Spanish Journal of Agricultural Research
16 (1), e0103, 14 pages (2018)
eISSN: 2171-9292
https://doi.org/10.5424/sjar/2018161-11254
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, O.A, M.P. (INIA)

RESEARCH ARTICLE

OPEN ACCESS

Do increasing prices affect food deprivation in the European Union?

Sol García-Germán, Isabel Bardají and Alberto Garrido

Research Centre for the Management of Agricultural and Environmental Risks (CEIGRAM), Universidad Politécnica de Madrid (UPM), C/ Senda del Rey no. 13, 28040 Madrid, Spain

Abstract

The rise of prices of agricultural commodities in global markets during 2007-2012 was followed by increased consumer food prices around the world. More expensive food may have an impact on consumer food access and thus on their welfare, not only in developing countries but also amongst the most vulnerable in developed countries. Using a longitudinal database from the Statistics on Income and Living Conditions and population-averaged models, we tested whether increasing food prices had an impact on household food deprivation in 26 European Union (EU) member states. Results revealed a significant relationship between food deprivation and the consumer food price index and disposable income. Households in the lowest income quintile in the member states recently acceded to the EU were the most vulnerable to food deprivation. Results also showed that low-income households in densely populated areas were more vulnerable to food deprivation. This should be taken into account when evaluating food assistance programmes that focus on the segments of the population most at risk of food deprivation.

Additional keywords: consumer food prices; food deprivation indicator; consumers' well-being; food crises.

Abbreviations used: COICOP (classification of individual consumption by purpose); DSU (Denmark, Sweden and UK); EU (European Union); EU-SILC (European Union-Statistics on Income and Living Conditions); GEE (generalized estimating equations); HICP (harmonized index of consumer prices); MS (member state); NMS (new member state); OECD (Organisation for Economic Co-operation and Development); OR (odds ratio).

Authors' contributions: The three authors conceived, designed, analysed and interpreted the data and wrote the paper. Supervised the work: IB and AG.

Citation: García-Germán, S.; Bardají, I.; Garrido, A. (2018). Do increasing prices affect food deprivation in the European Union? Spanish Journal of Agricultural Research, Volume 16, Issue 1, e0103. https://doi.org/10.5424/sjar/2018161-11254

Received: 04 Mar 2017. **Accepted:** 20 Mar 2018.

Funding: ULYSSES project, EU 7th Framework Programme (312182 KBBE.2012.1.4-05). Any information reflects only the authors´ view and not that from the European Union.

Competing interests: The authors have declared that no competing interests exist.

Correspondence should be addressed to Sol García-Germán: sol.garciagerman@upm.es

Introduction

The rise of agricultural commodities prices in global markets that occurred in 2007-2008 and 2011-2012 was followed by increased consumer food prices around the world. In addition, between 2005 and 2012 food prices in the European Union (EU) rose more rapidly than general consumer prices (McCorriston, 2014). Food price increases change consumers' eating habits and purchasing strategies (Beatty, 2010; Antentas & Vivas, 2014) and thus may have severe negative impacts on the access of the population to an adequate diet, adversely affecting the welfare of the most vulnerable. Besides, food and nutrition security has not yet been completely fulfilled in the EU and micronutrient deficiencies are still widespread (Cockx *et al.*, 2015). The developments in food prices have coincided in time with other factors that have also affected consumer incomes and purchasing power across the EU, such as the rise in energy prices and the economic and financial crisis (Swinnen *et al.*, 2013). The combination of all these factors and their relation to food demand, coupled with the rise in the number of the food insecure population in recent years, have given rise to the idea that food insecurity might be rising in the EU (Loopstra *et al.*, 2015). As of yet, it is not clear to what extent food insecurity has increased in the EU and there is some uncertainty about the factors that may drive it beyond poverty and low income.

