Alma Mater Studiorum – Università di Bologna

DOTTORATO DI RICERCA IN SCIENZE STATISTICHE

Ciclo XXVIII

CELIAC DISEASE, PRICES AND CONSUMER FOOD CHOICES: EMPIRICAL EVIDENCE FROM THE UK

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Anno Accademico 2015/2016

Acknowledgements

I would like to express my sincere gratitude to my supervisor Prof.Mario Mazzocchi and to my co-supervisor Dr. Sara Capacci for their support. This thesis would not have been possible without their supervision.

A special acknowledgement shall be also made to Dr. Federico Banchelli, to my colleagues and to my family.

Abstract

Celiac disease is an autoimmune disease for which the only treatment is a strictly gluten free diet. Recently supermarkets have started to sell gluten free food, that were earlier sold only in chemist's or in specialist food shops. Gluten free food became more popular than before but prices of these kinds of products are higher than common grain-based food.
A consumer who must eat only gluten free products can't choose the price he prefers and faces higher prices. The aim of this research is to evaluate the economic impact associated with the higher prices faced by consumers who receive a celiac disease diagnosis.
A protocol to collecting price data on gluten and gluten free products was defined. Following the guidelines specified in the data collection protocol, gluten and gluten free prices were collected considering the on-line shops of the four most important UK supermarkets, and considering all products potentially containing gluten. The resulting dataset allows us to describe the current situation of gluten free food supply both in terms of the range of available product by category and the corresponding prices.
Using household purchase data from the 2012 Living Cost and Food Survey data, an Almost Ideal Demand System was estimated in order to obtain the average price elasticities for 15 food categories, including the most problematic for celiac people. The estimations of the AIDS model allows us to capture the general price response of UK consumer and provide the key informations needed for the evaluation of the impact of coeliac disease. In practice, we consider the price gap between gluten-free foods and foods containing gluten as an implicit tax.

The resulting welfare loss of the celiac consumers was then estimated using compensating variation, based on the AIDS coefficients estimated in the previous step and the collected price data. Hence, we estimate the additional amount of food expenditure which is needed by a celiac consumer to reach the same utility level of a consumer whose choice is not restricted to gluten-free products.

Demand and welfare analysis was conducted both for the total population and for three different income brackets, in order to explore the relative impact and potential inequalities across income groups.

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Chapter 1

Introduction

Coeliac disease is a chronic inflammatory small intestinal disease occurring in genetically predisposed individuals because of an immune response to gluten. Gluten is the term for the storage proteins found in wheat, barley and rye. The only remedy of coeliac disease is a gluten-free diet. Individuals with coeliac disease can consume several types of gluten-free products. These products fall into the categories of naturally occurring gluten free foods (fruits, vegetables, and unprocessed meat, fish and poultry) and gluten-free substitute foods (pasta, bread, cereals, crackers and snack foods) in which wheat flour is replaced by gluten free flours. The latter are purchased at general and specialist food stores as well as via the internet. This kind of food needs to be produced using machines for to gluten free cereals. This means higher prices due to higher production costs. A coeliac consumer has to deal with higher prices.

Scientific research has extensively dealt with the coeliac disease topic, particularly from a medical point of view. Economic aspects of the disease were discussed but most studies focused on the economic impact of the diagnosis in terms of health care costs. Just a few studies have tried to highlight the economic impact of a gluten free diet on consumers. As noted by Lee et al. (2007), a person on a gluten free diet spends more on food. 50% of gluten sensitive respondents reported that they spend more than 30% of their monthly food budget on gluten-free products. On average, gluten-free foods cost 240% more than one with gluten. The study by Lee at al. compared the market basket of regular wheat-based foods with a basket of gluten free food. The differences in price between purchase venues, both type of store and region was also analyzed. This study demonstrated that there is a limited availability of gluten-free foods and that they are more expensive than their gluten-containing counterpart.

Based on this evidence, the aim of this thesis is to estimate the economic impact of a gluten free diet on a consumer who received a coeliac disease diagnosis. The research question is: how much extra money is needed by coeliac consumers to maintain the same utility level which is provided by a gluten-containing diet?
To this purpose, using UK data, we proceed as follows:

- Using a partial demand system, we estimate the price elasticities for 15 food groups
- Based on supermarket price data, we estimate the price gap between foods containing gluten and their gluten-free counterpart
- Based on the price gaps and the estimated demand elasticities, we provide an estimate of the economic impact of a gluten free diet on food expenditure.

In other words, we regarded the price gaps between foods with gluten and gluten-free foods as an 'implicit' tax on celiac consumers.

Demand analysis was based on the Almost Ideal Demand System (Deaton and Muellbauer, 1980), based on the 2012 UK Living Cost and Food Survey data. This analysis describes the (average) purchase behavior of consumers who aren't forced to follow a therapeutic diet.
The data collection was targeted at prices of gluten and gluten free food sold in UK supermarkets. The main guidelines for data collection were set out in a protocol, so that the timing, the sources and the data structures were identified. Supermarket on-line shops can provide a representative view of supply of supermarkets in terms of quality targets, variety of supply and price levels. Using these on-line web shops for the main UK supermarkets, we obtained a complete and very detailed dataset.
A coeliac consumer is forced to buy only food certified suitable for him, and, as

mentioned before, the prices of these kinds of products are higher than the prices of wheat based products. To our purposes, a consumer whose choice is restricted to the more expensive alternatives of the gluten-containing foods, can be represented as a consumer who is subject to a taxation on these foods. In these terms, the problem with measuring the celiac consumer's economic loss can be seen as the welfare loss associated with a consumer tax. Therefore, methods to analyze economic welfare loss of consumers after a taxation were used to achieve this purpose. Compensating variation approach was used to evaluate the impact of a gluten free diet on food expenditure. Compensating variation provides a measure expressed in British pounds of economic welfare loss associated with higher prices. The compensating variation estimates represents the (weekly) amount of money needed by a coeliac consumer to achieve the same utility level associated with an unrestricted diet.

In the UK, patients diagnosed with coeliac disease can receive gluten-free staple foods via prescription from their general partitioner. Only products approved by the Advisory Committee on Borderline Substances can be bought. Prescriptions are based on The National Prescribing Guidelines endorsed by the Primary Care Society for Gastroenterology (PCSG) and the British Dietetic Association (BDA). The National Prescribing Guidelines supports the clinical decision making on the amounts of gluten-free staples people with coeliac disease can receive on prescription each month and assumes individuals also eat naturally gluten-free staple foods. These guidelines recommend an individual's monthly allocation of units based on their age, gender and whether they are pregnant or breast-feeding. Units are also allocated to the different types of gluten-free staples.

In England prescriptions are charged. However, some groups of people are exempt from prescription charges including children, the over 60's and those receiving income support. Usually a patient with celiac disease needs to pay one prescription charge for each item on their prescription. The prescription charge in England is £. 8.20. Prescriptions are instead free for everyone living in Scotland, Northern Ireland and Wales. Gluten free food obtainable by prescription is also only available in the pharmacy.

An English consumer afflicted with celiac disease is subsidised only to consume the quantity prescribed by his local doctor and within the range of products available in the pharmacy.

Estimation of how much a cealic consumer needs to compensate the higher prices of gluten free food could allow us to provide an evidence basis to elaborate a system of protection for consumers who need therapeutic diet, guaranteeing the free choice of products to purchase and the free choice of the place where to purchase them.

Chapter 2

Metodology

2.1 Demand analisys:preference based approach

The consumer in the neoclassical framework maximizes a direct utility function $U(q)$, where $q = (q_1, q_2, ..., q_n)$ is a vector of n quantities of goods consumed, given a budget level $x(p, q)$ and a vector of n prices $p = (p_1, p_2, ..., p_n)$, both determined exogenously. The optimization problem has two solutions: uncompensated and compensated demand functions. The first one is known as the Marshallian demand function:

$$q = g(x, p) \tag{2.1}$$

In this case quantities are functions of budget and prices whereas the second solution - known as the Hicksian demand function - considers demanded quantities as the function of prices and utility level:

$$q = h(U, p) \tag{2.2}$$

These demand functions represent only a different approach to the same problem. They are strictly connected to each other, thus in correspondence with a given level of the direct utility function there exists only one level of budget x. Therefore for every x of the uncompensated demand function only a level u in compensated demand function can be reached and vice versa. Thus, this dual approach to the utility maximization problem follows two alternative but equivalent paths to the identification of the optimal basket of goods. On the one hand, given the budget constraints, the Marshallian approach aims for maximization of utility whereas on the other hand, Hicksian approach, given a utility level, aims at minimization of cost. In this framework a series of mathematical formalizations can be set. Following the Marshallian approach, indirect utility function can be defined starting from x and p:

$$U = U(q) = U(g(x,p)) = \psi(x,p) \tag{2.3}$$

This represents the maximum utility level achievable given prices and budget. The cost function is, instead, obtained following the Hicksian approach and it identifies quantities that minimize the budget given a utility level and prices:

$$x = p'q = p'h(U,p) = c(U,p) \tag{2.4}$$

Thus, for every product i $q_i = g_i(x,p) = h_i(U,p)$. Following Shephard's Lemma, the price derivatives of the cost function are the Hicksian demand functions. Furthermore, by inverting the indirect utility function and substituting it into the Hicksian demand function, the Marshallian demand function is obtained.

Both compensated and uncompensated demand functions need to meet some properties that have direct consequences on the econometric specification of demand systems and that are directly derived from the consumer's preferences structure. These are the reflexivity, completeness, transitivity, continuity, non-satiation and convexity axioms plus the budget constraint, which in this framework is assumed to be linear (Moro, 2004):

- *adding-up*: total expenditure,x, corresponds to the sum of demanded quantities multiplied by their prices;
- *homogeneity*: Marshallian demands are homogenous of degree zero in price and total expenditure and the Hicksian demands are homogeneous of degree zero in prices;

	Direct price elasticity	Cross-price elasticity
Marshallian Demand	$e_{ij} = \frac{\partial q_i(x,p)}{\partial p_i}\frac{p_i}{q_i}$	$e_{ij} = \frac{\partial q_i(x,p)}{\partial p_j}\frac{p_j}{q_i}$
Hicksian Demand	$e_{ij} = \frac{\partial q_i(u,p)}{\partial p_i}\frac{p_i}{q_i}$	$e_{ij} = \frac{\partial q_i(u,p)}{\partial p_j}\frac{p_i}{q_i}$

Table 2.1: Compensated and uncompensated price elasticities

- *symmetry*: the cross-price derivatives of the Hicksian demands must be symmetric

- *negative*:the substitution matrix [1] must be negative semidefinite.

Furthermore the Slutsky matrix must be negative semi-defined. This condition is commonly simplified into the requirement that the own-price elasticities are negative, although this is a necessary but not sufficient condition.
Analysis of demands responsiveness to price changes is of main interest. Direct price elasticities measure the percentage change in demand of good i per marginal percentage change in the price of good i, whereas cross-price elasticity measure the percentage change in demand of good i per marginal percentage change in the price of good j.

