take away or meal out.*

Table A.1: *Descriptive statistics*

	Mean	SD	Min	Max
Expenditure on food (GBP per week)	53.82	28.67	0.00	460.87
Expenditure on non-durables (GBP per week)	138.64	108.11	6.32	2,030.94
Number of children	1.33	1.13	0.00	11.00
Age head of house	39.81	9.02	25.00	60.00
Age secondary earner	37.66	8.85	25.00	60.00
Hours worked head of house	43.46	7.40	31.00	70.00
Hours worked secondary earner	18.74	15.87	0.00	70.00
Labour market participation seconary earner	0.70	0.46	0.00	1.00
Wage head of house (GBP per hour)	5.16	3.08	1.12	29.94
Wage secondary earner (GBP per hour)	3.89	2.46	0.60	24.51

Notes: Data from the UK Family Expenditure Survey 1980-2000. 27,193 observations on all households with 2 adults aged 25-60 where the head of household works full-time.

Figure A.1: *Expenditure on food in 1980 prices*



Note: Sample of 27,193 households with two adults aged 25-60, with any number (including zero) of dependent children. Lines are fitted local polynomials. Expenditure is in constant 1980 prices.

A.2 Time use data

In the TUS, 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 25-60, 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 1,055 households.

The PAUT is a smaller survey (of over 3,000 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.[11]

[11] The survey was collected in four waves between August 1974 and March 1975. We exclude the 2nd wave because the data only has diaries of two workdays instead of all seven days. For all other waves 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 25-60 and the man works full-time. There are 408 such couples.

Table A.3: *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: Sample of 25-60 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)

Table A.4: *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: The table reports time spent on food management as the main activity. Sample of 25-60 year old couples where the male is employed full-time. Source: UK Time Use Survey 2000 (TUS).

Table A.5 reports the coefficients from 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. Women's time spent on food management is negatively correlated with her own wage, and positively correlated with the number of children. Interestingly, men'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 A.5: *Tobit regressions of weekly hours on food management on weekly working hours*

	(1) female	(2) female	(3) female	(4) male	(5) male	(6) male
female in work	-4.625***			0.800*		
	(0.481)			(0.371)		
one child		0.531	1.390**		0.203	0.247
		(0.526)	(0.516)		(0.492)	(0.471)
two children		1.628**	2.549***		0.851	0.868
		(0.566)	(0.545)		(0.529)	(0.497)
$\geq$ 3 children		3.246***	4.256***		0.0404	0.0267
		(0.866)	(0.854)		(0.813)	(0.784)
male working hours		0.00273			-0.0239	
		(0.0220)			(0.0209)	
female working hours		-0.0961***			-0.00196	
		(0.0183)			(0.0172)	
male wage			-0.0726			-0.752
			(0.449)			(0.409)
female wage			-1.149**			-0.156
			(0.437)			(0.397)
Observations	688	530	530	688	530	530
Adjusted R^2						

Standard errors in parentheses

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

Note: Dependent variable is hours in a week spent on food management as a main activity; in columns (1)-(3) for the female and in columns (4)-(6) for the male. Reported estimates are from tobit regressions. 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). Columns (1) and (4) use the full 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 last take-home pay divided by usual hours per week. All columns include age, age squared and education of both adults.

B Predicted wages

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

$$\ln W_i^p = X_i\theta + Q_i\delta + u_i, \tag{B.1}$$

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

$$\ln W_i^r = X_i\alpha + Zi\beta + \varepsilon_i, \tag{B.2}$$

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_i are variables that shift both participation and reservation wage; we include the woman's age, age squared, age cubic, the woman's education in seven bands and year dummies. Q_i are variables that shift participation wages; we include dummies for eleven regions of the UK based on where the household resides and interactions between year dummies and four broader region dummies, so as to control for local labour market conditions. Z_{it} are variables that shift the reservation wage; we include a dummy for whether there are children present in the household, the number of children, a 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

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

We estimate the model using the Heckman two-step estimation and report the results in Table B.1. The selection equation results are as expected: the probability to participate is increasing in the education of the secondary earner, 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.

Table B.1: *Heckman wage equation, part 1*

	wage equation ln wage spouse b/se	select b/se	/mills b/se
Age secondary earner	0.039	0.075	
	(0.018)	(0.068)	
Age secondary earner squared	-0.001	-0.001	
	(0.000)	(0.002)	
Age secondary earner cubed	0.000	-0.000	
	(0.000)	(0.000)	
Spouse left education 15	0.041	0.047	
	(0.013)	(0.050)	
Spouse left education 16	0.154	0.201	
	(0.014)	(0.052)	
Spouse left education 17-18	0.292	0.341	
	(0.014)	(0.055)	
Spouse left education 19-20	0.382	0.231	
	(0.019)	(0.071)	
Spouse left education 21-22	0.623	0.586	
	(0.016)	(0.064)	
Spouse left education after 22	0.606	0.493	
	(0.021)	(0.085)	
Any children		-2.016	
		(0.121)	
Number of children		0.223	
		(0.020)	
Youngest child aged 0		0.014	
		(0.102)	
Youngest child aged 1		0.239	
		(0.102)	
Youngest child aged 2		0.007	
		(0.034)	
Youngest child aged 3		-0.003	
		(0.005)	
Youngest child aged 4		0.000	
		(0.000)	
Youngest child aged 5		-0.000	
		(0.000)	
Receive any benefits		0.696	
		(0.093)	
Log benefit income		-0.711	
		(0.029)	
Log wages head		-0.723	
		(0.078)	
Hours work Head		-0.015	
		(0.001)	
lambda			0.031
			(0.009)
N	24299		

Notes: Dependent variable is log wage. The wage equation also includes dummies for eleven regions of the UK based on where the household resides and interactions between year dummies and four broader region dummies, so as to control for local labour market conditions. The selection equation also include dummies for 12 regions, and interactions between yearly dummies and 4 broad regions, the household's unearned income, the head of household's age, education, and occupation, market prices of the goods in our model, housing tenure, and interaction between year dummies and the presence of children. For the spouse's education, the reference category is leaving education at age 14 or below.

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 $k\widehat{(\theta-\alpha)}$, $\widehat{k\delta}$, 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 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 :

$$\min_{\delta} \left((\widehat{\delta}-\delta)', (\widehat{k\delta}-k\delta)' \right) \sum{}^{-1} \begin{pmatrix} \widehat{\delta}-\delta \\ \widehat{k\delta}-k\delta \end{pmatrix} \tag{B.3}$$

where k takes the calibrated value and $\sum$ 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 $\widehat{\delta}$

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 $\widehat{\theta} - k\widehat{(\theta-\alpha)}/k$, assuming k takes the calibrated value .

We predict the market wage as

$$E(\ln W_i^p) = X_i\widehat{\theta} + Q_i\widetilde{\delta} \tag{B.4}$$

and the predicted reservation wage is

$$E[\ln W_i^r] = X_i\hat{\alpha} + Z_i\hat{\beta}. \tag{B.5}$$

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 $E[\ln W_i^r|X,Z] < E[\ln W_i^p|X,Z]$ 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 also use the max of the two log wages as one measure of their log value of time when constructing the shadow price.