The literature on food access and consumption has focused mostly on developing countries, but a few authors have focused on food consumption, demand and poverty in the UK (Beatty, 2010; Jones *et al.*, 2014), the US (Huang & Wu Huang, 2012; Gregory & Coleman-

Jensen, 2013; Nord *et al.*, 2014), Spain (Antentas & Vivas, 2014), and Israel (Grethe *et al.*, 2012) amongst others. This literature shows that poverty is associated with the consumption of lower quality goods and that the rise of consumer food prices worsens food security (Gregory & Coleman-Jensen, 2013). Recently, Jones *et al.* (2014) have shown that healthier food items are significantly more expensive than unhealthy items, suggesting that the price of food might be a major driver of the increase of unhealthy diets in Britain.

The consequences of increasing food prices on the welfare of EU consumers may seem limited because they depend on the share of food in total household income, which is on average relatively low (Dewbre *et al.*, 2008; EC, 2008; Gilbert & Morgan, 2010; Huang & Wu Huang, 2012; Swinnen *et al.*, 2013; Lloyd *et al.*, 2015). But because of the inequalities existing between and within member states (MSs) in terms of consumer food prices, household's food budget and income levels, some segments of the population may find difficulties in accessing certain types of food. There are large differences in the share of income spent on food across EU MSs and even across income classes within each MS. Food price inflation behaved quite differently across MSs, and disposable income differed in 2012 from €7,924 in Latvia to €29,847 in Luxembourg (the average in EU-28 is €20,085; EUROSTAT, 2014a). Figure 1 shows the overall food consumption expenditure of households and food consumption expenditure in the lowest income quintile in the EU

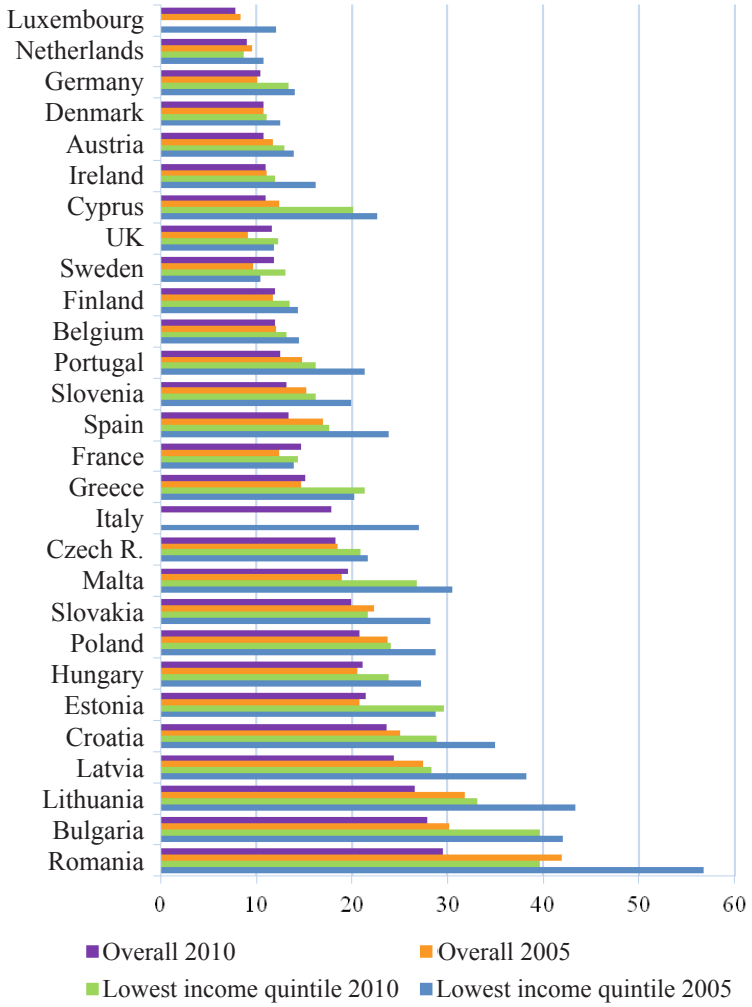

Figure 1. Percentage of food consumption expenditure of households in the EU. *Source:* Author's elaboration based on EUROSTAT. Household Budget Surveys: Overall Structure of consumption expenditure and Structure of consumption expenditure by income quintile (COICOP level 2). Data for Italy's lowest income quintile (2010) and overall (2005) not available. Data for Luxembourg's lowest income quintile (2010) not available. Methodologies used by the countries for data collection are not totally harmonized.

