Deconstructing Supermarket Interventions as a Mechanism for Improving Diet: Lessons from the Seacroft Intervention Study

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Abstract:

Supermarkets, with vast product ranges and relatively low prices, are an established solution to problems of availability of healthy foodstuffs in areas of limited retail access. However, where they may indeed raise consumption of desirable goods they also open up new opportunities to buy less healthful items for less, a situation which potentially undermines their ability to improve diet. Using under-reported diary data from the Seacroft Intervention Study in the United Kingdom takes this paper beyond the extant fruit and vegetable focus, giving it scope to explore the full effect of supermarkets. Quantile regressions show existing behaviours are reinforced, and intervention stores may do little to improve diet. Switching to Tesco Seacroft is shown to increase the portions of unhealthy food consumed by almost 1 portion per day for the least healthy. Managing demand through promoting balanced diets and restricting offers on unhealthy items will be more effective than intervention, and is an essential accompaniment to new large format retailers if they are not to entrench dietary inequality further. Policymakers and practitioners alike should avoided being distracted by aggregate conclusions if food deserts are to be truly tackled.

Keywords: retail intervention, food deserts, diet, healthy eating

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1 Introduction

Where we shop necessarily impacts on the types of food that we consume, stores with larger product variety offer more chances to try something different[1]. When new stores open offering whole ranges of goods that were previously hard to come by it is inevitable that households will reappraise their habits and re-evaluate their diet. Policymakers will thus be keen to understand precisely how that can be used to achieve important goals, particularly how health may be improved. Since the out-of-town expansion of large format stores has helped only those with use of a motor vehicle many communities have been left without access to nutritious products, in particular fresh meat, fruit and vegetables. For those living in these "food deserts"[2], and lacking the ability to travel to shop, a clear problem exists. A natural solution was to bring the large format stores to the area, guaranteeing product range and typically lower prices. However, as Gill and Rudkin (2014) illustrated with fruit and vegetables, for one such opening in West Yorkshire, in fact there is a much more complex picture for policymakers to consider beyond that which bivariate analyses and linear regressions have been able to expose.

This paper asks what happens to consumption of all food stuffs, and whether when presented with greater choice consumers will take the healthy option. Such a major extension has clear benefits in assessing dietary impact over using fruit and vegetables as a proxy, allowing study of the foods households have shown preference for in having an unhealthy diet. Inevitably there is an aggregate story to tell, and first focus is given to the wider distribution and two-sample t-tests of equality before and after consumption after splitting respondents by key characteristics, such as car access, or whether they use the new store. Three key research questions emerge and are addressed within this work. Firstly, does the new supermarket opening lead to more consumption of the additional healthy products stocked compared to smaller convenience stores? Secondly, can a supermarket reduce the proportion of shoppers' diets that could be regarded as unhealthy? Finally, which factors are the drivers of poor diet amongst all members of a community? Each of these questions represents a key addition to the current literature and promotes the use of the latest quantitative techniques to provide rigorous answers. For policy makers there is a clear message, supermarkets do not deliver the unilateral improvements that early work on fruit and vegetables suggested, and more focus should be placed on influencing consumer demand.

To evaluate changing diet we make use of all four components of the Seacroft Intervention study, which is available as study SN5056 (Wrigley et al, 2004b). Although the research was undertaken more than a decade ago it remains the best source of information about major supermarkets

[1] For example, J Sainsbury plc in the United Kingdom ran an advertising campaign which encouraged shoppers to "try something new today" and promoted products from their range which were not commonly consumed in the UK. This approach is representative of the way supermarkets can introduce their shoppers to wider varieties and new product ranges.

[2] The term "food desert" was coined to describe an area without access to a retailer of healthy foods within 500m. It has been widely applied in the literature since to describe precisely the communities that had been left out of initial development waves.

opening in food deserts, and one of the only before and after studies (Donald, 2013). The Ordnance Survey Integrated Transport Network (ITN) dataset forms the measurement of accessibility as it improves greatly on the "as the crow flies" distances used in earlier studies such as Wrigley et al (2003) (Schwanen et al, 2015). Unlike extant works focus here will be on broader choices between healthy and unhealthy options, such as the consideration of diet versus full fat soft drinks, processed food or fresh meat and snack foods against fruits. Research into retail interventions provides a series of insights into likely patterns that will be observed and forms the first substantial section of this paper. Next the dataset and methodologies are exposited, with particular attention paid to the consumption measurements that are applied in the regression and simple bivariate analyses thereof. Results of the quantile regression are presented identifying the factors that drive consumption choices across the respective distributions. Evaluating these results against the current literature allows the formation of policy conclusions and reinforces the fact that aggregate measurements often neglect important consequences of large format retail intervention.

2 Background

Issues of access to healthy foodstuffs are well documented, with strategies to improve diet being a mainstay of policy in developed nations for at least two decades. Solutions typically evolved around bringing supermarkets, with vast product ranges and low prices, to those communities that had been ignored in the initial raft of large format openings. Indeed the USA still offer financial incentives for superstores to enter poor access areas (United States Department of Treasury, 2014). Tesco Extra in Seacroft, West Yorkshire sits alongside Asda, Sport City in Manchester and others reviewed as part of a retail led regeneration agenda in Wrigley et al (2002b). There are also cases of similar outlets being built on radial access roads in poorer communities much more recently; indeed Tesco alone has opened more than 40 "regeneration stores" (Tesco plc, 2011) with more to come[3]. While this paper focuses on the United Kingdom there have been similar concerns about access, and links to supermarkets as an ideal solution, in other countries. Morgan (2014) reviews the wider debate on food access and the particular issues faced in developed nations with diet. USA focused works include Sohi et al (2014), Aggrawal et al (2014) and Ghosh-Dastidar et al (2014), which update the earlier works by Powell et al (2007), Ford and Dzewaltovski (2011) and others in studying links between availability and consumption. Shaw (2012) is an example of a study which does similar in continental Europe, while Murakami et al (2010), Liu et al (2013) and Kelly et al (2014) consider food access, diet and the role of the supermarket in Asia. A common feature of all is that improved availability, such as that offered by the larger retailers, would lead to dietary improvements. Equally focus is commonly placed on urban areas but food deserts are not confined to cities, anywhere where there is a shortage of local options can be a desert. Though the distance involved will necessarily be larger, rural communities can suffer, as seen in the UK in Findlay and Sparks (2008) and Fitch (2004), reviewed in the USA by Lenardson et al (2015), and in New Zealand by Pearson et al (2014).

One feature underpinning to the majority of the work on supermarket interventions was the focus on healthy food, especially fruit and vegetables. In granting planning permission for the new stores

[3] A full list of the Tesco stores to open up to 2011 is available on the company's website via http://www.tescoplc.com/index.asp?pageid=17&newsid=387, and this list continues to grow with Tesco Extra opening in Rotherham, South Yorkshire in January 2015.

the motivation was increased access, with lower prices being a win-win for the communities served. Empirical support for both was strong, and continues to be so, but from the early stages concern was raised about what this meant for unhealthy food. Cummins et al (2005) are amongst the first to flag up the issue. More recent studies have highlighted issues with unhealthy foods, particularly following the Seattle study (Ghosh-Dastidar et al, 2014). However, the ability to ask questions of impact there is limited (Donald, 2013), bringing attention back to the value of Seacroft. Typically prior to the opening of the new store the retail landscape was characterised by convenience stores and discounters which did not carry fruit and vegetables but did stock convenience and processed foods. Were people to continue their shopping habits then all the supermarkets would do is reduce the cost of their shopping baskets, so the is a need for households to revisit their choices if diet is to improve. Consequently given the continued use of intervention stores, and the potential for change in unhealthy consumption patterns, there is tremendous value in appraising what happened in Seacroft using the new variables and techniques of this paper.