2.1.1 Almost Ideal Demand System

The AIDS model is derived from a cost function representing a PIGLOG class of preferences. These preferences, represented by a cost function define the minimum expenditure necessary to attain a specific utility level at a given price. The cost function $c(U, p)$ can be defined using the PIGLOG class of preferences by

$$\log c(u, P) = (1 - u)\log(a(P)) + u\log(b(P)) \tag{2.5}$$

where u lies between 0, which represents the subsistence level, and 1 represents bliss, therefore the positive linear homogeneous function $\log(a(P))$ and $\log(b(P))$ can be regarded respectively as the costs of subsistence and bliss. The first one is specified as a price function homogeneous of degree one, that uses the translog form:

[1]the matrix of the second order price derivatives of the cost function.

$$\log(a(P)) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log(p_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij}^{*} \log p_i \log p_j \tag{2.6}$$

and the second one is homogeneous of degree zero and uses a Cobb-Douglas form:

$$\log(b(P)) = \log(a(P)) + u\beta_0 \prod_{i=1}^{n} p_i^{\beta_i} \tag{2.7}$$

By substituting 2.6 and 2.7 in 2.5, the cost function written in its extended form can be obtained:

$$\log(c(u,P)) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log(p_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \log p_i \log p_j + u\beta_0 \prod_{i=1}^{n} p_i^{\beta_i} \tag{2.8}$$

Following Deaton and Muellbauer (1980), by inverting 2.8, the indirect utility function can be written as:

$$u = \frac{(\ln x - (\alpha_0 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i \ln p_j))}{\beta_0 \prod_i p_i^{\beta_i}} \tag{2.9}$$

Shepard's Lemma - applied to 2.8 - returns a set of Hicksian demand functions. With the substitution of 2.9 in the Hicksian demands, a set of Marshallian demand function expressed in budget shares and as a function of total expenditure and prices is generated:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log(x/P) \tag{2.10}$$

where w_i is the share of total expenditure allocated to the i-th good and P is the non-linear price index $a(p)$ defined as follow:

$$\log(P) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log(p_i) + \frac{1}{2}\sum_{i=1}^{n}\sum_{j=1}^{n} \gamma_{ij} \log p_i \log p_j \tag{2.11}$$

On the bases of economic theory, the homogeneity, Slutsky symmetry, adding-up and the semi-defined negativity of the Slutsky matrix are constraints which must be met and can be tested or imposed on the parameters of the AIDS equation. *Adding-up* requires that:

$$\sum_{i=1}^{n} \alpha_i = 1 \sum_{i=1}^{n} \gamma_{ij} = 0 \sum_{i=1}^{n} \beta_i = 0 \tag{2.12}$$

Homogeneity requires that:

$$\sum_{j=1}^{n} \gamma_{ij} = 0 \tag{2.13}$$

and *symmetry* requires that:

$$\gamma_{ij} = \gamma_{ji} \tag{2.14}$$

The requirement that the Slutsky matrix is negative semi-definite is less straightforward and most empirical studies focus on the necessary condition that the resulting own-price elasticities are negative. If homogeneity, symmetry and adding up are not rejected, the estimated demand functions are homogenous of degree zero in prices and expenditure taken together (Deaton and Muellbauer, 1980). Provided equations 2.12, 2.13 and 2.14 hold, equation 2.10 represents a system of demand functions which add up to total expenditure $\sum w_i = 1$, and are homogenous of degree zero in prices and total expenditure thus satisfying Slutsky symmetry. When there is no change in relative price and in X/P , the budget shares are constants. Changes in relative prices take effect through γ_{ij} and changes in expenditure operate through the β_i coefficients which are summed to zero and are positive for luxuries and negative for necessities (Deaton and Muellbauer, 1980)

General formulas for compensated and uncompensated price elasticities are displayed in Table 2.1. By applying these elasticity formulas to 2.10 , the equations for the uncompensated price and income elasticities for AIDS model are obtained (Green et al.1990):

$$e_{ij} = -\delta_{ij} + \frac{\gamma_{ij}}{w_i} - \beta_i \frac{\alpha_j}{w_i} - \frac{\beta_i}{w_i} \sum_{k}^{n} \log p_k \tag{2.15}$$

where δ_{ij} is the Kronecher delta: $\delta_{ij} = 1$ for $i = j$ and $\delta_{ij} = o$ for $i \neq j$.

2.2 Consumer Welfare

A consumer forced to shift to a gluten free diet is a consumer who must face higher prices than before. Considering this starting point, we can look at prices of gluten free food as normal food prices that were subjected to an exogenous increase. In this framework, a welfare analysis can be performed to evaluate the welfare loss experienced by coeliac consumers.

Let (p, x) be the starting consumer's situation and (p', x) the consumer's situation after the price change. Therefore, this implies a change in the utility level that shifts from $u(p, x)$ to $u(p', x)$. A natural measure of welfare change can be obtained comparing the two utility functions, in particular observing the difference between $u(p, x)$ and $u(p', x)$. The problem is that the result of this comparison is expressed in terms of utility, without a real univocal meaning (Becht, 1995). Instead, considering the expenditure function as a measure of consumer welfare, a monetary value can be computed (Levin et al., 2004). The first step is to choose the level of utility to be used as a reference point: if we choose the utility level prior to the price change we can evaluate how much money - more or less - a consumer needs to achieve the reference utility. Otherwise, if we choose the utility level achieved after the price change we can evaluate how much money - more or less - the consumer would have needed before the price change to be as well off as he/she currently is (Levin et al., 2004). These two approaches use two specific instruments to achieve their goals: the first one is the compensating variation, which allows to evaluate the consumer welfare after price change by comparing two cost functions that differ only for the level of prices.

$$CV = c(u, P) - c(u, P') = x - c(u, P') \tag{2.16}$$

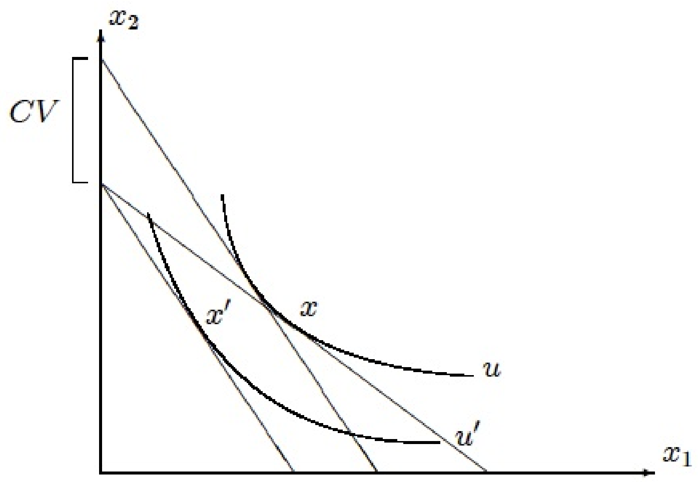

Figure 2.1: Compensating Variation. Source: Levin 2004

The second approach described before uses as economic instrument the equivalent variation, which gives the change in the expenditure that would be required at the original prices to offset the price change effect.

$$EV = c(u', P) - c(u', P') = c(u', P) - x \tag{2.17}$$

The main differences between the compensating and equivalent variation is the choice of the utility level: CV uses as reference utility level the situation prior to the price change whereas EV considers the new utility level achieved after price change (Levin et al., 2004).

Figure 2.1 represents compensating variation referring to a context where only a single price changes . From Figure 2.1 we note that the change can be broken down into two components: 1) the effect of the price rise can be considered as made up of two parts 2) the price rise makes the individual worse off and also changes the relative prices of the two goods. The first of these shifts the budget line and the second rotates it. To isolate these two changes we can introduce a sort of 'intermediate' budget line.It has a slope equal to the new budget line and therefore reflects the new relative prices while it touches the same indifference curve as the individual was originally on. In this sense we could consider that between the original budget line and this intermediate one the individual is indifferent. So moving from the original budget line

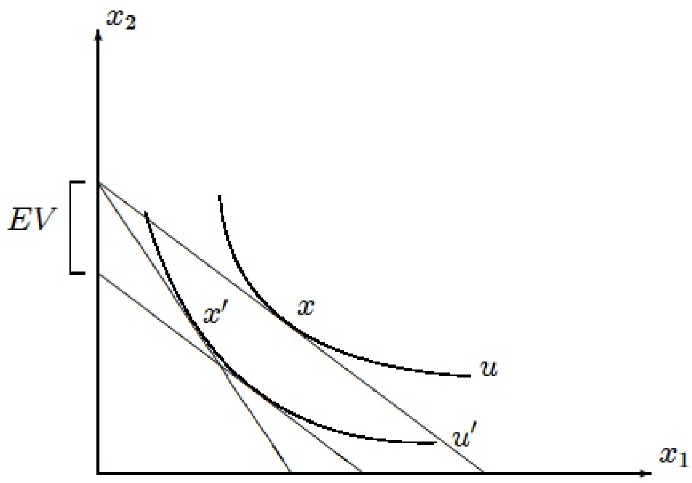

Figure 2.2: Equivalent Variation. Source: Levin 2004

to this intermediate one captures the relative price effect of the price change, while moving from the intermediate one to the new one captures the income effect.
In general, after an increase of prices, compensating variation will be negative, otherwise will be positive.

Figure 2.2 represents equivalent variation. In this case the intermediate budget line is parallel to the original budget line and thus reflects the original relative prices but at the optimal point the individual has the same level of welfare as in the new position. The loss of welfare can therefore be measured by the Equivalent Variation of the price rise as the vertical distance between the original budget line and the intermediate budget line.
Compensating variation and equivalent variation are both linked to Hicksian demand functions. Assuming that price change only affects one product i, CV can be related to uncompensated demand functions as follows:

$$CV = c(u, P) - c(u, P') = \int_{p'_i}^{p_i} \frac{\partial c(u, P)}{\partial p_i} dp_i = \int_{p'_i}^{p_i} h_i(u, P) dp_i \tag{2.18}$$

Similarly, equivalent variation can be expressed in relation with the Hicksian demand function:

$$EV = c(u', P) - c(u', P') = \int_{p_i'}^{p_i} \frac{\partial c(u', P)}{\partial p_i} dp_i = \int_{p_i'}^{p_i} h_i(u', P) dp_i \tag{2.19}$$

Another common measure of consumer welfare is Marshallian surplus. This measure is particularly used in that empirical work where a Marshallian demand function is estimated (Levin et al., 2004).

$$ConsumerSurplus = \int_{p_i'}^{p_i} g_i(x, P) dp_i \tag{2.20}$$

Consumer surplus is typically an intermediate measure that lies between compensating and equivalent variation, $min(CV, EV) \leq CS \leq max(CV, EV)$ (Becht, 1995).

2.2.1 Welfare analysis in partial demand system

Compensating variations (or equivalent variation) can be used as a tool in welfare analysis. In theory, compensating variation can be evaluated using estimates of a complete demand system. Because researcher seldom have information on all prices and conceptions, empirical studies use either partial or incomplete demand system. An incomplete demand system is a system of n goods of interest, artificially augmented by a composite numberer good. A partial demand system includes only the n demand equations(Bocksteal et al., 2005). In these cases, the issue for welfare analysis is that incomplete and partial demand system doesn't contain sufficient information about preferences to completely derive the underlying indirect utility function (Hanemann et al., 1992). Assuming separability, partial demand system can be estimated and partial compensating (or equivalent) variation can be derived. A frequent reason for invoking separability is lack of data.
Assuming separability, the consumer's preferences can be represented by the following direct utility function:

$$u = u(y, z) \tag{2.21}$$

where $y = (y_1, y_2, ..., y_n)$is a subset of commodities for which consumption and price data are available and $z = (z_1, z_2, ..., z_n)$ is the set of commodities for which there are no data. The demand functions referred to y are

$$q_j = g_{yj}(p, x_y) \quad j = 1, 2, ..., n \tag{2.22}$$

where x_y is the total expenditure in y. The 2.22 are partial demand function because they are conditional on the budget allocation to the y commodities group (Pollak, 1971). The partial cost function, in turn, is the following:

$$c(u_y, P) \tag{2.23}$$

where u_y is the partial direct utility function referred to the available data on y. Therefore, assuming separability ,partial compensating variation can be specify as CV_y. Partial or conditional CV is associated whit a change in quantity and prices of commodities for which data are available (Hanemann et al, 1992).
Following Hanemann et al. (1992), given separability assumption, the following will be valid

$$CV_y \leq CV \tag{2.24}$$

due to the change of consumer's budget allocation between the y and z commodities. Only CV incorporates this budget adjustment. Therefore, in those cases where demand and price data are not complete, CV_y is not in general equal to CV.
Some corollaries follow from 2.24:

- $CV_y > 0$ is a sufficient, but not a necessary, condition for $CV > 0$;
- $CV_y < 0$ doesn't give information about the sign of CV.

A clarification is needed about the second corollary: assuming that increase of prices only affects considered commodities and assuming that all other prices don't vary, CV will show the same negative sign of CV_y.
In conclusion, considering separability assumption, CV_y is a partial welfare measure. This is not equal to CV in general and it is only a lower bound on the complete CV (Hanemann et al, 1992).

Chapter 3

Demand analysis

3.1 Data: Living Cost and Food Survey

The estimation of the demand system for the purposes of this thesis is based on data from the 2012 UK *Living Cost and Food Survey* (LCS). LCS data is collected from a sample of English households, which are required to keep a diary of purchases over a two weeks period. Each adult individual (16 years old and over) is asked to note down in the diary the daily expenditure. A simplified diary form is available for children aged between 7 and 15 years old. LCS data includes quantities and expenditure values for food products. Goods and services are classified according to United Nations Statistical Commission's Classification of Individual Consumption by Purpose (COICOP) . Food items are coded using the code structure developed in the past by the Ministry of Agriculture, Food and Fisheries (now Department of Environment, Food and Agriculture) and are classified using an additional level of disaggregation with respect to standard COICOP classification. Total expenditure and total quantities purchased in grams are provided for each household and for each food item.