MSs. There are significant differences across MSs, ranging from less than 10% of average expenditure devoted to food in Luxembourg, to nearly 30% in Romania in 2010 (slightly more than 40% in 2005), reflecting widely different income and welfare levels. But the share of food expenditure in total household expenditure in the EU-27 as a whole stood in 2007 at about the same level than in 2000 (EUROSTAT, 2012). And in Germany, UK, Estonia, Hungary, Malta, Greece, France, Finland and Sweden the share increased from 2005 to 2010 for all households indicating that at least in these MSs' vulnerability to increased food prices may have grown (see Fig. 1). In the US the share of the highest (lowest) income quintile spent 11.6% (16.1%) of disposable income in food in 2012 (Schnepf, 2013).

Cockx *et al.* (2015) pointed out that despite the sufficient availability of food and the stable food security environment, food and nutrition security has not been fully achieved in the EU. They identified malnutrition as the main challenge in terms of food and nutrition security. The large food expenditures in the household budget in some new MSs will potentially affect both food access and household vulnerability. Davis & Geiger (2017) found that food insecurity has increased in European countries, the highest increase taking place in the UK and Ireland, rather than in Southern or Eastern MSs. Reeves *et al.* (2017) showed that the relation between food prices and stagnating wages are a major driver of food insecurity, especially in deprived groups in EU countries. Rizov *et al.* (2014) showed that food security is not a significant threat in Slovakia, reflecting trends more consistent to those of more developed countries, while Alexandri *et al.* (2014) revealed that Romania´s population continue to be very sensitive to food price and income shocks.

The goal of this paper was to test whether increasing food prices had an impact on consumer food deprivation in households belonging to 26 EU MSs —all the MSs except Germany and Croatia—, which have been classified according to eurozone membership to control for potential fixed effects across groups of MSs (as will be outlined below). The period of analysis coincides with the increase in agricultural commodities prices occurred in 2007-2008 and 2011-2012. Using the EU Statistics on Income and Living Conditions (EU-SILC), which have cross-section and longitudinal household panels covering, up to now, the period 2003-2011, we were able to test whether the proportion of EU households suffering some level of material deprivation, specifically from not affording a sufficient protein intake, was affected by increasing consumer food prices. To our knowledge, this is the first attempt to study the impacts on food access in the EU caused by the food crises of 2007-2010, with such a detailed and large database of households. This paper contributes to the literature in several aspects. First, we evaluated the impact of consumer food price changes on the percentage of EU households that can afford a protein intake at least every other day. Second, we measured the impact of the deviation of food prices relative to general consumer prices on the same food access variable. Third, we controlled for households' disposable income level to test whether the economic and financial crisis is associated with food deprivation. These issues were addressed taking into account the differences across the 26 EU MSs.

Material and methods

The EU-SILC survey[1]

The EU-SILC is the EU reference source for comparative statistics on income distribution, living conditions and the level and composition of poverty and social exclusion. The aim of the survey is to monitor key EU social inclusion and social protection indicators. Although the survey focuses mainly on income variables (of which the survey computes different indicators), it also contains a wide range of variables that permit measuring indicators of material deprivation, including the variable that checks whether the household can afford an adequate protein intake — the food deprivation indicator analyzed in this paper.

The EU-SILC survey follows a dual approach, containing cross-sectional and longitudinal dimensions. Although priority is given to the cross-sectional dimension, which refers to a specific given time, the longitudinal dimension permits following specific households over time and studying the changes that occur due to changes in socioeconomic variables and policies. The survey is performed annually in all EU MSs and was started in 2003 in some MSs, while the remaining MSs have been incorporated gradually. Cross-sectional and longitudinal dimensions cover different variables. The cross-sectional dimension gives