That household's would continue their previous habits, but taking advantage of the lower prices is not far-fetched. Volpe et al (2013) show that as super centres increase in market share so does the proportion of diet that is unhealthy. Their study makes use of US homescan food data, rather than exploring an intervention, but the suggestions therefrom align with what we show here. Unlike Volpe et al it is possible for the Seacroft data to provide a detailed picture of the area and accessibility, as we have the postcode information of the households and two clear periods across which there is a major change to the retail landscape. Meanwhile, other studies such as Sohi et al (2014) continue to support the conclusions of Wrigley et al (2003) and others, that supermarkets have a positive impact on health. By exploiting the full database, and constructing a large set of new variables, this study significantly expands the distributional analysis to find out what happened to other food groups; the concerns voiced in Cummins et al (2005), Volpe et al (2013), and others, indeed played out.

By no means are supermarkets the only interventions studied as farmers markets and convenience store schemes are also considered. Hosler and Krammer (2014) review the history of interventions in a New York district, considering the relative effectiveness of each. Farmers markets, found to be effective in the USA by Wetherspoon et al (2013), Evans et al (2012) and Jilcott Pitts et al (2014), do increase availability but are limited by opening hours and seasonality. For other suburbs it is supporting healthy food within convenience stores which is most effective, a move reviewed as positive in the USA by Gittelsohn et al (2009), but having relatively less support in Northern England in Adams et al (2012). Where farmers markets can be more effective is when financial support is offered to customers to shop thereat (Gustat et al, 2015; Pearson et al, 2014). However, evidence in these studies also indicates that there is self-selection, particularly with farmers markets which tend to have more affluent customers who seek out fresh fruits and vegetables. To help those who do not purchase fruit and vegetables regularly, convenience and financial incentives leap out from the literature. A similar average versus distribution effect is thus hinted at along the lines of that revealed for supermarkets in Gill and Rudkin (2014). This study explores and fleshes out these hints.

Households demand for food is driven by the attitudes of the head of household, money and of course access to retailers. No one of these factors should be seen as sufficient to change fundamentally the way in which people behave when carrying out food shopping. Aggrawal et al (2014) note the importance of attitude, while O'Brien et al (2014) reflect on the impressions of

access and the lack of familiarity new options possess. A key tenant of O'Brien et al (2014) is the existence of a battle between the self-motivation of food consumption, and the need to provide the best for the family when choosing store, or goods within the store. Perhaps the time we must be most selfless is when considering what to buy for children, as Wigent et al (2013) and O'Brien et al (2014) point out. However, children like sugar and processed options like breaded chicken or fish fingers, each of which can be seen as unhealthy. There is a balance to be struck by all parents and typically this brings children into the regressions as a negative influence on healthy intake and a positive one on less healthy products.

From the work of the initial Policy Action Teams[4] in the UK and similar governmental agencies in the USA, access has been defined by straight line distance. Limited attention was paid to what that actually meant for individual households, say the difference between car ownership and a lack of vehicular availability. This paper is in a limited set which make use of the Ordnance Survey Integrated Transport Network (ITN) layer to better capture the accessibility of the store[5]. Schwanen (2015) presents a broad review of the study of accessibility, noting the benefits that the ITN approach has. Caspi et al (2012a) comment on the importance of walkability, something which Wrigley et al (2003) had already found was difficult for the new Tesco store, which faced out onto the non-pedestrian friendly Leeds Outer Ring Road[6]. For a number of reasons consumers do not use their nearest store (Gustat et al, 2015) hence it is helpful to consider why not. Here, with a clear intervention store, distance to that new store can be seen as important to its new neighbours and those furthest from the outlet alike.

Quantile regression allows researchers to explore the driving forces of changes in the dependent variable across its distribution. Therefore it is possible to look not only at how average healthy food consumption changes, but what is causing observed behaviour amongst the least healthy, the group the intervention seeks to help. Adoption of the framework is expanding across the disciplines, with more studies taking advantage of the technique within the field of health and diet, Kim et al (2014) and Das (2014) being recent examples. Here the limited dataset size means focus is placed on quartiles for the regression, maintaining equally sized groupings to ensure that there are sufficient numbers of observations which combine each level with the explanatory variables. That average coefficients, such as those estimated by Ordinary Least Squares (OLS), hide important information is intuitive and explains the adoption of quantile regression here and elsewhere. In perhaps the most relevant example Ljungvall and Zimmerman (2012) show that income is a major determinant of Body Mass Index (BMI) and this is seen here as the deprivation variables of unemployment, needing rental support and not having access to a motor vehicle are all significant in at least one of the regressions. Again this is an effect which simple OLS does not pick up.

Studies of fruit and vegetables have shown that the largest increases in consumption occur at the top end of the distribution of consumption (Gill and Rudkin, 2014; Dimitri et al, 2014). Immediately

[4] Policy Action Teams (PATs) were set up by the incoming Labour government in 1997 to report on various issues in which exclusion problems had been identified. PAT13 was responsible for the food desert definition and creation of potential solutions, such as supermarket interventions.

[5] As time passes so the road network will change. Here the layer as downloaded in 2006 is used as the closest created to the study date.

[6] Focus groups revealed in Wrigley et al (2004a) that there is a perception that the new store is non-porous for pedestrians with too great a focus on the ring road and those who arrive by car.

the question is raised as to whether similar to end effects happen amongst those who already consumed a lot of unhealthy foods. Such a suggestion would leave the intervention store delivering a worse diet to those whose healthfulness was already low. From the Seacroft study it is shown there is a legitimate concern about poor diet households, which policy should seek to address; increases in unhealthy consumption are significant and largest amongst those who already consume the most. Whilst many of these conclusions are intuitive, initial data descriptions ignored these important effects leaving it for current research to fill in the gaps and bring out worries about interventions that might otherwise be overlooked as lacking empirical support.

Inevitably the setting of any empirical analysis is quite specific, however the Seacroft Intervention Study has been noted for its ability to be generalised to other markets and countries (Donald, 2013). Wrigley et al (2002b) offers an invaluable review of the study area, the aims of opening Tesco as a new build superstore, and the basic changes to diet that occurred following the opening. In a preliminary review Wrigley et al (2002a) use a simple logistic regression with poor diet defined by low fruit and vegetable consumption, and being associated pre-intervention with being young, low educational attainment and having a smoking habit. Wrigley et al (2003) point to a significant quarter portion per day increase in fruit and vegetables eaten. Such results were taken as justification for further intervention superstores owing to the strengths of the Seacroft data. A second key factor in the Wrigley et al (2003) paper is the access households have to motor vehicles, a factor which is incorporated at the heart of the access discussion and the regressions that follow. The authors conclude that there is "evidence of both direct and indirect positive impacts of the intervention on diet" (Page 175). As even later studies of fruit and vegetables have shown, this was a premature generalisation of the rich detail that the raw dataset contains, and this study brings out.

Set upon this canvas is a study of the factors that influence the consumption of healthy foodstuffs, unhealthy foodstuffs and the proportion of diet which is made up of less healthy items. This paper makes use of quantile regression to get behind average conclusions, the ITN layer to better fit accessibility, and the full diary information from the Seacroft Intervention Study. Hence it can provide a more accurate insight into the use of intervention supermarkets in areas of previously poor food retail availability.