Our analysis was based on 15 food groups corresponding the main food categories. In this list of commodities, five are relevant to coealic consumers, particularly bread, flour, cakes, buns and pastry, biscuits and all the other foods that need cereal for their production. Categories such as milk or fats present very few products containing gluten and this characteristic makes these groups non-problematic for coealic people due to the high level of substitutability and the wide range of alternatives. Table 3.3 shows the average per capita of all food group consumption disaggregated by income

Total Population- Average of grams purchased				
	Milk	**Cheese**	**Meat**	**Fish**
Grams	3690	252	2076	318
Dev.Standard	3073	298	1706	451
	Eggs	**Fat**	**Sugar**	**Vegetables**
Grams	210	308	290	3911
Dev.Standard	300	528	502	2998
	Fruit	**Bread**	**Flour**	**Cakes**
Grams	2542	1353	149	346
Dev.Standard	2493	1031	724	434
	Buiscuits	**Other cereals**	**Confectionery**	
Grams	358	1046	280	
Dev.Standard	405	1044	382	

Table 3.1: Average of grams per capita purchased per week- Total population

brackets. The first bracket represents the lowest income quartile, the third bracket is the highest income quartile, and the remaining bracket combines the second and third quartiles.

People on lower incomes consume in general less food than high income bracket. Some exceptions are fats and sugar. Consumers in middle income group consume on average more bread, cakes and biscuits than the others. The highest consumption of flour is instead observed in the lowest income bracket. Table 3.4 shows the main differences in the price of purchase between the three income groups considered. In Table 3.4 mean unit values by food category are reported together with the percentage difference between the mean unit values paid by a low income household and the mean unit values paid by a high income household. Low income households spend less than their high income counterpart, as it could be reasonably expected. There are no big differences between low and middle income brackets.

Total Population - Unit values average				
	Milk	**Cheees**	**Meat**	**Fish**
Unit Values	0.11	0.71	0.58	0.82
Dev.Standard	0.01	0.07	0.05	0.13
	Eggs	**Fat**	**Sugar**	**Vegetables**
Unit Values	0.34	0.27	0.19	0.19
Dev.Standard	0.04	0.03	0.051	0.02
	Fruit	**Bread**	**Flour**	**Cakes**
Unit Values	0.21	0.19	0.09	0.45
Dev.Standard	0.02	0.02	0.02	0.07
	Buiscuits	**Other cereals**	**Confectionary**	
Unit Values	0.46	0.35	0.80	
Dev.Standard	0.06	0.04	0.10	

Table 3.2: Average of unite values - Total population

	Low income	**Middle income**	**High income**
Milk	3256.78	3871.9	3807.6
Dev.Standard	3063.70	3095.38	3005.02
Cheese	211.8	245.5	312.7
Dev.Standard	322.99	271.40	329.39
Meat	1937.3	2145.1	2122.9
Dev.Standard	1673.76	1639.55	1782.91
Fish	250.9	318.8	379.9
Dev.Standard	453.01	439.78	463.95
Eggs	204.8	212.4	212.2
Dev.Standard	308.17	291.82	338.17
Fats	328.5	319.3	259.5
Dev.Standard	553.64	477.43	637.67
Sugar	324.6	294.7	234.7
Dev.Standard	588.94	498.99	435.23
Vegetables	3548.6	4007.8	4113.9
Dev.Standard	3111.52	3003.13	2825.77
Fruit	1971.5	2556.4	3137.1
Dev.Standard	2208.92	2483.21	2688.45
Bread	1351.9	1428.7	1241.1
Dev.Standard	1150.49	1024.22	865.47
Fluor	165.9	142.9	117.5
Dev.Standard	1034.00	720.36	614.00
Cakes,pastry	311.4	383.2	320.5
Dev.Standard	392.67	422.24	466.07
Buiscuits	335.6	387.8	329.0
Dev.Standard	377.20	415.51	391.54
Other cereals	992.8	1030.8	1128.8
Dev.Standard	1252.11	898.13	1226.73
Confectionary	253.8	298.3	284.5
Dev.Standard	340.99	357.05	399.92
Other food	7334.4	7150.7	7857.3
Dev.Standard	7093.63	6462.05	6776.44

Table 3.3: Average per capita of grams purchased per week

	Low income	Middle income	High income	% variation from low to high income
Milk	0.102	0.106	0.120	18
Dev.Standard	0.02	0.01	0.02	
Cheese	0.679	0.700	0.788	16
Dev.Standard	0.10	0.08	0.11	
Meat	0.521	0.572	0.683	31
Dev.Standard	0.07	0.05	0.09	
Fish	0.707	0.783	0.982	39
Dev.Standard	0.18	0.12	0.20	
Eggs	0.300	0.339	0.400	33
Dev.Standard	0.06	0.05	0.07	
Fats	0.252	0.269	0.329	31
Dev.Standard	0.07	0.05	0.09	
Sugar	0.160	0.196	0.257	61
Dev.Standard	0.06	0.10	0.11	
Vegetables	0.170	0.188	0.237	39
Dev.Standard	0.03	0.02	0.04	
Fruit	0.183	0.202	0.243	33
Dev.Standard	0.03	0.03	0.04	
Bread	0.179	0.187	0.223	25
Dev.Standard	0.03	0.02	0.04	
Fluor	0.082	0.075	0.089	9
Dev.Standard	0.03	0.03	0.04	
Cakes,bun,pastry	0.425	0.444	0.515	21
Dev.Standard	0.08	0.07	0.18	
Buiscuits	0.421	0.448	0.568	35
Dev.Standard	0.11	0.07	0.11	
Other cereals	0.328	0.350	0.400	22
Dev.Standard	0.07	0.05	0.07	
Confectionary	0.750	0.792	0.959	28
Dev.Standard	0.14	0.12	0.23	

Table 3.4: Unit values average by income quartile and percentage variation from low to high income group

3.2 Estimation of the demand system

3.2.1 Unit values

ONS in LCS doesn't collect data on prices paid by the individual households at the time of purchase, but collects information on expenditure and purchased quantities. Furthermore, the LCS provides some additional variables that give useful information about household characteristics. Based on expenditure and purchased quantities, it is possible to compute unit values as their ratio. Unit values computed in this way reflect the heterogeneity in real prices faced by the different households, but also the quality choice made by the household. In order to purge the unit values data from the endogenous quality component, the assumption is that price variation occurs across region and month, but household surveyed within the same region/month face identical prices. Hence, we define prices as the mean of unit values by region and month, which also allows to obtain price information for those households which didn't purchase some foods in a given month. Thus, the issue of quality and aggregation has been addressed by first computing individual household unit values, then averaging them across each of n clusters, where each cluster corresponded to a given month and region.

3.2.2 The demand system

A demand system conditional on food expenditure was estimated considering 15 aggregate food groups: (1) *Milk*, (2) *Cheese*, (3) *Meat*, (4) *Fish*, (5) *Eggs*, (6) *Fats*, (7) *Sugar and preserves*, (8) *Vegetables*, (9) *Fruit*, (10) *Bread*, (11) *Flour*, (12) *Cakes, Buns and pastry*, (13) *Biscuits and crispbread*, (14) *Other cereals and cereal products*, (15) *Confectionary*. A residual food group, (16) *Total other food*, was also considered. Beverages were not included in the demand system and only domestic purchases were considered.

The non-linear AIDS model was estimated using an Iterated non-linear Seemingly Unrelated Regression (ITSUR) procedure, implemented both in SAS and Stata to check for the validity of estimates, and identical results were obtained.

In order to overcome the singularity problem associated with the adding-up condition, only 15 categories were considered (Barten, 1969), and the residual group (16)

was dropped, so that a system of 15 equations was estimated. The coefficients for the omitted equation could be retrieved through the adding-up constraint.
According to consumer theory, symmetry and homogeneity were imposed and tests against the unrestricted demand system led to non-rejection of the theoretical constraints. The demand system was specified as follows:

$$w_i = \alpha_i + \sum_{j=1}^{n} \gamma_{ij} \log p_j + \beta_i \log(x/P) \tag{3.1}$$

Following to the original specification of AIDS (Deaton et al., 1980), P is a non linear price index, specified as:

$$\log(P) = \alpha_0 + \sum_{i=1}^{n} \alpha_i \log(p_i) + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \gamma_{ij} \log p_i \log p_j \tag{3.2}$$

We assumed α_0 to be equal to the minimum value of the logarithm of total food expenditure, which corresponds to the subsistence level when all prices are unity.
Total food expenditure, x, corresponds to the sum of all outlays in the 16 considered food groups. Unit values, computed considering the region of residence and the month of interview were the proxy for market prices.
In this application, the main interest was the economic welfare loss by individual but the LCS data are at the household level. Therefore data were translated back into an individual dimension, using covariates available in LCS referring to the composition of households. In particular, based on the OECD equivalence scale a value of 1 was assigned to the first adult household member, a value of 0.7 to each additional adult and a value of 0.5 to each child (OECD, 1982). Household food expenditure was translated into individual food expenditure using this equivalence scale. Expenditure shares are invariant to the application of such deflator, which affects both expenditures and quantities in the same way.
The analysis was also conducted separately for the three aforementioned levels of income.

	Milk	**Cheeese**	**Meat**	**Fish**
R-square	0.5621	0.4433	0.7455	0.3871
	Eggs	**Fat**	**Sugar**	**Vegetables**
R-square	0.3048	0.2840	0.2149	0.7779
	Fruit	**Bread**	**Flour**	**Cakes**
R-square	0.00	0.03	0.04	0.16
	Biscuits	**Other cereals**	**Confectionary**	
R-square	0.4315	0.5662	0.3539	

Table 3.5: R-square - AIDS Total population

3.2.3 Empirical results

Four demand systems were estimated: three considering the income classification and one for the total population. The last system gives general results useful to draw a general conclusion, while not considering potential income inequalities. The other three demand systems allow to capture different demand behaviours according to the income level.

Table 3.5 shows that all models present relatively high R-squares, with the exception of the flour equation.
As shown in Tables A1, A2, A3, A3, A4, A5, A6, A7, A8 available in the Appendix, most of the estimated coefficients are statistically significant at the 5% and 10% level both for the overall model referred and for the models by income level. More specifically, most of the own-price effects are statistically significant, as shown Tables 3.7 and 3.8. Symmetry and homogeneity restrictions were not rejected (P-values > 0.05).

The price elasticities of demand were estimated using the equations reported in Green and Alston (1990). Table 3.7 shows the estimated own-price elasticities along with their p-values for total population. The own-price elasticities have the expected negative sign for all food groups and bread, flour, cake, biscuits show low own-price elasticities values. The own-price elasticities are less than unity as is often the case for food commodities. These elasticities are expected to be low for essential commodities and relatively high for commodities that are not essential items.

Differences and similarities among income groups come to light from Table 3.8. Among the differences, bread emerges as an essential food, therefore it presents low and a similar elasticity across income groups. Flour, instead, shows an elastic demand in low income and a clear inelastic demand in middle and high income groups.