[1]This publication is based on data from European Commission, Eurostat, EU Statistics on Income and Living Conditions, specifically the EUSILC LONGITUDINAL UDB 2005 – vers. 2005-1 from 15-09-07; the EUSILC LONGITUDINAL UDB 2006 – vers. 2006-2 from 01-03-2009; the EUSILC LONGITUDINAL UDB 2007 – vers. 2007-5 from 01-08-2011; the EUSILC LONGITUDINAL UDB 2008 – vers. 2008-4 from 01-03-2012; the EUSILC LONGITUDINAL UDB 2009 – vers. 2009-4 from 01-03-2013; the EUSILC LONGITUDINAL UDB 2010 – vers. 2010-4 from 01-03-2014; the EUSILC LONGITUDINAL UDB 2011 – vers. 2011-2 from 01-03-2014 (EUROSTAT has no responsibility for the results and conclusions. The responsibility for all conclusions drawn from the data lies entirely with the authors).

a greater focus to income, poverty, social exclusion and other living conditions, whereas the longitudinal dimension not only targets income variables but also a series of non-monetary material deprivation variables, which are used to assess the dynamics of poverty and social exclusion.

For most MSs, the EU-SILC longitudinal dimension is a rotational panel. In a rotational panel, the same households are surveyed for a specific period —in most MSs usually for four consecutive years— and each year a quarter of them are replaced by a new sample of households. Both the cross-sectional and longitudinal dimensions are based on a nationally representative probability sample of the population living in private households within the country. The minimum effective sample size is around 131,000 households in the EU as a whole in the cross-section component and 98,000 households for the longitudinal component. The time frame analyzed in this study spans nine years (2003-2011).

The food deprivation indicator

The variable that measures food deprivation in the EU-SILC survey was obtained from the questionnaire using the following question: "Can your household afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day?" which has a binary outcome (*Yes(1) / No(0)*). This was our models' dependent variable.

Table 1 summarizes the share of households that report not being able to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day, both for the entire sample —including all income quintiles— and for households that belong to the lowest income quintile across groups of MSs and the EU-28 as a whole. As for the groups of MSs, they were divided into groups according to two criterions so that each MS belonged only to one group. In the first place, MSs were classified according to whether they belonged to the eurozone or not. In turn, non-eurozone MSs were divided into two groups. On the one hand, Denmark, Sweden and the UK were grouped together (DSU from now on) on account of being former EU MSs not belonging to the eurozone. On the other hand, the rest of non-eurozone MSs were grouped together (other non-eurozone from now on). Thus, MSs were classified into three groups, the eurozone group (eurozone from now on), the DSU group, and the other non-eurozone group. MSs which belong to the eurozone group are Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Malta,

Table 1. Share of food deprivation in the entire sample and the lowest income quintile across groups of MSs and the EU-28 (percentage of households that report not being able to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day).

	Eurozone		DSU[1]		Other non-eurozone (except DSU)		EU-28	
	All sample	Lowest income quintile[2]	All sample	Lowest income quintile[2]	All sample	Lowest income quintile[2]	All sample	Lowest income quintile[2]
2003	14.3	32.7	1.8	3.5	-	-	10.1	21.2
2004	6.6	13.5	4.2	9.0	-	-	6.4	13.1
2005	7.7	16.8	5.1	9.8	33.9	55.7	10.5	19.8
2006	7.1	15.2	4.5	10.1	30.1	52.4	10.0	19.1
2007	6.1	13.6	3.9	8.0	26.7	49.2	9.9	19.1
2008	6.9	15.7	4.2	8.2	22.8	43.7	9.8	20.0
2009	6.2	14.4	3.8	8.4	22.1	42.4	9.1	18.8
2010	6.6	15.3	4.5	8.8	21.6	42.5	9.4	19.5
2011	7.6	18.1	4.3	9.1	21.5	41.7	9.9	20.9
Chi-squared	0.0000	0.0000	0.0000	0.0243	0.0000	0.0000	0.0000	0.0000

Source: Authors´ calculations based on data from EU-SILC longitudinal waves (2005-2011). Weighted shares according to the household cross-sectional weight included in the survey's longitudinal files. Unweighted shares relative to the population of MSs that comprise each group. Although the share of self-reported food deprivation described in the table includes data for Croatia and Germany, these MSs were not included in the analysis. [1]DSU stands for Denmark, Sweden and the UK. [2]Lowest equivalised disposable income quintile specific for each MS.