3 Data and Variables

Before any meaningful regression analysis can be conducted it is necessary to understand more about the survey area and the basic conclusions that emerge from its study. Exploration of healthfulness of diet necessitates the construction of further variables to capture informatively household's dietary composition. This paper focuses on the 581 respondents for whom key variables and accurate locational information are available, dropping 34 data points from the total sample of 615 who completed both waves of the survey[7]. As with earlier studies, variables are grouped into consumption levels, distance slope dummies, deprivation dummies and a detailed set of dummies to explain what factors shoppers feel influence their purchasing decisions. Preliminary analysis is presented using paired two-sample t-tests and splitting the 581 observations into sub-samples of interest, for example car access or distance to travel to the new store. Most obvious of the splits is

[7] In their formative review of the study, Wrigley et al (2003) maintain the full 615 observations and avoid including any variable with missing observations in the regression. However, as the aim here is to use GIS systems for distance it is not possible to include households with no valid postcode.

between those who change to shopping at the new Tesco store, switchers, and those who use other outlets, as it is the dietary impact of the intervention which is targeted by this work.

3.1 Construction of the Variables

A major contribution of this paper is the examination of healthy and non-healthy foods concurrently. Each household in the study completed a week long food diary measuring the number of times they consumed each of seventy one food groups. Regrettably portion sizes are not available for both waves, so only number of incidents can be measured. However this still provides an excellent representation of diet, and gives data which is little explored in the literature more than a decade after the original survey. Pulling together the 71 food stuffs is done following Table 1, illustrating the initial groupings created for study. Drinks with no calorific value are excluded from the modelling so the group drk features in neither of the two larger sets studied[8]. In all that follows only the two groupings are referred to, but there are many pictures behind each of the smaller sets described[9].

	Group Name	Contains
N/A	Drinks	Water, any hot drink, evaporated milk and other drinks
Healthy	Low fat dairy	Skimmed milk, low fat yoghurt and low-calorie margarine
	Low sugar drinks	Diet fizzy drinks and real fruit juice
	Healthy cereals	Museli, brown bread and soup
	Fruit	Apples, oranges, bananas, peaches and other fruits
	Vegetables	Carrots, peas, broccoli, tomatoes, salads and other vegetables
	Fresh meats	Meat, poultry and non-processed fish
	Starches	Boiled potatoes, roast potatoes, rice and pasta.
	Low fat snacks	Crackers/crispbreads
Unhealthy	High fat dairy	Full fat milk, ice cream, normal yoghurt, butter, cream, cheese and normal margarine
	High sugar drinks	Normal fizzy drinks, squash, beer and wine
	Unhealthy cereals	Cereal and white bread
	Spreads and oils	Oil, lard, sweet spreads and savoury spreads
	Other greens	Dried fruits and baked beans
	High fat mains	Processed vegetables, processed poultry, processed meat, processed fish, battered fish, meat pies, vegetable pasties, prepared ready meals, pizzas and chips
	Take away	Take away
	Deserts	Fruit puddings, other puddings, packet mix cakes, cakes, sweet biscuits and other sweets
	High fat snacks	Chocolate biscuits, chocolate and cake

Table 1: Food groupings used in dietary analysis

To ease the exposition the average daily number of incidents of consumption of healthy foodstuffs over the week is denoted by h, while the same for unhealthy is u. The proportion of a households diet from the unhealthy group is then defined as p. Capitals indicate post-intervention.

[8] Dropping this group is common in the literature, for example the highly cited study of food diversity by Drescher et al (2007).

[9] Rudkin (2015) gives a fuller review of each of these smaller groupings and the impact of switching to the new Tesco store on each.

Group	Name	Description	Mean	Standard Deviation	Min	Max
Consumption	H	Post-intervention healthy consumption	7.681	4.570	0.286	56.860
	h	Pre-intervention healthy consumption	7.195	4.305	0.714	38.000
	U	Post-intervention unhealthy consumption	5.682	3.629	0.571	46.570
	u	Pre-intervention unhealthy consumption	5.670	3.293	0.143	35.290
	P	Post-intervention unhealthy proportion	0.433	0.169	0.062	0.956
	p	Pre-intervention unhealthy proportion	0.455	0.169	0.020	0.921
Consumption slope dummies	$hq1$	$0 \leq h < 4.287$	0.837	1.433	0	4.286
	$hq2$	$4.287 \leq h < 6.429$	1.306	2.339	0	6.429
	$hq3$	$6.429 \leq h < 9.430$	1.936	3.447	0	9.429
	$hq4$	$9.430 \leq h$	3.117	5.925	0	38.000
	$uq1$	$0 \leq u < 3.715$	0.719	1.266	0	3.714
	$uq2$	$3.715 \leq u < 5.287$	1.312	2.065	0	5.286
	$uq3$	$5.287 \leq u < 7.287$	1.513	2.715	0	7.286
	$uq4$	$7.287 \leq u$	2.126	4.555	0	35.290
	$pq1$	$0 \leq p < 0.340$	0.069	0.117	0	0.339
	$pq2$	$0.340 \leq p < 0.445$	0.091	0.167	0	0.444
	$pq3$	$0{,}445 \leq p < 0.581$	0.128	0.221	0	0.580
	$pq4$	$0.581 \leq p \leq 1$	0.167	0.296	0	0.921
Shop Choice	$switch$	Main supermarket is Tesco Seacroft	0.449	0.498	0	1
	$asda$	Main supermarket is Asda Killingbeck	0.327	0.470	0	1
Distance (km) to Seacroft (d) and 'no car' (nc) interaction	$nc1$	$0 < d \leq 1.2$	0.095	0.286	0	1.186
	$nc2$	$1.2 < d \leq 1.6$	0.166	0.454	0	1.593
	$nc3$	$1.6 < d \leq 2.0$	0.201	0.573	0	1.998
	$nc4$	$2.0 < d$	0.146	0.545	0	2.727
Distance (km) to Seacroft (d) and 'car access' (ca) interaction	$ca1$	$0 < d \leq 1.2$	0.123	0.326	0	1.186
	$ca2$	$1.2 < d \leq 1.6$	0.223	0.510	0	1.593
	$ca3$	$1.6 < d \leq 2.0$	0.229	0.605	0	1.998
	$ca4$	$2.0 < d$	0.402	0.878	0	2.949
Deprivation dummies	$nocar$	Household has no access to a motor vehicle	0.404	0.491	0	1
	$unemp$	Household contains unemployed adult	0.129	0.336	0	1
	$rent$	Household requires rental support	0.575	0.495	0	1
Lifestyle variables	$smoke$	Light or heavy smoker	0.448	0.498	0	1
	$child$	Child in the household	0.392	0.489	0	1
	$highed$	Respondent has GCSE or above	0.172	0.378	0	1
	$a1734$	Respondent age 17-34	0.231	0.423	0	1
Factors influencing the purchasing decisions of households	$cost$	Cost/budget	0.728	0.445	0	1
	$health$	Health advice	0.162	0.369	0	1
	$seat$	Spouse eating habits	0.477	0.500	0	1
	$ceat$	Children's eating habits	0.446	0.497	0	1
	bal	Trying to achieve a balanced diet	0.534	0.499	0	1
	$like$	Foods liked	0.635	0.482	0	1
	$conv$	Convenience	0.375	0.485	0	1
	$spouse$	Presence of spouse/partner shopping	0.182	0.387	0	1
	$child$	Presence of children on shopping trip	0.172	0.378	0	1
	$hunger$	Hunger	0.275	0.447	0	1
	$offer$	Special offers	0.640	0.480	0	1

Table 2: Variables Included in the Analyses and Summary Statistics ($n = 581$) (Source: Own Calculations on Wrigley et al, 2004b)