Equations	Low income	Middle income	High income
Milk	0.5169	0.6059	0.5708
Cheese	0.4929	0.4439	0.4285
Meat	0.7356	0.7647	0.7200
Fish	0.3635	0.3823	0.4140
Eggs	0.3288	0.3096	0.3217
Fat	0.3504	0.2872	0.2494
Sugar	0.2435	0.2517	0.1844
Vegetables	0.7540	0.7960	0.7804
Fruit	0.5189	0.5915	0.6158
Bread	0.5864	0.6430	0.5679
Flour	0.0721	0.0672	0.0689
Cakes	0.3997	0.4294	0.2946
Biscuits	0.3835	0.4789	0.3997
Other cereals	0.5690	0.5969	0.5302
Confectionery	0.3316	0.3808	0.3064

Table 3.6: R-square - AIDS by income

	Milk	**Cheese**	**Meat**	**Fish**
Elasticities	-0.92	-0.79	-0.46	-0.66
P-value	0.00	0.00	0.00	0.00
	Eggs	**Fat**	**Sugar**	**Vegetables**
Elasticities	-0.93	-0.89	-0.59	-0.87
P-value	0.00	0.00	0.00	0.00
	Fruit	**Bread**	**Flour**	**Cakes**
Elasticities	-0.50	-0.31	-0.54	-0.18
P-value	0.00	0.03	0.04	0.16
	Buiscuits	**Other cereals**	**Confectionary**	**Other food**
Elasticities	-0.64	-0.87	-0.71	-1.27
P-value	0.00	0.00	0.00	0.00

Table 3.7: Own-price elasticities-Total population

	Low income	Middle income	High income
Milk	-1.19	-0.50	-0.64
p-value	0.00	0.00	0.00
Cheese	-1.60	-0.83	-0.55
p-value	0.00	0.00	0.04
Meat	-0.48	-0.70	-0.65
p-value	0.00	0.00	0.00
Fish	-0.40	-0.49	-0.92
p-value	0.03	0.12	0.00
Eggs	-1.05	-1.01	-1.11
p-value	0.00	0.00	0.00
Fat	-0.89	-0.64	-1.14
p-value	0.00	0.00	0.00
sugar	-0.77	-0.50	-0.67
p-value	0.00	0.00	0.02
Vegetables	-0.91	-0.95	-0.86
p-value	0.00	0.00	0.00
Fruit	-0.59	-0.74	-0.47
p-value	0.00	0.00	0.00
Bread	-0.34	-0.43	-0.40
p-value	0.10	0.00	0.10
Flour	-1.00	-0.10	-0.36
p-value	0.01	0.33	0.23
Cakes	-0.45	-0.46	-0.27
p-value	0.00	0.00	0.04
Biscuits	-0.89	-0.48	-0.77
p-value	0.00	0.01	0.01
Other cereals	-0.83	-0.80	-0.57
p-value	0.00	0.00	0.00
Confectionery	-1.07	-0.67	-0.99
p-value	0.00	0.03	0.00
Other food	-1.24	-1.14	-1.30
p-value	0.00	0.00	0.00

Table 3.8: own-price elasticities by income

Chapter 4

The impact of celiac disease on food expenditure

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4.1 Protocol

A protocol was defined to collect prices of gluten free and non gluten free food sold in UK supermarkets. The protocol is structured in six sequential steps:

- Identification of inclusion criteria for supermarkets;
- Identification of data sources;
- Definition of the time frame for data collection;
- Definition of criteria for choosing food categories;
- Identification of classification of goods and level of disaggregation;
- Identification of a strategy for data collection.

First of all, the inclusion criteria were defined to identify the UK supermarkets to be included in the study. We considered those supermarkets that: (1) had a 2014 market share of no less than 4%; (2) had a web page dedicated to online shopping; (3) sold online gluten free foods. According to these criteria four supermarkets were identified: Asda, Tesco, Sainsbury's and Waitrose.
The supermarkets pages dedicated to on-line shopping were used as the data source.

Prices were collected in August 2014, over 30 days, and we followed the COICOP classification was used, as in the LCS. Thirty days was considered a sufficient amount of time to ensure that major variations in price do not occur between the first collected price and the last one. Only prices of foods belonging to the category of bread and cereal products were collected, as they are, indeed, the most problematic for coeliac people, due to the low substitutability. In other food categories, where substitution is easier, it can be reasonably assumed that the average price faced by coeliac consumers is the same as for coeliac consumers. Therefore, prices in pence at 100 grams of all cereal products were collected, building eight datasets, four for gluten free food (one per supermarket) and four for gluten products. In the gluten free data sets only products that were certified as suitable for coeliac consumers were included. Therefore, foods which are naturally gluten free but are not certified as such were included in the gluten data sets. Dry rice was the only exception and it was included in both datasets.

4.2 Descriptives

The differences between the selected UK supermarkets considered do not only lie in different price levels and in the quality of products, but also in the range of gluten free food offered. The choice of these four supermarkets was based on specific criteria that were defined in the previous paragraph; the result of this choice was a representative sample that well describes the heterogeneity of gluten free food supply. Gluten free foods are available in the four supermarkets in very different ways. First of all, the number of available products differ not also between supermarkets but also between the different categories of food. Thus, in some supermarkets it is easy to find gluten free bread and in an others it is easier to find different flour types. Table 4.1 shows the percentages of food suitable for coeliac people (intended as the ration between the number of gluten-free alternatives and the total number of available products in the same category), grouped by commodity category and supermarkets. From table 4.1 it appears that Tesco is the most equipped with gluten free food, therefore it presents the highest percentage of products for most food categories.

	Tesco	**Asda**	**Sains.**	**Wait.**
White bread	15%	9%	7%	10%
Cake, buns and teacakes	27%	3%	10%	20%
Buiscuits and crispbread	8%	8%	4%	8%
Oatmeal and oat product	22%	5%	9%	12%
Breakfast cereal	17%	7%	9%	5%
Rice	39%	33%	70%	68%
Infant cereal food	10%	0%	0%	6%
Cake and pastry-frozen	0%	4%	4%	0%
Pasta	10%	7%	7%	5%
Pizza	3%	1%	2%	1%
Other cereal food	10%	9%	5%	9%
Flour	44%	18%	10%	8%

Table 4.1: *Percentage of gluten free food by supermarket*

Food suitable for coeliac people must be produced in factories when only gluten free cereals are involved in the production process. Furthermore, manufacturing is more complicated than traditional grain-based products and needs separate processes and specific machineries that are more onerous than standard processes and machineries. For all these reasons, a coeliac consumer has to deal with higher prices. The four supermarkets considered present different price levels both for gluten and for gluten free products. Tesco in particular represents the cheapest of the four and its supply is varied. Asda is very similar to Tesco in terms of prices and presumably of product quality. Sainsbury's and Waitrose, instead, are in general more expensive than Tesco and Asda. If we accept that prices are a proxy for quality in a competitive market, this means that their supply, is reasonably targeted at a higher quality level, especially Waitrose. These differences are evident both for gluten free and gluten foods. Table 4.2 shows the means collected prices for some categories of food. Differences in prices are evident not only between gluten and gluten free products but also between supermarkets. However, the percentage difference of mean prices between gluten-free and the grain-based equivalent is almost identical in all supermarkets. One of the most evident differences between the prices of the different kinds of products concerns bread. Therefore, coeliac consumers can buy bread - that is a staple food by definition - spending 78% to 79% more than consumers who don't follow a therapeutic diet. In some cases, e.g. pizza o cereal snacks, Waitrose and Sainsbury 's have higher prices compared to Tesco and Asda. However, considering the gap between gluten and gluten-free products, the price gap is higher for Tesco and Asda.

4.3 Compensating variations

4.3.1 Partial welfare analysis in previous studies

A common problem of welfare studies is lack of consumption or prices data. In these cases, researchers resort particularly to partial welfare measure.
Attanasio et al. (2013) evaluated the welfare consequences of food price increases in rural Mexico computing partial compensating variation. Data on no-food commodities were not available , therefore they assumed separability between food and non food commodities and estimated food conditional demand system.They underlined that separability is a strong but necessary assumption. Wood et al. (2011), starting

Gluten food prices (£)								
	Bread	**Cakes,buns and teacakes**	**Oatmeal and oat products**	**Breakfast cereals**	**Cooked rice**	**Pasta**	**Pizza**	**cereal snacks**
Tesco	0.19	0.38	0.52	0.47	0.34	0.28	0.61	0.67
Asda	0.19	0.39	0.56	0.52	0.45	0.29	0.66	0.71
Sainsbury	0.21	0.45	1.04	0.57	0.46	0.31	1.03	1.02
Waitrose	0.24	0.48	0.62	0.58	0.48	0.36	1.00	1.25
Gluten free food prices (£)								
	Bread	**Cakes,buns and teacakes**	**Oatmeal and oat products**	**Breakfast cereals**	**Cooked rice**	**Pasta**	**Pizza**	**cereal snacks**
Tesco	0.86	1.00	0.96	0.72	0.55	0.46	1.06	1.31
Asda	0.87	1.24	1.37	0.88	0.87	0.68	1.11	0.93
Sainsbury	0.98	1.39	1.37	0.82	0.88	0.62	1.25	1.27
Waitrose	1.10	1.42	1.48	1.08	0.89	0.55	1.35	1.61
Price variation between gluten and gluten free food (%)								
	Bread	**Cakes,buns and teacakes**	**Oatmeal and oat products**	**Breakfast cereals**	**Cooked rice**	**Pasta**	**Pizza**	**cereal snacks**
Tesco	78%	62%	46%	35%	37%	39%	42%	49%
Asda	78%	69%	59%	41%	48%	57%	41%	24%
Sainsbury	79%	68%	24%	31%	47%	50%	18%	20%
Waitrose	78%	66%	58%	46%	46%	35%	26%	22%

Table 4.2: *Price of gluten free an gluten food in four supermarkets- Collected data*

from a food conditional almost ideal demand system, performed a partial welfare analysis by compensating variation. They evaluated the welfare impact of food price escalation on Mexican population comparing poor and no-poor population. They didn't explicitly assume separability between food and non food utility function but they performed all analysis considering conditional demand system and computing a partial welfare measure. Tefera et al.(2012) estimated a food conditional QUAID system and computed partial compensating variation to evaluate welfare impact of rising food prices in Ethiopia. The authors performed the analysis for three income brackets. As Wood et al.(2011) they didn't explicitly assume separability between food and no-food commodities utility function. Ackah et al. (2007) assuming that the demand for food does not depend on prices of non-food items given total food spending, adopted weak separability assumption. To describe the welfare impact in Ghana after food prices change, they estimated a food conditional demand system and computed compensating variation.

When prices or comsuption data are not complete, the use of partial compensating variation to perform welfare analysis is a common practice.As Hanemann et al. (1992) underline, partial welfare measure can be used only under separability assumption.

This is a strong one and if this assumption is appropriate results must be explain consider the limitation of this kind of measure due to the partial nature of it.

4.3.2 Estimation of Compensating Variation

Welfare analysis was performed through compensating variations following Wood et al. (2011). In a scenario of price variation, CV shows how much more (or less) income (in our case total food expenditure) consumers need in order to achieve the same utility level they had before the price change.
Using AIDS parameters, compensating variation was computed. The demand system estimated was conditional to food, therefore CV represent a partial measure of welfare. Lack of data about prices of no-food commodities allows to estimate only a partial demand system. For this reason, following Attanasio et al. (2013) separability between food and no-food utility functions was assumed. Separability is a strong assumption but, as Hanemman (1992) explained, the common response to the lack of data is estimated conditional system assuming separability. Therefore, according with the conditional demand system estimated, a partial compensating variation was computed.

A consumer with a diagnosis of coeliac disease is bound to purchase gluten free products, facing higher prices than the non coeliac counterpart. Within this context, compensating variation evaluates how much more food expenditure is needed by coeliac consumer to achieve the utility level without such a diagnosis.
Compensating variation was obtained considering the cost function referred to the average UK consumer (i.e. without assuming food range restrictions) and the cost function computed using gluten-free food prices but assuming the utility level of the non-coeliac consumer:

$$cv(p^G, p^{GF}, x) = x - c(p^{GF}, u^G) \tag{4.1}$$

where p^G are the prices of gluten products, p^{GF} are prices of gluten free foods and u^G is the utility level of a consumer who didn't receive a diagnosis of coeliac disease.

Therefore, $c(p^{GF}, u^G)$ represents a cost function referred to a coeliac consumer, computed at the utility level before the diagnosis, and x is the cost function referred to a non coeliac consumer.
Following Deaton and Mulleber (1980) $c(p^{GF}, u^G)$ was built as:

$$\ln c(p^{GF}, u^G) = \alpha_0 + \sum_i \ln p_i^{GF} + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i^1 p_j^1 + \tag{4.2}$$
$$+[\frac{\ln x - \alpha_0 - \sum_i \alpha_i \ln p_i^0 - \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i^0 \ln p_j^0}{\prod_i p_i^{0\beta_i}}]\beta_0 \prod_i p_i^{1\beta_i}$$

Therefore, compensating variation is computed as follows:

$$CV = x - \exp\{\alpha_0 + \sum_i \ln p_i^{GF} + \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i^1 p_j^1 + \tag{4.3}$$
$$+[\frac{\ln x - \alpha_0 - \sum_i \alpha_i \ln p_i^0 - \frac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_i^0 \ln p_j^0}{\prod_i p_i^{0\beta_i}}]\beta_0 \prod_i p_i^{1\beta_i}\}$$

Compensating variations were then estimated considering the same categories of foods used in the demand analysis and using the coefficients estimated through the AIDS model (Wood et al., 2011).
Collected supermarket prices were used for bread, flour, cakes and pastry, biscuits and other categories of cereals. Collected supermarket prices of gluten free foods were used to compute the cost function referred to coeliac consumers (see Table 4.3),whereas prices of gluten food were used to compute the pre-diagnosis cost function. For all other categories average unit values and no variation was assumed between the two cost functions.