Netherlands, Portugal, Slovakia, Slovenia and Spain. Latvia and Lithuania are not considered eurozone MSs, but other non-eurozone MSs in this analysis due to the fact that they acceded to the eurozone in 2014 and 2015 respectively, which are not covered in the studied period. MSs which belong to the other non-eurozone group are Latvia, Lithuania, Romania, Hungary, Croatia, Poland, Czech Republic and Bulgaria, as considered in this analysis. Chi-squared tests were performed to determine whether there was statistical significant change in the food deprivation indicator for each group of countries over the period 2003-2011. The tests examine whether the null hypothesis that the variables are independent holds. If the null is rejected, the variables are dependent. Tests show that there was a statistically significant change in the share of households that report suffering food deprivation in the 2003-2011 period for the three groups of MSs considered.

From Table 1, several conclusions can be drawn. First, the share of households belonging to the lowest income quintile that report suffering food deprivation was larger than the share of households of the entire sample in all groups of countries. Second, food deprivation was more frequent for households from the other non-eurozone group than from the eurozone and the DSU groups. Food deprivation was the least frequent within households belonging to the DSU group. These differences between groups were quite large, especially when taking into account the other non-eurozone group, in which the share was much larger than in the other two groups. Third, there was no significant shift in the share of households that report suffering food deprivation following the rise of world agricultural commodities prices in 2007-2008. However, the share of households belonging to the lowest income quintile in the EU-28 who reported suffering food deprivation increased in 2008 (from 19.1% in 2007 to 20% in 2008). The same happened to the share of food deprived households in the eurozone group in both of the income segments and to the DSU group for the entire sample. Breaking up the EU-28 in our three country groups clearly conceals differences across MSs belonging to the same group. Lastly, although the share of food deprivation reported by households in the other non-eurozone group was much higher than that of the other two groups, these differences have decreased over time. The percentage of households reporting food deprivation in the other non-eurozone group has decreased over the period analysed, whereas trends were quite regular for households belonging to the other two groups. Even if decreasing, the share of households reporting food insecurity was still larger in the MSs belonging to the non-eurozone group. These decreasing trends, which possibly reflect the convergence of new member states (NMSs) towards former EU MSs, are not surprising and may be associated with the transition process the MSs recently acceded to the EU have undergone in recent years. In addition, these results are consistent with the reduction of the share of expenditures in food consumption between 2005 and 2010 described in Fig. 1.

Other socio-economic variables

A multivariate panel approach was developed to examine whether increasing food prices had an impact on households' food deprivation. The dependent binary variable "food deprivation indicator" was regressed on a number of MSs' specific economic measures and household level variables. Among the MSs specific economic measures, the consumer food price and the relative price of food, measured as the ratio of consumer food prices to general consumer prices, were used as independent variables. We also used the equivalised disposable household income, the equivalised household size and the degree of urbanization, which were obtained from each surveyed household.

Data on consumer prices were obtained from EUROSTAT (2014b). Consumer food prices were measured as the annual average of the harmonized index of consumer prices (HICP) for food. General consumer prices were measured as the annual average of the monthly HICP for all items. Thus, the relative price of food was defined as the ratio of the food HICP to the general HICP, expressed as a percentage. The food HICP is a component of the general HICP and therefore the ratio between both indicates whether and to what extent food prices run above general prices. A single annual value of country specific consumer food prices and relative price of food were used as the explanatory variables in the models.

Data on the equivalised household size, equivalised disposable income and the degree of urbanization were taken from the EU-SILC longitudinal files from 2005 to 2011. The equivalised household size accounts for household members which are weighted in order to convert them into equalised adults (the weighting is based on the modified OECD scale, which gives the first adult a weight of 1, the second and each subsequent person aged 14 and over a weight of 0.5 and each child under 14 a weight of 0.3). The equivalised disposable income measures the total income of a household, including social benefits and after taxes and other deductions, weighted to take into account household members employing the same scale used to calculate the equivalised household size. Thus, the equivalised disposable income, available for spending and saving, is attributed equally to each member of the household.

The degree of urbanization has three possible outcomes: (1) densely populated area; (2) intermediate area; and (3) thinly populated area.