3.2 Preliminary Analyses

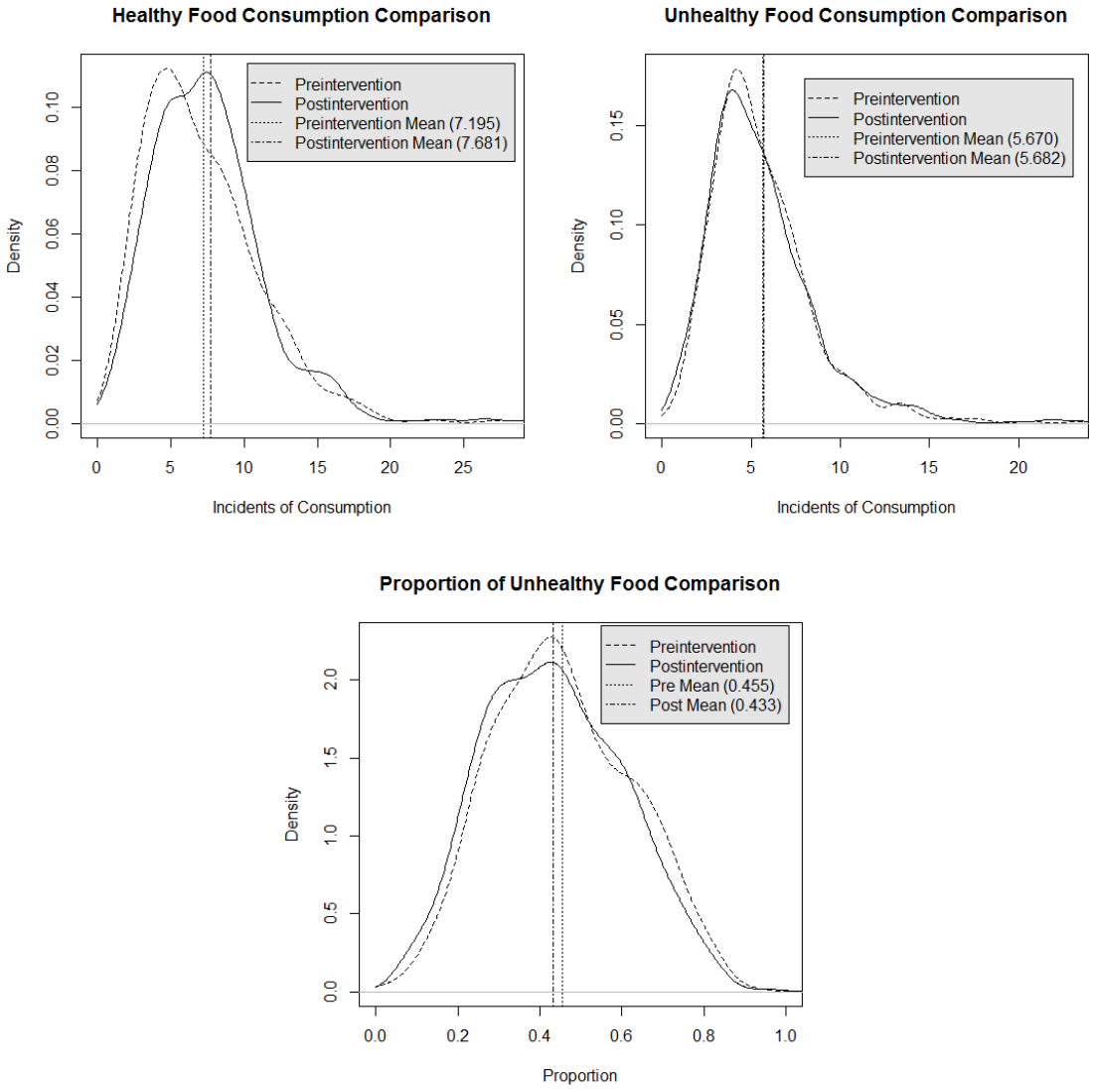

Figure 1: Densities of before and after consumption (Source: Own calculations on Wrigley et al 2004b)

An initial impression of the changes in diet can be gleamed from the density plots of pre- and post-intervention constumption. Healthy food shows a general shift to the right, while few real changes can be seen in the unhealthy plot. Most interstingly the proportion of unhealthy foodstuffs shifts to the left, indicating that people are getting healthier with their diets. However, underlying this is a notable lack of correlation between the values for individual households, the Spearman's rank correlations being -0.05, 0.11 and 0.02 for healthy, unhealthy and proportion unhealthy respectively[10]. Whilst the distribution plots do not immediately show a change to study, the correlation coefficients indicate that there must be many factors at play that can change households dietary position.

Understanding the impact of Tesco Seacroft necessitates a look at the differentials between those who switch and those who do not, but also it is useful to explore that issue withing the context of an

[10] These correlations are produced in R using the variables constructed by the author from the data of Wrigley et al (2004b).

	Distance (km) to Tesco Seacroft				Overall
	$0 < d \leq 1.2$	$1.2 < d \leq 1.6$	$1.6 < d \leq 2.0$	$2.0 < d$	
All Shoppers					
h	7.188	6.955	7.972	6.725	7.195
H	8.459	7.036	6.706	8.601	7.681
Difference	1.271*	0.081	-1.267**	1.875***	0.486*
n	140	163	137	141	581
u	6.255	5.466	5.660	5.335	5.670
U	6.080	5.520	5.764	5.394	5.682
Difference	-0.176	0.053	0.104	0.059	0.012
p	0.474	0.448	0.432	0.464	0.455
P	0.426	0.446	0.473	0.388	0.433
Difference	-0.048**	-0.003	0.041**	-0.076***	-0.021**
Switchers					
h	7.434	7.126	8.088	6.786	7.379
H	8.167	6.650	6.705	8.166	7.430
Difference	0.733	-0.476	-1.393*	1.380**	0.051
n	82	69	60	50	261
u	6.152	5.729	4.981	5.249	5.598
U	6.556	6.010	5.855	5.166	5.984
Difference	0.404	0.282	0.874*	-0.083	0.386
p	0.465	0.453	0.401	0.453	0.445
P	0.460	0.473	0.486	0.393	0.456
Difference	-0.005	0.020	0.084***	-0.060*	0.012
Non-Switchers					
h	6.840	6.830	7.881	6.692	7.046
H	8.872	7.319	6.707	8.840	7.886
Difference	2.032**	0.489	-1.174*	2.148***	0.840**
n	58	94	77	91	320
u	6.401	5.274	6.189	5.383	5.729
U	5.406	5.160	5.694	5.520	5.435
Difference	-0.995	-0.114	-0.495	0.137	-0.294
p	0.486	0.446	0.456	0.471	0.463
P	0.377	0.426	0.463	0.386	0.415
Difference	-0.109***	-0.019	0.007	-0.085**	-0.048***

Significance levels: * 10%, ** 5%, *** 1%

Table 3: Paired sample t-tests of pre-intervention and post-intervention number of daily incidents of consumption of healthy and non-healthy foodstuffs, and proportion of household diet which is classified as unhealthy, grouped by quartiles of road distance from Tesco Seacroft. (Soure: Own calculations on Wrigley et al (2004b))

investigation of the distance to store, local residents being the target. Table 3 presents the full set of results, with two-sample t-tests for equality of means between pre- and postintervention levels. Healthier items rise almost half an incidence per day, while the propirtion of respondents diets that is unhealthy falls by 2%. These conclusions are significant and therefore it would easy to determine that the intervention was a good thing. Splitting by distance also encourages the use of intervention stores, healthy food is up and the proportion of unhealthy down almost 5%. However, the healthiest region is the furthest from Tesco, while in the third quartile healthy drops more than one instance per day to be below average, leaving the unhealthy proportion up 4%. A mixed message results.

When focusing on the switchers the positive impacts in the nearest distance qurtile disppoear, with the significant effects concetrated in the furthest reaches of the map. Again quantile 3 is a concern, but those making the effort to travel from the furthest extents do show significant dietary improvement. Non-switchers by contrast show marked improvements in the nearest quartile, as they do in the furthest. As with others in the third quartile a negative impact is felt on healthy but the proportion is not significant. Support for intevention becomes diminshed, the aggregate conclusions apparently driven from the extremes of the map and those who did not switch to Tesco. Whatever the cause of these patterns, be it competition from Tesco, or individual effects, there is reason to be wary of accepting claims of positive dietary impact. Indeed it may simply be that those in the third quartile who used convenience stores now find snacks they like at lower prices and consume more.