Cereal products prices and food purchases used in the analysis were referred to two different years and came from two different sources. Supermarket data was collected in 2014, whereas unit values were computed using 2012 data. From the comparison of the ONS price index for 2012 with the collected prices means (Table 4.3.2) we can state with a good level of confidence that these prices can be used in welfare analysis together. For example, Table 4.3.2 shows that in 2012 the price index for 800gr of

£ per 100gr	**Bread**	**Fluor**	**Cakes**	**Biscuits**	**Other C.**
Gluten	0.20	0.13	0.42	0.70	0.56
Gluten free	0.96	1.14	1.26	1.27	1.03

Table 4.3: *Gluten and gluten free prices used to compute CV for total population and for the first simulation by income*

	ONS price index(2012)	**ONS price range(2012)**	**Collected prices mean(2014)**	**Collected price range(2104)**
White bread 800gr	1.33£	0.79£- 1.55£	1.34£	0.80£- 1.58£
Wholemeal bread 800gr	1.33£	0.79£- 1.55£	1.36£	0.78£- 1.60£

Table 4.4: *Comparison between mean of collected prices (2014) and ONS price index (2012)*

white bread was £1.33 and in 2014, the mean price from the data collected in supermarkets and referring to the same bread type and weight was just £0.01 more. The similarity of these prices over the years allows us to use unit values obtained from the 2012 LCS (the latest available data at the time of running the analysis) together with prices collected 2014.

4.3.3 Impact of gluten free diet by income

Compensating variation was estimated to evaluate economic impact of a gluten free diet by different levels of incomes. Using the estimated coefficients from the demand models by income group, two different simulation experiments were performed.
In the first simulation - considering separately all three income brackets - compensating variations was estimated using the same methodology described before. Therefore the estimated AIDS coefficients were used together with collected prices averages of bread, flour, cakes and pastry, biscuits and other categories of cereals in Table 4.3.

£ per 100gr	**Bread**	**Flour**	**Cakes**	**Buiscuits**	**Other cereals**
Low income	0.181	0.081	0.424	0.412	0.333
Middle income	0.187	0.075	0.440	0.453	0.349
High income	0.218	0.090	0.506	0.546	0.395
Total Population	0.191	0.078	0.449	0.463	0.357

Table 4.5: *Mean unit value of cereal based products- Total population and income brackets*

In this way prices of cereal products were the same for all income brackets.

Following Abramovsky et al. (2011), the second simulation was performed using different prices for the three different income levels. Table 4.5 shows the different values between unit values paid by low, middle and high income brackets. Considering only cereal-based products, the percentage difference between the total unit values and the income conditioned unite values were computed. Table 4.6 shows e.g. that consumers with low incomes pay on average for bread 5% less than the mean of total population. Instead consumers in high income pay 14% more. Prices used in welfare analysis for bread, flour, cakes and pastry, biscuits and other categories of cereals were rescaled in order to meet the observed proportions among percentage variations of unit values in the three income levels. Therefore in the low income case e.g. gluten free bread mean collected prices was reduce by 5%, in middle income case was reduce by 2% and in high income was increased by 14%. In Table 4.7 prices used in the second simulation are displayed.

4.3.4 Empirical results

Compensating variation was estimated considering the AIDS estimated coefficients and the collected prices. According to our estimates, an English consumer who receives a coeliac disease diagnosis needs, on average, an extra £26.45 weekly, to achieve that same level of utility than consumers without a gluten-free restriction. The negative sign of compensating variation (Table 4.8) is consistent with an increase of prices

	Bread	Flour	Cakes	Buiscuits	Other cereals
Low income	-5%	3%	-6%	-11%	-7%
Middle income	-2%	-5%	-2%	-2%	-2%
High income	14%	15%	13%	18%	11%

Table 4.6: *Percentage difference between the total unit values and the income conditioned unite values*

Gluten food prices - £ per 100gr					
	Bread	**Flour**	**Cakes**	**Buiscuits**	**Other C.**
Low income	0.19	0.13	0.40	0.62	0.52
Middle income	0.20	0.12	0.41	0.68	0.55
High income	0.23	0.15	0.47	0.83	0.62
Gluten free food prices - £ per 100gr					
	Bread	**Flour**	**Cakes**	**Buiscuits**	**Other C.**
Low income	0.91	1.18	1.19	1.13	0.96
Middle income	0.94	1.09	1.23	1.24	1.01
High income	1.10	1.31	1.42	1.50	1.14

Table 4.7: *Gluten and gluten free prices used to compute CV -Second simulation by income*

	Compensating Variation	St.Error	P-value	Confidence Interval 95%
Total Population	-26.45	1.25	0	-23.98 -28.91

Table 4.8: *Compensating variation on per capita data*

	Compensating Variation	St.Error	P-value	Confidence Interval 95%
Low income	-19.12	2.13	0	-14.93 -23.29
Middle income	-22.71	1.50	0	-25.64 -19.76
High income	-27.29	2.08	0	-23.21 31.37

Table 4.9: *Compensating variation per income bracket*

and it means that the consumer needs to give away money to compensate for the fact that they are better off than before. The measure obtained is a partial compensating variation, therefore it is lesser or equal to the complete CV (Hanemann,1992). Table 4.8 shows the compensating result, standard error , p-value and the confidence interval referred to total population.

We also recognize the importance of determining how different population groups are affected in different ways by gluten free food prices. Thus, to illustrate which groups of population were relatively disadvantaged by the price changes, we disaggregate the compensating variation measure by income group (Wood et al.,2011) (Abramowsky et al., 2011) (Tefera et al., 2012). The results obtained by the first simulation - illustrated before - suggest that the impact of gluten free diet on food expenditure is very similar way in all groups, at least in absolute terms. Observing the values in Tables 4.9 the results reveal some little differences in the impact of price variations on the three income groups. This differences - observing the confidence interval in particular - could be ignored but the different value of compensating variation reflect differences in own-price elasticities and average unit values for different income levels. High income bracket emerge as the most penalized by the high level of gluten free food because they tend to purchase more expensive foods, whereas a consumer belonging to the low bracket seems be the least penalized. The average impact of a gluten-free diet is £19.12 per week for a consumer in the low income bracket, £22.70 per week for a coeliac person in middle income bracket and £28.26 per week for a consumer with a high income. The impact of a price change upon a consumer is a function of both the magnitude of the price change as well as the relative importance of different food items in the consumption basket. The little differences observed in compensating variation values can be connected to demand elasticities and to the different price levels the consumer is used to pay. Of course this result stems from the assumption that consumers in different income brackets face different prices, or - more reasonably - that the quality heterogeneity across income groups should be maintained for coeliac consumers to obtain a credible estimate of the welfare loss.

Cereal products are a key food group so as Table 3.3 shows, demand is not very elastic to price changes. However, considering values referred to bread, flour, cakes, biscuits and other cereals reported in Table 3.3 some differences by income bracket are evident: more specifically, low income consumers present an almost elastic demand for most of these goods. Instead for middle and particularly for high income consumers, demand is definitely inelastic. Consumers who belong to the low income bracket reduce their outlay if they have to pay higher prices so the almost elastic demand of this consumer group explains why it presents the lower level of welfare loss estimated. On the other hand, consumers in the high income bracket, accept to pay high prices and their budget reallocation is less evident. The unit value of bread referred to the high income group is on average 25% higher than unite value referred to low income bracket. Biscuits unit values are on average higer by 35% and so on. In Table3.4, the percentage variation of the unit values is reported.

However, differences between the three income brackets are minimal and in the impact - in terms of British pounds - of the transition from a standard diet to a gluten free diet can be considered almost the same for the aggregate population.

Table 4.10 shows compensating variation values computed using the method described

	Compensating Variation	St.Error	P-value	Confidence Interval 95%
Low income	-19.12	2.13	0	-14.93 -23.29
Middle income	-22.70	1.51	0	-25.66 -19.75
High income	-28.26	2.28	0	-23.79 32.74

Table 4.10: *Compensating variation per income bracket*

for the second simulation. Therefore these results consider the price choices of consumers but they are very similar to the previous compensating variation values.In low and middle income brackets, only a difference of a few pence can be observed and for the high income group the difference between the two estimates amounts only to £1.

Chapter 5

Conclusions

This research focused on quantifying the impact on food expenditure of a gluten free diet on a consumer forced to have this therapeutic diet, hence facing higher prices. Data collection provided a comprehensive dataset that explains the current situation of gluten free food supply in UK supermarkets. It is important to consider that supermarkets are not the only places where gluten free products can be found and in particular medical prescriptions can not be used there. Collected data demonstrated that in the UK, coeliac consumers can easily find food suitable for them. The supermarkets being considered provide some gluten free products for the main cereal based food groups.

The four big names studied in the research are differentiated by quality of supply and prices of sales. These differences are reflected in the supply of gluten free products. Therefore Tesco and Asda offer middle quality products at low-middle prices whereas Sainsbury's and Waitrose have higher prices and - reasonably - higher quality. The main common characteristic is that gluten free food is more expensive than its gluten equivalent therefore this evidence is at the basis of the present research.

Using data from the 2012 Living Cost and Food Survey, a demand analysis - based on the Almost Ideal Demand System specification - allowed to describe the UK food demand response to price changes. The fifteen food categories considered are all essential for modern nutrition, and as expected own-price elasticities are all less than one. However, some goods present an almost elastic demand (i.e. similar to -1). This becomes more evident in the analysis by income groups. Low income consumers show for some food groups a more responsive demand to price changes. Middle and high income brackets, instead, present almost regularly an inelastic demand. These results

were particularly useful for the development and for the interpretations of the welfare analysis.
To evaluate the impact of a gluten free diet on a coeliac consumer, we exploited the demand system coefficient estimates together with the prices collected on supermarkets. In this research, coeliac people were considered as consumers who deal with a price increase similar to a tax. Therefore partial compensating variation was computed comparing a utility cost function that represents the pre-diagnosis situation and another utility function built considering the price increase. To simulate this price change, mean collected prices of the most problematic categories for coeliac people were used in place of the unit values from the LCS. The Compensating Variation allows to obtain a value expressed in British pounds able to measure how much more money a consumer needs to achieve the pre-diagnosis utility level. Not considering differences of income levels an average English consumer who receives a coeliac disease diagnosis needs on average £26.45. The weekly food outlay for an English consumer - using LCS data from 2012 - is on average £54.24. After a coeliac disease diagnosis an English consumer who doesn't want to change their dietary habits needs to increase their food expenditure by 48%. Considering a monthly value, a coeliac consumer needs £105.8 more monthly to achieve the same utility level they had before the diagnosis.
Income analysis didn't highlight strong differences in terms of compensating variations among the three income brackets considered in this study. However, consumers in the low income bracket seem the least penalized by a gluten free diet in absolute terms, based on the assumption that they pursue a lower quality. However, the impact of the welfare loss as a percentage of total food expenditure or income is much higher for lower incomes. As mentioned before, the almost elastic demand observed for some problematic food categories for coeliac people means that these consumers are more prone to reduce the food outlay of these food groups and substitute them with other (relatively cheaper) foods. This is why we observe the smallest economic welfare loss for the lowest income bracket. An English consumer belonging to low income bracket forced to shift to a gluten free diet needs an extra £19.12. Considering an average weekly food expenditure - from LCS data from 2012 - of £42.20, a consumer in the low bracket needs to increase their income by 46% and in a month

they need £76.48 per person more on average. Consumers both in middle and high income brackets show an absolutely inelastic demand. This means that they tend not to modify their food outlay in correspondence with price variations - this is true for high income group in particular. This inelastic demand can explain why this group needs more money than consumers in the low income bracket. If we also allow for consumer belonging to the high income bracket to buys at higher price levels, this evidence reinforces the obtained results. Consumers in middle income bracket need an extra £22.71 per week and consumers in high income group need £27.29. The weekly average food expenditure of the middle income bracket is £52.82. Shifting to a gluten free diet a consumer belonging to this group needs 43% extra food expenditure to achieve the same utility level they had before and needs monthly - on average - £90.84. The high income group starts from a weekly average food expenditure of £68.80 and needs an extra £26.45 oer week to maintain the dietary habits they had before the diagnosis. Considering this data, this kind of consumer needs to increase their income by 38% and needs an extra £109.16 per month.
Thus, the similarity of economic impact of coeliac disease between the three income brackets considered is illusory, since considering the compensating variations as a percentage of average food expenditure (income) shows how this is the most penalized group due to their initial low outlay. Consumers in middle income bracket are also seriously affected by the higher prices faced, and as consumers in the low income group, they need more than half of their usual expenditure to compensate the price rise. The percentage impact of price change on consumers in high income bracket is less than the other two groups, but it is still close to 40%.