Table 2 shows some descriptive statistics for the independent variables used in the models for each of the groups of MSs considered in the previous table in years 2005, 2008 and 2011. As can be seen, the mean of the mean equivalised disposable income was larger in the DSU group, followed by the eurozone group and finally by the other non-eurozone group. When we focus on the food HICP, we can see that the mean of food prices increased more in the other non-eurozone group than in the other two groups, taking 2005 as base year. The literature also documents the fact that food inflation was considerably higher in the NMSs (Bukeviciute *et al.*, 2009; Lloyd *et al.*, 2013). However, we noted above that food deprivation, though more acute, had decreased more in the recently acceded EU MSs that do not belong to the eurozone. This may seem contradictory at first, but other factors apart from prices may have had also a role in explaining the affordability of food. The mean equivalised disposable income has in fact increased in these countries during the period (see Table 2), which suggests that the income growth may have offset the negative impact of the food price increase. Despite this, the difference in average income between these countries and the MSs included in the other two groups was considerable, and therefore its food deprivation level still greatly exceeded the level of the other two groups. The standard deviation of food prices was also larger for this group of MSs. As for the relative price of food, defined as the ratio of the food HICP to the general HICP, we noted that generally their means were larger than one, meaning that prices of food run above general prices during the period of study.

Methods

After examining the uncertain trends of the food deprivation indicator over the period 2003-2011 in the previous section, we developed the multivariate panel approach to investigate more thoroughly whether increasing food prices had an effect in food deprivation in the EU. Theoretically, food demand is a function of the household´s budget, which in turn depends on income and prices; as well as of several household demographic characteristics that affect food consumption. Hence, the food demand of household *i* and period *t* can be defined by the following equation:

$$FD_{it} = \alpha + \beta P_t + \gamma I_{it} + \delta Z_{it} + \varepsilon_{it} \qquad [1]$$

where FD_{it} is the food deprivation indicator, P_t and I_{it} are the consumer food price index and household income, respectively, Z_{it} a is vector of household characteristics and ε_{it} the error term. In this particular case, food demand is measured as the household's ability to afford an adequate protein intake.

Other authors estimate more complex complete demand models that capture substitution and complementary relations between food items as a base for further simulations. While complete food demand models appropriately represent households' consumption behaviour, they are conditioned to the availability of detailed consumption or expenditure data. The EU-SILC survey used in the analysis does not provide such data, but does provide the measure of access to specific food items we analyse. Therefore, our methodological approach did not account for possible household behavioral changes as a result of price or income changes. By doing this, we assumed that households were not able to substitute toward other food items in light of price or income changes. However, the aim of the present study was to undertake an ex-post analysis of survey-based evidence of households' ability to afford a certain type of food. Food price inflation affected most food items during the studied period, potentially leading certain lower-income households to reallocate their household budget across foods and to restrict the consumption of more costly foods such as meat, fish or fruit and vegetables favoring the consumption of staples.

We focused specifically on households in the lowest quintile of disposable income who spend a larger part of their income on food and are probably more exposed to food deprivation due to price and income changes. We first present the compilation of the database used in the analysis; afterwards we outline the specification of the model. The dataset used for the analysis was compiled only from the EU-SILC longitudinal dimension because it permits us to identify specific households across time, and thus to account for repeated measures that may be correlated within a household. EUROSTAT provided the authors with different longitudinal files which had been released from 2005 to 2011 on a yearly basis. Two issues about the longitudinal files provided by EUROSTAT should be clarified: (i) the survey started in 2003 in some MSs whereas the rest were progressively included. For this reason, the time frame in which the survey has been conducted is different depending on the MS considered; (ii) each longitudinal file contains data for the year in which the file is released along with data from at least the preceding year and as far as the three preceding years. For this reason, data for certain MSs are available from 2003 and the information on the same household is reported in several different longitudinal files. In short, the longitudinal files provided by EUROSTAT cover

Table 2. Statistics for independent variables.