Another unique feature of this study is its quantile analysis of the variables highlighted in Wrigley et al (2002a), of smoking status, education, age and the presence of children in the household. Attitudes to diet are captured via the influence variables as in that initial paper so focus here is on the other four identified factors. Table 4 presents the two-sample t-tests for the new additions. Younger respondents the picture is indded negative, large falls in healthy leading to a 5% rise in unhealthy proportion; this despite a fall of almost one portion per day on unhealthy. Amongst older household heads healthy foods increase so the proportion of unhealthy falls. Smokers do indeed have a less healthy diet, non smokers showing significant drops in the proportion of unhealthy foods

	Age		Smoking Status		Education Level		Child in Household	
	Under 35	Over 35	Non-Smoker	Smoker	GCSE	Higher	Yes	No
n	134	447	321	260	481	100	228	353
h	7.705	7.043	7.039	7.388	7.203	7.156	7.233	7.171
H	5.181	8.430	8.348	6.857	7.816	7.033	6.381	8.520
Diff	-2.523***	1.388***	-0.531	1.309**	0.612**	-0.123	-0.852**	1.350***
u	6.220	5.506	5.770	5.547	5.314	5.744	5.603	5.713
U	5.291	5.799	5.516	5.886	5.246	5.772	5.619	5.722
Diff	-0.929*	0.293	-0.254	0.340	-0.069	0.028	0.016	0.009
p	0.457	0.454	0.460	0.448	0.444	0.457	0.453	0.456
P	0.509	0.411	0.406	0.468	0.435	0.433	0.475	0.407
Diff	0.055***	-0.043***	-0.054***	0.020	-0.009	-0.024**	0.022	-0.049***

Significance Levels: * 10%, ** 5% and *** 1%

Table 4: Paired two sample t-tests of pre-intervention and post-intervention number of daily incidents of consumption of healthy and non-healthy foodstuffs, and proportion of household diet which is classified as unhealthy, split according to household characteristic variables. (Soure: Own calculations on Wrigley et al (2004b))

as caused primarily by rises in healthy items. Grouping on education shows that those who have had higher achievements do have a marginally healthier diet, but that it is the other respondents who show significant improvement. Given the low proportion of the former changes are roughly in line with the sample average. Finally, families with children see healthy fall by almost one portion per day, while those households comprising only adults show a greater than one portion rise and a fall in the proportion of their diet which is unhealthy by almost five percentage points. Broadly this is as suggested in the initial study, but there remain questions about how these results split down on the density distribution.

Although this study focuses on Tesco, there is also another major supermarket in the area, the Asda store at Killingbeck. Many of those who use Tesco Seacroft were previous shoppers of this store. Table 5 reports the changes amongst Asda shoppers, with significant changes being an increase in healthy intake amongst non-users, a reduction in unhealthy products amongst those who do use the Asda. Illustrating the impact of supermarkets even more the two big stores are combined into a single group labelled “big”, while the remaining shoppers are labelled “other”. No significant changes are observed amongs the “big” group, but those who use other stores have notably more healthy diets, increasing healthy intake and reducing the proportion that is unhealthy by more than seven percentage points. Also included in Table 5 are splits on those who are influenced by the foods they like, and those who say that having a balanced diet weighs on what they buy. Naturally what people like causes them to eat more, whether it is healthy or unhealthy there are significant rises. For those who say that their own personal tastes are not important there is a reduction in unhealthy foods which leads to a reduction in the overall proportion of their diet which is unhealthy. Being influenced by wanting a balanced diet does raise healthy consumption, and hence reduce the unheathy proportion, while not being has the complete opposite effect. The scope for supermarket shopping to reinforce behaviours is clearly outlined, and the importance of education on balanced diets indicated.

	Asda Shopper?		Tesco or Asda Shopper?		Influence: Foods Liked		Influence: Balanced Diet	
	Asda	Not	Big	Other	Yes	No	Yes	No
n					369	212	310	271
h	7.511	7.042	7.434	6.366	6.942	7.635	6.862	7.576
H	7.291	7.870	7.371	8.755	7.654	7.727	8.934	6.248
Diff	-0.220	0.828***	-0.063	2.389***	0.712**	0.092	2.071***	-1.328***
u	5.935	5.541	5.740	5.429	5.657	5.693	5.427	5.948
U	5.196	5.918	5.652	5.785	6.182	4.811	5.471	5.924
Diff	-0.739**	0.376	-0.088	0.356	0.525**	-0.882**	0.043	-0.025
p	0.454	0.455	0.449	0.475	0.462	0.442	0.455	0.454
P	0.423	0.439	0.442	0.404	0.459	0.389	0.378	0.497
Diff	-0.032*	-0.016	-0.007	-0.071***	-0.003	-0.053***	-0.077***	0.043***

Significance Levels: * 10%, ** 5% and *** 1%

Table 5: Paired two sample t-tests of pre-intervention and post-intervention number of daily incidents of consumption of healthy and non-healthy foodstuffs, and proportion of household diet which is classified as unhealthy, split according to shop and influence variables. (Soure: Own calculations on Wrigley et al (2004b))

	Distance (km) to Tesco Seacroft				Overall
	$0 < d \leq 1.2$	$1.2 < d \leq 1.6$	$1.6 < d \leq 2.0$	$2.0 < d$	
Healthy					
Have car access					
h	6.3590	7.0430	7.2090	6.4390	6.7440
H	7.9390	7.1890	6.1660	8.7390	7.6070
Difference	1.5804*	0.1458	-1.0431*	2.2993***	0.8636***
n	80	96	73	105	354
Do not have car access					
h	8.2370	6.6400	8.8120	7.3900	7.7770
H	9.3040	6.7620	7.2260	8.0870	7.7640
Difference	1.0670	0.0861	-1.5864*	0.6969	-0.0128
n	64	73	67	41	245
Unhealthy					
Have car access					
u	5.9910	5.6760	5.3030	5.0990	5.4990
U	5.8180	5.2490	5.2860	5.8800	5.4850
Difference	-0.1732	-0.4271	-0.0176	0.4884	-0.0137
n	80	96	73	105	354
Do not have car access					
u	6.4400	5.3150	6.0640	6.0730	5.9410
U	6.5940	5.8120	6.2710	4.7630	5.9660
Difference	0.1540	0.4791	0.2068	-1.3101	0.0257
n	64	73	67	41	245
Proportion Unhealthy					
Have car access					
p	0.4918	0.4460	0.4395	0.4686	0.4617
P	0.4285	0.4241	0.4698	0.3842	0.4227
Difference	-0.0633**	-0.0218	0.0303	-0.0844***	-0.0390***
n	80	96	73	105	354
Do not have car access					
p	0.4438	0.4630	0.4231	0.4562	0.4459
P	0.4205	0.4791	0.4782	0.3990	0.4510
Difference	-0.0233	0.0161	0.0551*	-0.0572	0.0042
n	64	73	67	41	245
Significance levels *-10%,**-5% and ***-1%.					

Table 6: Paired sample t-tests of pre-intervention and post-intervention proportion of incidents of healthy food consumption, grouped by quartiles of road distance from Tesco Seacroft and household access to a motor vehicle (source: Wrigley et al, 2004b and own calculations).

To pull out the role that accessibility to the new store plays the access households have to a motor vehicle is now given focus, Caspi et al (2012b) and Wrigley et al (2003) both pick out the need for walkability. An immediate result is that it is infact those who do have car access who gain benefits in the nearest distance quartile, shading the problems that those reliant on walking are still having. As

already noted there are concerns about the third distance quartile, especially on healthy foods, but car ownership does not influnece this effect overly. A significant increase in the proportion of unhealthy products in the third distance group will concern policymakers, and is something that would ned to be addressed. Overall comparisons show car access households getting healthier while their non accessible neighbours show no significant changes.