It is important to underline that compensating variation computed is a partial measure of welfare. Separability assumption between food and no-food utility function allows to performed this kind of analysis. Therefore, considering the partial nature of the welfare measures obtained some final consideration are needed:

- Compensating variations obtained are only a lower bound of complete CV;
- Compensating variation is an implicit consequence of separability assumption;

	Total food expenditure	**Deviation Standard**	**Increas of food expenditure - %**
Low income	42.20	28.47	46%
Middle income	52.82	28.78	43%
High income	68.80	43.44	38%
Total population	54.24	51.61	48%

Table 5.1: *Total food expenditure and percentage of increase of food expenditure after a celiac disease diagnosis*

- Separability assumption is a strong one but it was necessary due to the lack of no-food data.

Results describe the response of a consumer who has to face higher food prices than before, not considering the possibility of budget reallocation between food and not food commodities. Therefore, the main limitation of the research derives from the lack of price data referred to no-food commodities.

Appendix A

	Milk	Cheese	Meat	Fish	Eggs	Fat	Sugar	Vegetables	Fruit	Bread	Flour	Cakes	Biscuits	Other Cereals	Confectionary	Other Food
Alpha	**0.3046**	**0.0405**	-0.0312	**-0.0713**	**0.0299**	**0.0246**	**0.1458**	**0.0708**	**0.2401**	0.0028	**0.0429**	**0.0474**	**0.1216**	**0.0850**	**-0.0665**	**0.3046**
Beta	**-0.0222**	-0.0002	**0.0140**	**0.0117**	**-0.0020**	**-0.0016**	0.0003	**0.0049**	**-0.0183**	**-0.0004**	**-0.0035**	**-0.0016**	**-0.0062**	**-0.0070**	**0.0321**	**-0.0222**

Values highlighted in bold are significative at 5% or 10%.

Table A1 *: Estimation of alphas and betas parameters – AIDS Total Population*

	Milk	Cheese	Meat	Fish	Eggs	Fat	Sugar	Vegetables	Fruit	Bread	Flour	Cakes	Biscuits	Other Cereals	Confectionary	Other Food
Milk	-0.0006															
Cheese	0.0020	0.0060														
Meat	-0.0108	-0.0095	**0.1044**													
Fish	0.0055	-0.0019	**-0.0188**	**0.0118**												
Eggs	-0.0010	0.0023	-0.0033	**0.0026**	0.0007											
Fat	**0.0055**	**0.0055**	0.0091	-0.0020	**-0.0026**	0.0015										
Sugar	0.0030	**-0.0030**	-0.0006	0.0002	0.0010	-0.0014	**0.0037**									
Vegetables	0.0082	0.0042	**-0.0258**	0.0080	-0.0019	**-0.0065**	**-0.0041**	0.0157								
Fruit	0.0078	0.0066	**-0.0420**	**0.0101**	0.0034	0.0016	0.0021	**0.0150**	**0.0411**							
Bread	**-0.0088**	**-0.0080**	0.0131	-0.0041	-0.0008	0.0003	0.0032	-0.0001	**-0.0158**	**0.0290**						
Flour	0.0019	0.0015	0.0001	0.0004	0.0010	**-0.0015**	**-0.0017**	**-0.0031**	0.0000	-0.0007	**0.0009**					
Cakes	**-0.0089**	**-0.0056**	-0.0028	**0.0067**	-0.0021	**-0.0026**	-0.0002	**-0.0059**	0.0028	-0.0016	0.0007	**0.0215**				
Biscuits	-0.0048	**-0.0068**	0.0046	0.0005	-0.0002	-0.0004	**-0.0031**	**0.0125**	-0.0025	-0.0031	0.0011	**0.0041**	**0.0100**			
Other C	**0.0136**	0.0007	0.0052	**-0.0095**	**-0.0039**	**-0.0042**	0.0002	-0.0027	**-0.0172**	**0.0116**	**-0.0019**	**-0.0046**	0.0008	0.0073		
Confectionary	-0.0059	0.0038	-0.0002	0.0003	**0.0029**	-0.0009	0.0011	**-0.0105**	-0.0026	**-0.0106**	0.0010	-0.0016	**-0.0097**	**0.0150**	0.0103	
Other food	-0.0065	0.0022	**-0.0228**	**-0.0098**	0.0019	-0.0013	-0.0004	-0.0029	**-0.0103**	-0.0036	0.0003	0.0002	-0.0031	**-0.0104**	**0.0076**	**-0.0591**

Values highlighted in bold are significative at 5% or 10%.

Table A2 : *Estimation of gamma parameters – AIDS Total Population*

	Milk	Cheese	Meat	Fish	Eggs	Fat	Sugar	Vegetables	Fruit	Bread	Flour	Cakes	Biscuits	Other Cereals	Confectionary	Other Food
Alpha	***0.304***	0.022	***-0.120***	***-0.062***	0.008	-0.002	0.002	***0.119***	***0.157***	***0.187***	-0.001	***0.094***	***0.045***	***0.066***	***0.166***	0.016
Beta	***-0.028***	***0.002***	***0.022***	***0.009***	0.000	0.000	0.000	***0.004***	***0.000***	***-0.014***	0.000	***-0.004***	***-0.004***	-0.003	***-0.013***	***0.027***

Values highlighted in bold are significative at 5% or 10%.

Table A3 : *Estimation of alphas and betas parameters – AIDS Low Income*

	Milk	Cheese	Meat	Fish	Eggs	Fat	Sugar	Vegetables	Fruit	Bread	Flour	Cakes	Biscuits	Other Cereals	Confectionary	Other Food
Milk	**-0.0224**															
Cheese	-0.0007	***-0.0169***														
Meat	0.0041	-0.0117	***0.0983***													
Fish	***0.0106***	-0.0013	-0.0085	***0.0185***												
Eggs	-0.0010	0.0006	0.0071	0.0003	***-0.0006***											
Fat	***0.0059***	-0.0024	0.0136	0.0014	-0.0005	0.0018										
Sugar	-0.0003	-0.0031	0.0014	0.0025	-0.0004	-0.0002	0.0023									
Vegetables	0.0005	0.0021	-0.0175	0.0005	0.0002	-0.0030	0.0026	0.0110								
Fruit	0.0075	0.0009	-0.0424	-0.0096	0.0044	-0.0026	-0.0017	0.0161	***0.0311***							
Bread	***-0.0236***	0.0009	-0.0094	-0.0025	0.0023	-0.0064	0.0020	-0.0068	0.0104	0.0320						
Flour	0.0032	0.0007	-0.0017	-0.0003	-0.0006	-0.0017	***-0.0030***	0.0010	0.0027	-0.0030	0.0000					
Cakes	0.0064	***-0.0087***	-0.0144	0.0061	-0.0032	0.0000	-0.0014	-0.0018	0.0009	-0.0013	***0.0038***	***0.0146***				
Biscuits	-0.0080	***0.0116***	0.0076	-0.0007	0.0013	-0.0009	-0.0028	0.0029	-0.0010	0.0053	0.0010	-0.0041	0.0028			
Other C	***0.0207***	***0.0137***	0.0156	-0.0148	-0.0045	***-0.0065***	-0.0025	-0.0075	-0.0230	0.0080	***-0.0067***	0.0052	-0.0022	0.0121		
Confectionary	-0.0036	-0.0022	-0.0022	0.0030	-0.0030	***0.0060***	0.0043	-0.0101	-0.0009	-0.0053	0.0036	-0.0077	0.0003	0.0099	-0.0050	
Other food	0.0005	**0.007**	**-0.0395**	-0.0052	-0.0023	**-0.0043**	0.0004	0.0099	0.0075	-0.0024	0.0014	0.0057	**-0.0131**	**-0.0173**	**0.0028**	**-0.0494**

Values highlighted in bold are significative at 5% or 10%.

Table A4 : *Estimation of gamma parameters – AIDS Low Income*

	Milk	*Cheese*	*Meat*	*Fish*	*Eggs*	*Fat*	*Sugar*	*Vegetables*	*Fruit*	*Bread*	*Flour*	*Cakes*	*Biscuits*	*Other Cereals*	*Confectionary*	*Other Food*
Alpha	***0.3967***	***0.0381***	-0.0047	***-0.0785***	***0.0341***	***0.0391***	0.0046	***0.1383***	***0.1062***	***0.2020***	0.0044	0.0111	0.0136	***0.1317***	***0.0568***	***-0.0936***
Beta	***-0.0275***	-0.0010	***0.0176***	***0.0116***	***-0.0029***	***-0.0018***	0.0005	-0.0010	0.0021	***-0.0168***	-0.0002	-0.0008	0.0006	***-0.0077***	***-0.0037***	***0.0311***

Values highlighted in bold are significative at 5% or 10%.

Table A5 *: Estimation of alphas and betas parameters – AIDS Middle Income*

	Milk	*Cheese*	*Meat*	*Fish*	*Eggs*	*Fat*	*Sugar*	*Vegetables*	*Fruit*	*Bread*	*Flour*	*Cakes*	*Biscuits*	*Other Cereals*	*Confectionary*	*Other Food*
Milk	***0.0268***															
Cheese	-0.0026	0.0049														
Meat	0.0017	-0.0081	***0.0591***													
Fish	-0.0046	0.0014	***-0.0223***	***0.0184***												
Eggs	-0.0035	0.0013	-0.0022	***-0.0036***	-0.0002											
Fat	***0.0076***	-0.0022	***0.0079***	0.0001	-0.0021	***0.0050***										
Sugar	-0.0001	-0.0008	-0.0041	0.0025	0.0000	***-0.0032***	***0.0046***									
Vegetables	0.0077	0.0063	***-0.0166***	0.0068	-0.0033	***-0.0074***	***-0.0041***	0.0061								
Fruit	***0.0153***	0.0057	***-0.0438***	0.0071	-0.0003	***0.0082***	0.0015	0.0110	***0.0215***							
Bread	***-0.0201***	0.0006	0.0045	0.0017	0.0036	0.0038	0.0032	***-0.0128***	-0.0006	***0.0238***						
Flour	0.0006	0.0010	-0.0005	0.0012	-0.0008	-0.0012	-0.0001	-0.0018	0.0020	-0.0009	***0.0016***					
Cakes	***-0.0125***	-0.0024	0.0031	0.0021	***0.0037***	-0.0041	-0.0026	-0.0042	0.0001	0.0027	-0.0011	***0.0148***				
Biscuits	-0.0051	***-0.0062***	0.0042	-0.0020	0.0010	0.0009	-0.0004	***0.0125***	***-0.0088***	-0.0022	-0.0004	0.0030	***0.0148***			
Other C	-0.0040	0.0030	0.0073	***-0.0086***	-0.0040	***-0.0061***	0.0005	0.0044	-0.0030	-0.0014	-0.0001	0.0027	-0.0018	0.0111		
Confectionary	-0.0040	0.0046	-0.0070	0.0011	***0.0069***	-0.0027	***0.0038***	-0.0068	0.0024	-0.0046	0.0009	-0.0030	-0.0017	0.0020	***0.0122***	
Other food	-0.0029	***-0.0064***	***0.0167***	-0.0014	***0.0034***	***-0.0045***	-0.0005	0.0021	***-0.0183***	-0.0014	-0.0005	-0.0022	***-0.0076***	-0.0020	-0.0043	***-0.0299***

Values highlighted in bold are significative at 5% or 10%.