Variable	No. obser.	Mean	Std. Dev.	Minimum	Maximum
Eurozone					
Equivalised disposable income (in €)					
2005	101289	16046	21167	0	4980869
2008	97795	17589	15918	0	958397
2011	70889	18880	18568	0	1684067
Food HICP[1] (Base year 2005)					
2008	-	113.5	5.2	108.5	132.1
2011	-	118.0	7.6	107.4	141.4
Equivalised household size					
2005	101289	1.7	0.6	1	7.3
2008	97795	1.7	0.6	1	6.8
2011	70889	1.7	0.6	1	9
Ratio food HICP / general HICP (Base year 2005)					
2008	-	103.8	2.3	100.5	110.4
2011	-	102.2	4.5	95.3	114.7
Degree of urbanization					
Densely populated area					
2005	40708	0.40	0.49	0	1
2008	40052	0.41	0.49	0	1
2011	29103	0.41	0.49	0	1
Intermediate area					
2005	29306	0.29	0.45	0	1
2008	26780	0.27	0.45	0	1
2011	18871	0.27	0.44	0	1
Thinly populated area					
2005	31275	0.31	0.46	0	1
2008	30963	0.32	0.47	0	1
2011	22915	0.32	0.47	0	1
DSU					
Equivalised disposable income (in €)					
2005	18506	22411	15609	0	595656
2008	21898	25042	18627	0	846746
2011	12141	24968	16506	0	693987
Food HICP (Base year 2005)					
2008	-	115.1	2.8	110.5	117.7
2011	-	124.9	8.9	115.7	134.5
Equivalised household size					
2005	18506	1.6	0.5	1	4.6
2008	21898	1.6	0.5	1	5
2011	12141	1.6	0.5	1	4.4
Ratio food HICP / general HICP (Base year 2005)					
2008	-	106.9	1.9	103.6	108.5
2011	-	107.5	4.5	103.0	112.4
Degree of urbanization					

Table 2. Continued.

Variable	No. obser.	Mean	Std. Dev.	Minimum	Maximum
Densely populated area					
2005	8754	0.47	0.50	0	1
2008	8656	0.40	0.49	0	1
2011	4379	0.36	0.48	0	1
Intermediate area					
2005	3639	0.20	0.40	0	1
2008	6117	0.28	0.45	0	1
2011	3590	0.30	0.46	0	1
Thinly populated area					
2005	6113	0.33	0.47	0	1
2008	7125	0.33	0.47	0	1
2011	4172	0.34	0.47	0	1
Other non-eurozone					
Equivalised disposable income (in €)					
2005	29031	3308	2512	0	95330
2008	55788	4569	3451	0	118169
2011	44410	5030	3768	0	133919
Food HICP (Base year 2005)					
2008	-	125.1	13.2	111.6	146.6
2011	-	137.7	15.1	116.8	156.2
Equivalised household size					
2005	29031	1.8	0.7	1	6.5
2008	55788	1.8	0.7	1	6.9
2011	44410	1.8	0.7	1	10.9
Ratio food HICP / general HICP (Base year 2005)					
2008	-	106.0	5.4	98.4	114.5
2011	-	105.5	6.6	93.2	115.8
Degree of urbanization					
Densely populated area					
2005	11589	0.40	0.49	0	1
2008	20205	0.36	0.48	0	1
2011	16240	0.37	0.48	0	1
Intermediate area					
2005	3667	0.13	0.33	0	1
2008	7019	0.13	0.33	0	1
2011	5030	0.11	0.32	0	1
Thinly populated area					
2005	13775	0.47	0.50	0	1
2008	28564	0.51	0.50	0	1
2011	23140	0.52	0.50	0	1

Source: Data on equivalised disposable income and equivalised household size from EU-SILC longitudinal waves (2005 - 2011), own calculations. Data on food HICP and general HICP from EUROSTAT (2014b), authors' calculations. Although the statistics described in the table include data for Croatia and Germany, these MSs were not included in the subsequent analysis. [1]HICP stands for harmonized index of consumer prices.

the 2004-2011 or 2005-2011 period for households in most MSs. The exceptions are the following: (i) data for households in three MSs —Denmark, Greece and Luxembourg— are available from 2003 onwards, covering the 2003-2011 period; (ii) data for households in Bulgaria are available for 2006-2011; (iii) data for households in Croatia are available for 2010-2011; (iv) data for households in Germany are available for 2005-2006; (v) data for households in Ireland are available for 2004-2009; (vi) data for households in Malta are available for 2006-2011; and (vii) data for households in Romania are available for 2007-2011. Croatia and Germany were discarded from the analysis due to the fact that the longitudinal files only include a two-year period for these two MSs, and the two years for which data are available do not cover the years of the recent increases in world agricultural commodities prices.