A final look is taken at some more of the influence variables that could be considered important in shaping shopping habits. Specifically thought given to other household members in making purchasing decisions, and the influence of costs and offers. Table 7 reports the paired two-sample t-tests and shows a few statistically significant changes result. First those influenced by children reduce healthy intake, but those not reduce their proportion of unhealthy foods. This is similar to the story of spousal influence, although there it is those not influenced who get healthier, rather than those who are becoming less healthy. Generally not being influenced by others gives a household a lower proportion of poor diet items of between three and four percentage points. Households reporting the influence of their cost and budget are actually found to increase healthy consumption, with the unhealthy proportion falling. Such an observation runs contrary to the thought that in deprived areas cost is a constraint on health (Wrigley et al 2002a). Special offers influence households to improve their health too, although as will be seen later this is contrary to the impact in the quantile regression. Such contrasts highlight the benefit of the quantile approach adopted here.

	Influence: Children		Influence: Spouse		Influence: Cost/Budget		Influence: Special Offer	
	Asda	Not	Big	Other	Yes	No	Yes	No
n	259	322	304	277	423	158	372	209
h	7.479	6.967	7.518	6.841	7.038	7.616	6.983	7.572
H	6.532	8.605	7.669	7.694	7.860	7.202	7.783	7.534
Diff	-0.948**	1.638	0.151	0.853**	0.822***	-0.414	0.780**	-0.038
u	5.851	5.525	5.778	5.552	5.631	5.776	5.596	5.802
U	5.448	5.870	5.801	5.551	5.869	5.182	5.790	5.489
Diff	-0.739**	0.376	-0.088	0.356	0.525**	-0.882**	0.043	-0.025
p	0.455	0.455	0.447	0.463	0.457	0.447	0.460	0.444
P	0.464	0.409	0.437	0.430	0.436	0.428	0.431	0.437
Diff	0.010	-0.046***	-0.010	-0.033**	-0.022*	-0.020	-0.029**	-0.007

Significance Levels: * 10%, ** 5% and *** 1%

Table 7: Paired two sample t-tests of pre-intervention and post-intervention number of daily incidents of consumption of healthy and non-healthy foodstuffs, and proportion of household diet which is classified as unhealthy, split according to family and budgetary influence variables. (Soure: Own calculations on Wrigley et al (2004b))

From the preliminary analyses presented here it is clear that there many potential stories to tell about each of the newly constructed variables. One such phenomenon is that it is often those who do not switch to the new store that show the increases in healthfulness, such a result being in line with Volpe (2013) observation that large format stores do not drive impact, that it is the shoppers who determine the effect. Access concerns are also not seen as strongly since the fourth distance quartile does not show significant effects, although the third quartile often shows quite worrying unhealthy changes to diet. Still telling is that it is those with car access who are able to improve their diet, even post

intervention, while those who have no vehicle access show few significant impacts. These early conclusions presented in this section already offer great policy insight, suggesting that supermarket interventions may not be the answer. Next that tale must be fleshed out using quantile regression to explore what does truly motivate poor diet, and whether shopping at Tesco Seacroft improved things.

4 Modelling

Quantile regression uses all data points to estimate regression equations for each specified level of the distribution. Following Koenker and Bassett (1978) each of the three models solves:

$$\min_{\beta \in \mathbb{R}^k} \left[\sum_{t \in (t: y \geq x_t \beta)} \tau |y_t - \mathbf{x}_t \boldsymbol{\beta}_\tau| + \sum_{t \in (t: y \geq x_t \beta)} (1 - \tau) |y_t - \mathbf{x}_t \boldsymbol{\beta}_\tau| \right]$$

Where y_t is either the number of incidents of healthy food consumption, unhealthy food consumption, or the proportion of consumption which is unhealthy, after the intervention. Explanatory variables are collected together for each household, t, in the $K \times 1$ vector $\mathbf{x}_t$. Coefficients on these variables at the τ quantile are given by $\boldsymbol{\beta}_{\boldsymbol{\tau}}$**.** In estimating these coefficients the programme, R package quantreg, makes use of all available data, but care is still taken in regression to acknowledge the problems data holes may cause. Again due to the relatively low number of observations we keep the quantiles wide, and focus on quartiles ($\tau = 0.25, 0.5, 0.75$). To develop the final model the regression is estimated with the full set of explanatory variables described in Table 2, with the least significant variable eliminated before re-estimating the new reduced model. To ensure this is the correct action the new reduced model is tested against the previous version to see if it is an improvement of fit. For each of the three dependent variables a separate model is generated. As well as the quantile regression equations a test for equality of coefficients across quantiles is included, and an OLS linear model is estimated with the same independent variables for comparison.

5 Results

Quantile regressions are run for the three measures of diet constructed in section 3, healthy food consumption instances, unhealthy food consumption instances and the proportion of respondents diet that can be regarded as unhealthy. To allow quick comparison across the key factors all three models are reported in Table 8, together with tests for the equality of parameters across quantile and the ordinary least squares (OLS) regression which makes use of the same variables as are found to be significant in the respective quantile regression. Immediately it is apparent that there are some factors, including switching to the new store, which have influence on all three dependent variables. Meanwhile, others are specific to just one, or two. Comparing the OLS models shows how many of the issues that quantile regression highlights would be hidden if only the simple linear model was used, and therefore effects at the mean exposited.

Constants are highly significant in the models, a direct consequence of the lack of diet data on issues like price and consumer preferences. These can not be tested for equality but clearly do go a long way to explaining the differences. Interestingly the next variable, pre intervention consumption level, is