Table A6 *: Estimation of gamma parameters – AIDS Middle Income*

	Milk	Cheese	Meat	Fish	Eggs	Fat	Sugar	Vegetables	Fruit	Bread	Flour	Cakes	Biscuits	Other Cereals	Confectionary	Other Food
Alpha	**0.2388**	**0.0591**	-0.0412	**-0.0518**	**0.0376**	0.0128	0.0114	**0.1638**	0.0563	**0.2004**	0.0071	**0.0524**	**0.0512**	**0.1002**	0.1269	**-0.0250**
Beta	**-0.0168**	-0.0026	**0.0149**	**0.0106**	**-0.0041**	-0.0010	0.0000	-0.0016	**0.0077**	**-0.0157**	-0.0002	**-0.0041**	-0.0020	-0.0022	**-0.0108**	**0.0279**

Values highlighted in bold are significative at 5% or 10%.

Table A7 : *Estimation of alphas and betas parameters – AIDS High Income*

	Milk	Cheese	Meat	Fish	Eggs	Fat	Sugar	Vegetables	Fruit	Bread	Flour	Cakes	Biscuits	Other Cereals	Confectionary	Other Food
Milk	**0.0194**															
Cheese	**0.0120**	0.0145														
Meat	0.0056	0.0065	**0.0609**													
Fish	0.0029	-0.0020	-0.0153	0.0028												
Eggs	-0.0039	-0.0012	-0.0002	**0.0054**	-0.0015											
Fat	-0.0012	0.0009	**0.0129**	-0.0044	**-0.0030**	-0.0016										
Sugar	**0.0044**	-0.0014	0.0063	0.0006	0.0002	-0.0017	**0.0026**									
Vegetables	-0.0074	0.0116	**-0.0355**	0.0111	-0.0013	0.0008	0.0040	0.0180								
Fruit	-0.0065	**-0.0122**	**-0.0496**	**0.0153**	0.0003	**-0.0060**	-0.0009	**0.0260**	**0.0508**							
Bread	-0.0064	**-0.0115**	0.0153	-0.0055	-0.0049	0.0033	**-0.0068**	-0.0013	-0.0063	**0.0209**						
Flour	0.0001	-0.0002	-0.0021	-0.0010	0.0005	0.0006	-0.0005	0.0006	-0.0017	0.0004	**0.0011**					
Cakes	**-0.0074**	-0.0057	-0.0051	0.0042	**0.0051**	-0.0025	0.0002	0.0005	0.0005	0.0032	-0.0006	**0.0159**				
Biscuits	-0.0008	0.0005	0.0134	-0.0065	0.0016	0.0006	-0.0028	0.0042	-0.0016	-0.0027	0.0012	0.0027	0.0060			
Other C	0.0107	-0.0054	-0.0034	**-0.0110**	-0.0051	-0.0019	0.0009	-0.0119	0.0067	-0.0006	0.0009	**-0.0106**	0.0007	**0.0254**		
Confectionary	-0.0090	-0.0059	0.0086	**0.0097**	0.0041	0.0035	-0.0037	-0.0098	0.0038	0.0007	0.0003	0.0014	**-0.0129**	0.0093	-0.0010	
Other food	-0.0126	**0.0115**	-0.0061	-0.0208	**0.0040**	0.0049	0.0070	-0.0263	**-0.0523**	-0.0218	-0.0028	**-0.0094**	0.0062	-0.0347	0.0010	**-0.1522**

Values highlighted in bold are significative at 5% or 10%.

Table A8 : *Estimation of gamma parameters – AIDS High Income*

	Milk	***Cheese***	***Meat***	***Fish***	***Eggs***	***Fat***	***Sugar***	***Vegetables***	***Fruit***	***Bread***	***Flour***	***Cakes***	***Biscuits***	***Other Cereals***	***Confect ionary***	***Other Food***
Milk	***-0.92***	0.07	-0.08	0.06	-0.03	***0.42***	0.32	0.07	0.08	-0.07	1.05	***-0.30***	-0.15	***0.24***	-0.10	***-0.07***
Cheese	0.04	***-0.79***	-0.05	-0.06	0.19	***0.40***	***-0.33***	0.03	0.08	***-0.16***	0.80	***-0.21***	***-0.24***	0.01	0.10	0.01
Meat	-0.14	-0.32	***-0.46***	***-0.52***	-0.26	***0.66***	-0.07	***-0.21***	***-0.51***	***0.29***	0.07	-0.10	0.17	0.09	0.00	***-0.11***
Fish	0.05	-0.07	***-0.09***	***-0.66***	0.20	-0.15	0.03	0.07	***0.13***	-0.12	0.21	***0.24***	0.01	***-0.16***	-0.01	***-0.03***
Eggs	0.00	0.08	-0.02	0.06	***-0.93***	-0.18	0.11	-0.02	0.04	0.00	0.52	-0.07	-0.01	***-0.06***	0.08	0.00
Fat	***0.09***	***0.19***	***0.05***	-0.06	-0.21	***-0.89***	-0.16	***-0.05***	0.02	0.02	***-0.77***	-0.09	-0.01	-0.06	-0.02	-0.01
Sugar	0.04	***-0.10***	0.00	0.00	0.09	-0.10	***-0.59***	***-0.03***	0.03	***0.07***	***-0.91***	-0.01	***-0.11***	0.00	0.03	0.00
Vegetables	0.15	0.14	***-0.14***	0.18	-0.14	***-0.45***	***-0.46***	***-0.87***	***0.17***	0.04	***-1.61***	-0.21	***0.45***	-0.03	***-0.25***	-0.03
Fruit	0.12	0.23	***-0.22***	***0.26***	0.29	0.12	0.23	***0.12***	***-0.50***	***-0.32***	-0.01	0.11	-0.09	***-0.27***	-0.06	***-0.05***
Bread	-0.05	***-0.27***	0.05	***-0.18***	-0.03	0.05	0.35	0.00	***-0.21***	***-0.31***	-0.31	-0.03	-0.10	***0.21***	***-0.23***	***-0.05***
Flour	0.03	0.05	0.00	0.01	0.08	***-0.10***	***-0.19***	***-0.03***	0.00	-0.01	***-0.54***	0.03	0.04	***-0.03***	0.03	0.00
Cakes	***-0.11***	***-0.19***	-0.02	***0.16***	-0.16	-0.18	-0.03	-0.05	0.03	-0.01	0.37	-0.18	***0.15***	-0.07	-0.03	-0.01
Biscuits	-0.05	***-0.23***	0.02	0.00	-0.01	-0.02	***-0.34***	***0.10***	-0.03	-0.05	0.62	***0.16***	***-0.64***	0.02	***-0.24***	***-0.02***
Other C	***0.23***	0.03	0.02	***-0.30***	***-0.30***	-0.29	0.02	-0.02	***-0.22***	***0.29***	***-0.98***	-0.16	0.04	***-0.87***	***0.41***	***-0.06***
Confectionary	-0.05	-0.01	-0.01	-0.03	0.26	-0.05	0.12	***-0.09***	-0.04	***-0.18***	0.57	-0.04	***-0.34***	***0.25***	***-0.71***	0.02
Other food	-0.06	0.08	***-0.13***	***-0.29***	0.17	-0.09	-0.05	-0.02	***-0.13***	-0.04	0.18	0.02	-0.11	***-0.16***	***0.21***	***-1.27***

Values highlighted in bold are significative at 5% or 10%.

Table A9 *: Price Elasticities – Total Population*

	Milk	***Cheese***	***Meat***	***Fish***	***Eggs***	***Fat***	***Sugar***	***Vegetables***	***Fruit***	***Bread***	***Flour***	***Cakes***	***Biscuits***	***Other Cereals***	***Confectionary***	***Other Food***
Milk	***-1.19***	-0.05	-0.02	0.25	-0.09	***0.36***	-0.05	-0.01	0.10	***-0.36***	0.79	0.29	-0.23	***0.31***	0.02	-0.04
Cheese	-0.01	***-1.60***	-0.06	-0.04	0.05	-0.15	-0.31	0.02	0.01	0.02	0.17	***-0.32***	***0.41***	***0.19***	***0.20***	***0.03***
Meat	0.05	-0.42	***-0.48***	-0.26	0.57	***0.84***	0.15	-0.14	***-0.56***	-0.19	-0.46	-0.54	0.26	0.22	-0.07	***-0.18***
Fish	0.13	-0.04	-0.04	***-0.40***	0.03	0.09	0.25	0.01	-0.13	-0.06	-0.09	0.22	-0.03	***-0.21***	0.06	-0.02
Eggs	-0.01	0.02	0.04	0.01	***-1.05***	-0.03	-0.04	0.00	0.06	0.05	-0.16	-0.12	0.05	-0.06	-0.07	-0.01
Fat	***0.09***	-0.09	***0.07***	0.04	-0.04	***-0.89***	-0.03	-0.03	-0.03	-0.12	-0.45	0.00	-0.03	***-0.09***	***0.16***	***-0.02***
Sugar	0.00	-0.11	0.01	0.08	-0.03	-0.02	***-0.77***	0.02	-0.02	0.04	***-0.78***	-0.05	-0.10	-0.04	0.11	0.00
Vegetables	0.04	0.07	-0.10	-0.01	0.01	-0.19	0.25	***-0.91***	0.21	-0.11	0.24	-0.06	0.11	-0.10	-0.23	0.03
Fruit	0.14	0.03	***-0.23***	-0.33	0.34	-0.16	-0.17	0.13	***-0.59***	0.22	0.69	0.05	-0.02	***-0.32***	0.00	0.02
Bread	***-0.26***	0.02	-0.07	-0.13	0.18	-0.40	0.19	-0.06	0.14	-0.34	-0.80	-0.02	0.21	0.12	-0.07	-0.03
Flour	0.04	0.02	-0.01	-0.01	-0.05	-0.11	***-0.29***	0.01	0.04	-0.06	***-1.00***	***0.14***	0.03	***-0.10***	0.09	0.01
Cakes	0.12	***-0.31***	***-0.08***	0.18	-0.26	0.00	-0.14	-0.02	0.01	-0.01	***0.98***	***-0.45***	-0.13	0.08	-0.17	0.02
Biscuits	-0.08	***0.40***	0.03	-0.04	0.11	-0.06	-0.28	0.02	-0.01	0.12	0.24	-0.14	***-0.89***	-0.03	0.03	***-0.07***
Other C	***0.33***	***0.48***	0.07	***-0.49***	-0.36	***-0.41***	-0.25	-0.06	***-0.30***	0.18	***-1.77***	0.21	-0.06	***-0.83***	***0.28***	***-0.09***
Confectionary	0.02	-0.09	-0.03	0.05	-0.24	***0.37***	0.42	-0.09	-0.01	-0.05	0.92	-0.26	0.04	0.15	***-1.07***	-0.01
Other food	0.06	***0.23***	***-0.22***	-0.20	-0.19	***-0.27***	0.03	0.08	0.10	-0.01	0.34	0.23	***-0.44***	***-0.24***	0.12	***-1.24***

Values highlighted in bold are significative at 5% or 10%.