	Incidents of Healthy Food Consumption					Incidents of Unhealthy Food Consumption					Proportion of Consumption from Unhealthy Group				
	$\tau = 0.25$	$\tau = 0.5$	$\tau = 0.75$	F Test	OLS	$\tau = 0.25$	$\tau = 0.5$	$\tau = 0.75$	Equality?	OLS	$\tau = 0.25$	$\tau = 0.5$	$\tau = 0.75$	Equality?	OLS
Constant	6.116***	6.798***	10.130***		7.840***	2.530***	3.514***	4.371***		3.477***	0.249***	0.351***	0.454***		0.362***
	(0.390)	(0.471)	(0.503)		(0.555)	(0.319)	(0.481)	(0.669)		(0.522)	(0.025)	(0.030)	(0.027)		(0.018)
pre						0.065**	0.045	0.156**	2.382*	0.138***					
						(0.028)	(0.042)	(0.070)		(0.046)					
$nc2$						-0.004	0.634**	0.547	1.475	0.257	0.028	0.034*	0.013	0.890	0.020
						(0.054)	(0.258)	(0.343)		(0.325)	(0.018)	(0.019)	(0.023)		(0.014)
$ca3$	-0.625***	-0.606*	-0.232	1.861	-0.609**						0.002	0.025	0.033*	3.104**	0.014
	(0.210)	(0.313)	(0.300)		(0.283)						(0.012)	(0.019)	(0.019)		(0.010)
$preq2$						0.086	0.150**	0.100	1.215	0.165**					
						(0.054)	(0.058)	(0.089)		(0.073)					
$switch$	-0.643*	-1.360**	-1.740***	2.699*	-0.895**	0.151	0.181	0.764**	2.659*	0.447	0.037**	0.039**	0.025	0.497	0.027**
	(0.368)	(0.543)	(0.584)		(0.442)	(0.219)	(0.230)	(0.382)		(0.295)	(0.016)	(0.016)	(0.021)		(0.012)
$asda$	-0.143	-1.103**	-1.935***	7.322***	-0.919*										
	(0.390)	(0.525)	(0.622)		(0.472)										
$unemp$	-0.573	-0.714*	-0.727	0.111	-0.777										
	(0.365)	(0.365)	(0.747)		(0.522)										
$rent$	-0.751**	-0.675*	-0.143	2.174	0.286						0.027*	0.013	0.045**	2.170	0.031**
	(0.316)	(0.363)	(0.440)		(0.375)						(0.016)	(0.017)	(0.021)		(0.013)
$smoke$	-0.929***	-0.714**	-0.623	0.527	-0.730**						0.009	0.035*	0.045**	2.176	0.028**
	(0.276)	(0.345)	(0.467)		(0.358)						(0.019)	(0.020)	(0.020)		(0.013)
$kids$											0.048***	0.021	0.021	1.929	0.033**
											(0.016)	(0.020)	(0.024		(0.014)
$highed$	-0.965**	0.000	0.143	3.820**	-0.450										
	(0.486)	(0.393)	(0.556)		(0.469)										
$a1734$	-1.143***	-1.571***	-2.403***	5.384***	-2.280***	-0.291	-0.542**	-1.042**	3.278**	-0.798**	0.065***	0.055**	0.051**	0.208	0.046***
	(0.391)	(0.362)	(0.454)		(0.447)	(0.275)	(0.274)	(0.414)		(0.353)	(0.023)	(0.026)	(0.025)		(0.016)
$cost$	0.394	0.400	0.870**	1.755	0.944***	0.347	0.614**	0.352	0.887	0.770**					
	(0.336)	(0.316)	(0.375)		(0.384)	(0.256)	(0.324)	(0.396)		(0.341)					
$health$	0.464	0.828*	2.065***	3.723**	1.719***	-0.444	-0.740**	-0.372	0.938	-0.243	-0.034*	-0.041**	-0.051*	0.217	-0.030*
b	(0.457)	(0.375)	(0.743)		(0.483)	(0.256)	(0.333)	(0.554)		(0.417)	(0.020)	(0.022)	(0.027)		(0.018)
$ceat$	-0.606**	-0.286	-0.494	1.011	-0.886**										
D	(0.258)	(0.377)	(0.391)		(0.370)										
bal	1.892***	1.783***	1.597***	0.328	1.833***	-0.510**	-0.488*	-0.721*	0.402	-0.399	-0.090***	-0.092***	-0.108***	0.596	-0.095***
E	(0.315)	(0.297)	(0.447)		(0.362)	(0.214)	(0.272)	(0.371)		(0.308)	(0.010)	(0.021)	(0.023)		(0.013)
$like$						0.964***	1.409***	1.517	2.959*	1.412***	0.075***	0.072***	0.077***	0.046	0.069***
f						(0.225)	(0.246)	(0.363)		(0.309)	(0.016)	(0.019)	(0.021)		(0.013)
$conv$											0.032*	0.031	0.040**	0.174	0.029**
g											(0.018)	(0.019)	(0.019)		(0.013)
$offer$						0.123	0.049	0.743**	3.409**	-0.095					
p						(0.253)	(0.295)	(0.392)		(0.321)					

* Significance 10%; ** Significance 5%; *** Significance 1%

Table 8: Regression Coefficients and Tests of Equality of Slopes (Source Wrigley et al 2004b, calculations using R package quantreg)

only of importance to the healthy food consumption level. Distance is also less of significance than might be anticipated from the two-sample t-tests, only the second quartile of those without car access, and the third for those with, showing any sign of signifcant effect. Moving away from the interventions store increases unhealthy intake and reduces healthy, with the effect that the proportion of unhealthy foods goes up.

Switching to use the new store leads to lower consumption of healthy items across the board, with the OLS coefficient also highly significant but understating the magnitude of the effect amongst those whose diet would be considered the healthiest. Households with the highest levels of unhealthy consumption show marked increase due to Tesco, just over five instances per week. It is alsto notable that these are indeed significantly different across the quartiles. For the proportion of unhealthy foods eaten it is the lower end of the distribution where Tesco brings about significant increases of over 3%, with the OLS understating the increase at 2.7%. For healthy foods the neighbourhood's other store, Asda, also has an important impact, also distracting people from their healthier options and reducing intake by almost two portions per day. In all of this it is clear again that caution about the role of supermarkets in improving diet should be urged.

Unemployment, and the requirement of rental support are good proxies for the vulnerable groups about whom policymakers would naturally be concerned. Results show reductions in healthy foods assigned to both deprivation measures, while significant increase in the proportion of unhealthy food in a respondents diet is seen. More concerningly the decline in diet quality is more pronounced amongst those who already have a poor diet, an impact that is replicated amongst smokers as well. Younger respondents consume less, potentially due to their income being expected to be lower, but what they do consume is more likely to be unhealthy. Post intervention sees a rise of 5% for all healthfulness levels. Having a child in the household has been argued to exacerbate the effect (Wrigley et al, 2002a), but here this only holds amongst the proportion of low health intake, where at the lowest end all else equal the presence of a child adds 5% to the proportion of unhealthy products. Education was also highlighted by Wrigley et al (2002a) and others, but it is found only to impact on healthy intake, and in fact those with higher levels of education show a reduction in healtfulness at the bottom end of the distribution. Suggestion here is that attitudes and household characterisitics overcome the absolute level of education the head of household has received.

Self reported influences on shopping behaviour provide good clues as to what can be changed to promote better living. With so many poor households in the area the $cost$ variable is very important to many, but what we see here is that it actually aligns with an increase in consumption. Generally this is below the level suggested by OLS, and is always less than one portion per day. There is no impact of $cost$ on the proportion of diet which is unhealthy however. Health advice and believing in a balanced diet naturally move respondents towards a more nutritious lifestyle. Being influenced by children on the shopping trip moves things the other way, removing healthy items from the trolley. Clearly respondents like unhealthy foods, with significant increases in unhealthy items and the proportion of the diet which is unhealthy brought about by $like$. A major concern of the early literature was that those with a love of convenience would eat a poorer diet, and this is supported by the proportion of unhealthy food going up by between 3 and 4 percentage points, an impact OLS understates.