Table A10 *: Price Elasticities – Low Income*

	Milk	*Cheese*	*Meat*	*Fish*	*Eggs*	*Fat*	*Sugar*	*Vegetables*	*Fruit*	*Bread*	*Flour*	*Cakes*	*Biscuits*	*Other Cereals*	*Confect ionary*	*Other Food*
Milk	-0.50	-0.08	***-0.02***	-0.23	-0.20	0.58	-0.03	***0.07***	***0.17***	-0.29	0.36	-0.44	-0.19	-0.02	-0.07	***-0.06***
Cheese	***-0.02***	-0.83	***-0.04***	0.03	0.12	-0.15	-0.09	***0.05***	***0.07***	***0.03***	0.54	-0.09	-0.22	***0.05***	0.12	***-0.04***
Meat	0.03	-0.28	-0.70	-0.60	-0.17	0.56	-0.45	***-0.14***	-0.53	0.10	-0.25	0.11	0.15	0.12	-0.18	***0.07***
Fish	***-0.09***	0.05	***-0.11***	-0.49	-0.31	0.00	0.28	***0.06***	***0.09***	***0.01***	0.66	0.07	-0.07	***-0.15***	0.02	***0.01***
Eggs	***-0.03***	***0.05***	***-0.01***	***-0.11***	-1.01	-0.14	0.00	***-0.03***	***0.00***	***0.09***	-0.41	***0.13***	***0.03***	***-0.06***	***0.19***	***0.01***
Fat	***0.12***	-0.08	***0.04***	***-0.01***	-0.16	-0.64	-0.35	***-0.06***	***0.10***	***0.09***	-0.64	***-0.15***	***0.03***	***-0.09***	***-0.07***	***-0.03***
Sugar	***0.00***	***-0.03***	***-0.02***	***0.07***	0.00	-0.22	-0.50	***-0.03***	***0.02***	***0.07***	-0.05	***-0.09***	***-0.02***	***0.01***	***0.10***	***0.00***
Vegetables	0.16	0.22	***-0.10***	0.14	-0.23	-0.50	-0.46	***-0.95***	0.13	-0.22	-0.96	-0.15	0.44	0.09	-0.16	***-0.01***
Fruit	0.23	0.20	***-0.23***	0.17	-0.01	0.58	0.16	***0.09***	-0.74	0.01	1.09	0.01	-0.31	-0.04	0.07	***-0.09***
Bread	***-0.19***	0.03	***0.00***	-0.02	0.34	0.29	0.34	***-0.10***	***-0.01***	-0.43	-0.46	0.11	-0.08	***0.00***	-0.10	***-0.04***
Flour	***0.01***	***0.03***	***0.00***	***0.03***	***-0.06***	***-0.08***	***-0.01***	***-0.01***	***0.02***	***-0.02***	-0.10	***-0.04***	***-0.02***	***0.00***	***0.02***	***0.00***
Cakes	***-0.16***	-0.08	***0.01***	0.05	0.30	-0.28	-0.28	***-0.03***	***0.00***	***0.07***	-0.61	-0.46	0.10	***0.05***	***-0.07***	***-0.02***
Biscuits	***-0.06***	-0.21	***0.02***	-0.06	0.08	0.07	-0.05	***0.10***	***-0.11***	***-0.04***	-0.24	0.11	-0.48	***-0.03***	***-0.04***	***-0.04***
Other C	***0.00***	0.11	***0.02***	-0.27	-0.28	-0.41	0.04	***0.04***	***-0.04***	0.02	-0.02	0.10	-0.07	-0.80	0.07	***-0.03***
Confectionary	***-0.02***	-0.24	***-0.04***	0.00	0.57	-0.18	0.41	***-0.05***	***0.03***	***-0.07***	0.48	-0.11	-0.06	***0.04***	-0.67	***-0.03***
Other food	***-0.04***	-0.22	***0.09***	-0.04	0.27	-0.32	-0.06	***0.02***	***-0.22***	***-0.03***	-0.26	-0.08	-0.27	***-0.03***	-0.11	***-1.14***

Values highlighted in bold are significative at 5% or 10%.

Table A11 *: Price Elasticities – Middle Income*

	Milk	*Cheese*	*Meat*	*Fish*	*Eggs*	*Fat*	*Sugar*	*Vegetables*	*Fruit*	*Bread*	*Flour*	*Cakes*	*Biscuits*	*Other Cereals*	*Confectionary*	*Other Food*
Milk	***-0.64***	***0.39***	0.01	0.01	-0.25	-0.08	0.57	-0.06	-0.09	-0.07	0.08	-0.29	-0.01	0.19	-0.17	***-0.08***
Cheese	***0.20***	***-0.55***	0.03	-0.06	-0.08	0.09	-0.18	0.09	***-0.13***	-0.26	-0.10	-0.25	0.02	-0.09	-0.14	-0.01
Meat	0.09	0.20	***-0.65***	-0.35	-0.01	***1.14***	0.81	***-0.28***	***-0.52***	0.39	-1.28	-0.23	0.51	-0.06	0.23	-0.08
Fish	0.03	-0.07	-0.08	***-0.92***	***0.42***	-0.39	0.07	0.09	***0.16***	-0.16	-0.62	0.18	-0.25	***-0.19***	0.24	-0.02
Eggs	-0.05	-0.03	-0.01	0.11	***-1.11***	-0.26	0.03	-0.01	0.00	-0.10	0.28	***0.24***	0.07	-0.08	***0.12***	0.01
Fat	-0.01	0.03	***0.07***	-0.11	-0.24	***-1.14***	-0.22	0.01	***-0.06***	0.09	0.38	-0.11	0.03	-0.03	0.10	0.00
Sugar	0.07	-0.04	0.04	0.01	0.02	-0.15	***-0.67***	0.03	-0.01	***-0.17***	-0.27	0.01	-0.10	0.01	-0.10	-0.01
Vegetables	-0.08	0.37	***-0.22***	0.22	-0.06	0.08	0.52	***-0.86***	***0.26***	0.02	0.37	0.05	0.17	-0.19	-0.22	-0.06
Fruit	-0.10	***-0.37***	***-0.29***	***0.34***	0.03	-0.53	-0.12	***0.21***	***-0.47***	-0.15	-1.01	0.03	-0.06	0.11	0.11	***-0.08***
Bread	-0.05	-0.34	0.07	-0.17	-0.34	0.31	***-0.88***	-0.01	-0.08	***-0.40***	0.28	0.18	-0.09	0.00	0.08	-0.01
Flour	0.00	-0.01	-0.01	-0.02	0.04	0.06	-0.06	0.00	-0.02	0.01	-0.36	-0.03	0.05	0.01	0.01	0.00
Cakes	-0.10	-0.17	-0.04	0.08	***0.44***	-0.22	0.03	0.00	0.00	0.10	-0.37	-0.27	0.11	***-0.17***	0.05	-0.01
Biscuits	0.00	0.02	0.07	-0.16	0.15	0.06	-0.36	0.03	-0.02	-0.05	0.74	0.13	***-0.77***	0.01	***-0.33***	-0.02
Other C	0.19	-0.16	-0.03	***-0.27***	-0.39	-0.16	0.11	-0.09	0.06	0.02	0.53	***-0.46***	0.03	***-0.57***	0.27	-0.03
Confectionary	-0.10	0.27	0.04	0.19	0.38	0.32	-0.48	-0.08	0.03	0.07	0.22	0.09	***-0.48***	0.16	***-0.99***	-0.01
Other food	-0.16	0.00	-0.12	-0.18	***0.37***	-0.02	-0.18	-0.07	***-0.21***	0.11	0.31	-0.05	-0.13	-0.07	0.06	***-1.30***

Values highlighted in bold are significative at 5% or 10%.

Table A12 *: Price Elasticities – High Income*

References

Abramovsky, L., Attanasio, O., Phillips D., (2011). “Demand responses to changes in consumer prices in Mexico: lessons for policy and an application to the 2010 Mexican tax reforms”. Institute for Fiscal Studies, London, England.

Ackah, C., Appleton, S., (2007) : Food price changes and consumer welfare in Ghana in the 1990s, *CREDIT Research Paper*, 7(3)

Anderson, G., Blundell R., (1983) “ Testing Restrictions in a Flexible Dynamic Demand System: An Application to Consumers' Expenditure in Canada“. *The Review of Economic Studies*, 50(3):397-410.

Attanasio, O., Di Maro, V., Lechene, V., Philips, D., (2013). “Welfare consequences of food prices increases: evidence from rural Mexico”. *Journal of Development Economics* 104:136-151

Banks, J., Blundell, R., Lewbel, A., (1996). “Tax reform and welfare measurement: do we need demand system estimation”. *The Economic Journal* 106(9):1227-1241

Banks, J., Blundell, R., Lewbel, A. , (1997) . “Quadratic Engel curves, welfare measurement and consumer demand“. *The Review of Economics and Statistics* 79 (4): 527–539.

Barten, A..P.,(1969). “Maximum Likelihood Estimation of a Complete System of Demand Equations.” *European Economic Review* 1(1):7–73.

Blackorby, C., Donaldson D., Moloney D., (1984), “Consumer's Surplus and Welfare Change in a Simple Dynamic Model”. *The Review of Economic Studies* 50(1):171-176

Becht, M. (1995). "The theory and estimation of individual and social welfare measures". *Journal of economic Survey* 9(1):53-87.

Bocksteal, N., Myrick, F., (2005) .“Welfare Theory and Valuation” in "Handbook of Environmental Economics” 2(2):517-570.

Blundell, R., Pashardes, P., and Weber, G. (1993). "What do we learn about consumer demand patterns from micro data?". *American Economic Review* 83(3):570-597.

Cash, S.B., Sunding, D.L. Zilberman. D., (2005). “Fat Taxes and Thin Subsidies: Prices, Diet, and Health Outcomes.” *Acta Agriculturae Scandinavica Section C* 2(3/4) :167.

Deaton, A. and Muellbauer, J. (1980a). "An Almost deal Demand System". *American Economic Review* 70(3):312-326

DEFRA. (2013). "Family food 2012". "A National Statistics Publication".

Drescher, L., Thiele, S., Roosen, J., Mensink,G., "Consumer demand for healthy eating considering diversity –an economic approach for German individuals ". (2009) *International Journal of Consumer Studies* 33: 684–696.

Ferreira, F.H.G., Fruttero, A., Leite, P., Lucchetti, L., (2011). Rising food prices and household welfare: evidence from brazil in 2008. Policy research working paper 5652, World Bank.

Green, R. and Alston, J. M. (1990). "Elasticities in Aids Models". *American Journal of Agricultural Economics* 72(2):442-445.

Hanemann,M., Morey,E.(1992). "Separability, partial demand system and consumer surplus measures". *Journal of environmental economics and management* 22:241-258

Hossain, F., Jensen, H.H., "Lithuania's food demand during economic transition". (2002) *Agriculture Economics* 23: 31-40.

Lee, A.,E., Ng, L.D, Zivin, J., Green, P.,H.,R., "Economic burden of a gluten free diet". (2007) *Journal of Human Nutrion Diet* 20(5):443-430

Levin, J., Milgron, P., (2004). Consumer Theory. Stanford University.

Long, K.,H., Tapla, R.,A., Wagle, A.,E., Melton, L.,J., Lahr, B.,D., Van Dyke, C. T.,Murray, J.A."The economics of coeliac disease: a population-based study". (2010) *Alimentary Pharmacology Therapeutics* 32: 261–269

McKelvey, C. (2011). " Price, unit value, and quality demanded". *Journal of Development Economics* 95, 157–169.

Morey, E.,R., (1984). "Confuser Surplus". *The American Economic Review* 74(19): 163-173

Moro, D. (2004). Analisi della domanda. Teoria e metodi. Milano, Franco Angeli.

OECD (2008), Growing Unequal? Income Distribution and Poverty in OECD Countries, Paris.

OECD (2011), Divided We Stand – Why Inequality Keeps Rising, Paris.

Pollak , R., A., (1969). "Conditional Demand Functions and Consumption Theory". *The Quarterly Journal of Economics* 83 (1): 60-78

Pollak , R., A., (1985). “Conditional demand function and the implication of separable utility” . *Southern Economic Journal* 37:221-236.

Rafferty A. (2009). Introductory guide to the Expenditure and Food Survey. ESDS Government

Ravallion, M., van de Walle, D., (1991). “The impact on poverty of food pricing reforms:
a welfare analysis for Indonesia”. *Journal of Policy Modeling* 13 (2), 281–299.

Rodriguez, J. P., Jordan, D.R., Sanz, J.F. (2005) . “ Is a Tax Cut on Cultural Goods Consumption Actually Desirable? A Microsimulation Analysis applied to Spain”. *Fisical Studies* 26(4):549-575

Tefera,N.,Demeke, M.,Rashid, S., (2012), “Welfare impact on rising food prices in rural Ethiopia: a quadaratic almost ideal demand system approach” . (2012) Triennal Conference of Association of Agricaulture Economist, 18-24 August, 2012 Foz do Iguaçu, Brazil.

Tiezzi, S., “The welfare effects and the distributive impact of carbon taxation on Italian households”. (2005) *Energy Policy* 33: 1597-1612

Wilson, N.,L.,W., “How the cookie crumbles: a case study of gluten-free cookies and random utility”. (2011) American Journal of Agricultural Economics 94(2): 576–582

Wood, B.,Nelson, C.,Nogueira, L., “Poverty effects of food price escalation: thr importance of substitution effects in Mexican housolds” (2012). *Food Policy* 37:77-85

Worosz,M., Wlson, N.,L.,W., “A Cautionary Tale of Purity, Labeling and Product Literacy in the Gluten-Free Market“. (2012) *The Journal of Consumer Affairs* 288–318