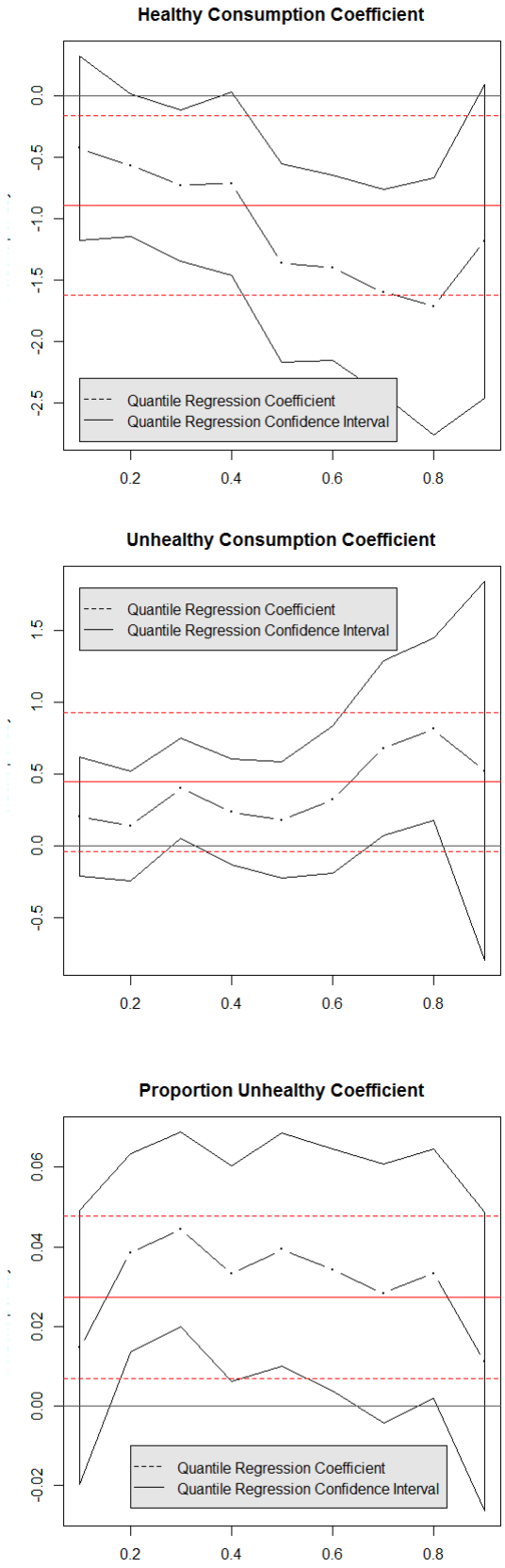

Figure 4: The Effect of Switching to Tesco Seacroft at $\tau = 0.1,0.2,0.3,0.4,0.5,0.6,0.7,0.8,0.9$ on healthy and unhealthy consumption and dietary make up. (Source: Own Calculations on Wrigley et al, 2004b)

A major drawback of the study is the lack of price data with which to model health. However, where $cost$ can go some way to addressing that, and there is usually a broad similarity between charges at all major supermarkets. Research shows that stores do not flex their general prices to local market conditions, and as such the opening of Tesco Seacroft is unlikely to have made any difference to regular pricing at Asda Killingbeck, but they do change their product range according to the location of the store[11].There is also an ability for stores to compete using special offers, and here it is clear that those who consume the most unhealthy foods see special offers as a motivating factor for this. An increase of 0.75 portions per day can be attributed to the $offer$ variable, with this parameter significantly different from others. Also important here is that there is no significance in the OLS regression meaning that this could have been overlooked by ignoring the quantile story.

Figure 4 shows how the coefficients of our regression vary across the different quantiles, with estimation undertaken at intervals in τ of 0.1. OLS coefficients and confidence intervals are also plotted for comparison. From the top graph it is obvious that as the diet becomes healthier so the influence of Tesco in pulling it back increases, the most negative impacts coming at the higher end of the healthful distribution. A mirror is only partially found for the unhealthy intake, with coefficients returned below the OLS level for the majority of levels. Only for the upper quartile of poor diet is any rise above the OLS value seen, with $\tau = 0.7$ and $\tau = 0.8$ moving above. For the proportion of unhealthy food consumed there is an understatement of the role of Tesco in the OLS model, but the actual impact does not vary much across the τ distribution. In all cases the new store raises the proportion by between 3 and 4 percentage points. Some support for the intervention is found amongst the low coefficients in the healthy case, and the general overstating of impact by the unhealthy OLS. However, the raising of the unhealthy proportion, and the higher coefficients amongst those with an already unhealthy diet, would continue to point to intervention supermarkets not improving the lot of the households their very opening is designed to help.

6 Conclusions and Policy Implications

Supermarkets have great potential to improve diet in areas where access to healthy foodstuffs has been limited or non-existent. Although a limited number of studies have raised concerns about the broad validity of this statement, few have presented evidence which significantly differs from the well supported improvement view. Within each aggregate story are a series of subjects which are of particular interest to policy makers and practitioners alike. Utilising quantile regression these effects can be explored and expanded upon to see just what is driving the aggregate result and what is hiding behind it. One such tale is that those with preferences for less healthy foodstuffs will take advantage of the lower prices and greater availability in a supermarket to buy more than they used to. As a conclusion this is intuitive but it is ignored by the current empirical studies of Seacroft due to the average effect being an improvement in diet. New retailers do increase convenience and reduce the distance households must travel to access their services, but this is only helpful if opening them up to more residents leads to the purchase of healthful foods. At almost all quantile levels Tesco Seacroft has reduced healthy food intake, increased unhealthy consumption and hence raised the proportion of unhealthy items in households diet. Most worryingly these facts hold with the largest coefficients for the least healthy respondents.

[11] Dobson and Waterson (2008) provides a detailed review of UK practice, and covers the time of the intervention study.

One of the key results of the paired two-sample t-tests was that those who did not switch to using the new Tesco store actually shifted their behaviour in a more healthy direction. The quantile regression results also support this potentially surprising relationship. By expectation there would be no notable change at any of the alternative stores, but it appears that household were able to find more healthy options between the two study waves. Although it is distance to the intervention store that is considered it should not be neglected that for many there are nearby supermarkets just outside the study area, Asda Killingbeck being a popular example. Asda shoppers post-intervention also displayed lower consumption of healthy items, with significant coefficients to those for Tesco Seacroft. No significant changes were observed for unhealthy, or proportion unhealthy as a result. Tesco will undoubtedly influence the strategy of Asda, and while UK supermarkets do not flex their prices to local conditions they certainly do alter special offers and product ranges[12]. Conclusions on switchers are therefore relevant to all and the impact of the intervention supermarket needs to be viewed as having direct and indirect effects on all residents regardless of where they shop.

In all of the regression presented there is a consistent move towards unhealthy eating coming from budgetary issues. Despite supermarkets offering lower prices than others at this time being unemployed, or requiring rental support, leads to reduced healthy intake and a greater proportion of unhealthy foods in the diet. It was precisely this issue that the Seacroft intervention set out to solve, but the evidence points to this having limited success. Where coefficients on cost, unemployment and rental support are insignificant, or moving in a healthful direction, the quantile is one at which households were more healthy anyway. Success at improving diet came from health advice, and those who saw the importance of a balanced diet. Education and emphasis on these items might be able to influence the tastes and preferences of consumers such that the foods liked variable also moves food consumption away from unhealthy foods. At a supermarket level discouraging promotions on processed or high fat items is shown to be an effective method to address the rising proportion of unhealthy products predicted from switching to Tesco. Financial support for those shopping at farmers markets was suggested by Dimitri et al (2015), Gustat et al (2015) and Pearson et al (2014), and so it appears such schemes in supermarkets will also help. Again there is a large amount of intuition in such policies, but to now no empirical evidence has been presented which highlights either the need, or how critical these controls are.

Households will always benefit from new supermarkets, with lower prices and higher product ranges they are more likely to find the foods they like at prices they can afford. Undoubtedly this means cheaper fruit and vegetables and this has led many to conclude that large format retailers are a workable solution to the problem of poor diet in food deserts. However, policy makers should be clear that such aggregate conclusions from OLS regression hide a multitude of issues that can actually leave a negative dietary legacy. Expanding beyond fruit and vegetables this study shows that healthy intake will always increase amongst those who prefer such foods, but that likewise households preferring unhealthy products will also increase their consumption thereof. Both are only exposed by quantile regression as these large changes are balanced by small changes amongst those who consume less of each category when OLS coefficients are calculated. Interventions yield aggregate improvements, directly or indirectly, but do need to be managed and considered carefully.

[12] See Dobson and Waterson 2008 for a detailed review of UK practice, with confirmation that this was the norm at the time of the Seacroft Intervention Study.

Despite the specific nature of the study and its focus on Seacroft, the intuitive nature of the conclusions and commonality between the study area and countless low income poor access areas worldwide, there is little reason results should not generalise a decade on. New research might seek to address the same issues in the modern environment, Donald (2013) being amongst the many papers which identifies the key need for a more contemporary intervention study. Policy makers should therefore ensure the right balance of education and price policies accompany any openings, such that benefits of intervention stores can be felt by the targeted poor diet groups, and pitfalls of increased unhealthy consumption identified here can be avoided.

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