The longitudinal files provided by EUROSTAT and released from 2005 to 2011 on a yearly basis were merged to obtain the longitudinal structure used for the analysis in order to cover the entire period for which data were available, to increase the overall sample size and to increase the number of households that are surveyed for the 4-year period of the rotational panel. Thus, we generated a single unbalanced panel dataset from 2003 to 2011 that includes data on all MSs for the entire period even if, as described above, not all MSs appear in the entire longitudinal span. The final dataset consists of 1,203,546 households and 255,973 households belonging to the lowest quintile of the countries' income distribution. Due to the manner used to organize the data —releases in different longitudinal files— the information on almost all households was included in different panel files. Following Engel & Schaffner's (2012) approach, in these cases the information of the most recent longitudinal file was included in the single dataset used for the analysis.

To test whether increasing food prices had an impact on EU consumers' food access, we used population-averaged panel data models by applying the method of generalized estimating equations (GEE), which extends the generalized linear model to account for correlated or clustered dependent data (see Liang & Zeger (1986) and Zeger & Liang (1986) for developments of this approach). Since the dependent variable —the food deprivation indicator— is binomial, we used the logit link function for modelling the binary response variable. According to Ballinger (2004), the binomial distribution should be defined when using binary data and the logit link is appropriate for this type of data. This approach seemed appropriate due to the longitudinal nature of the EU-SILC data, which entails the correlation of repeated measures.

We used control variables (dummies) for the three groups of MSs considered in the previous subsections in order to control for potential fixed effects across groups of MSs linked to differences in their general economic conditions. As stated previously, the MSs were classified into three groups, the eurozone group (eurozone), the DSU group (DSU) and the other non-eurozone group (other non-eurozone) so that each MS belonged only to one group. Hence, two binary control variables were defined —$D_{eurozone}$ and D_{DSU}— and included in the models controlling the MSs to which each household belongs. For a list of MSs that belong to each of the three groups see previous subsections.

Thus, the model was specified by the following equation, assuming that FD_{it} has a binomial distribution:

$$logit\{P(FD_{it})\} = \alpha + \beta I_{it} + \gamma P_t + \delta R_t + \epsilon Z_{it} + \\ + \mu D_{urb2} + \pi D_{urb3} + +\theta D_{eurozone} + \vartheta D_{DSU} + \varepsilon_{it} \quad [2]$$

where $logit\{P(FD_{it})\}$ is the model´s outcome —the logit distribution of the probability of the food deprivation indicator, which is defined as: $logit\{P(FD_{it})\} = \log\left(\frac{P(FD_{it})}{1-P(FD_{it})}\right)$ —, I_{it} is the household equivalised disposable income, P_i and R_i are the consumer food price index and the relative price of food, measured as stated previously, respectively, Z_{it} is a vector of household characteristics, D_{urb2} and D_{urb3} are binary variables which define the degree of urbanization, $D_{eurozone}$ and D_{DSU} are the binary control variables for the groups of countries and ε_{it} is the error term. In this specific case, the outcome was being able to access a sufficient protein intake —or not being food deprived— and the probability that the outcome will happen was given by the following equation: $\mathrm{odds}_i = \frac{P(FD_{it})}{1-P(FD_{it})}$; which is the odds ratio (OR). The exponential function of the coefficients —$e^{\alpha+\beta+\gamma+\delta+\epsilon+\theta+\vartheta+\mu}$ — is the OR associated with each unit increase in the exposure (for example, our predictors food price or income level). The OR is commonly used in the literature to interpret regression results in which the outcome is a binary variable. When OR>1, the odds of being food secure increase with a one unit increase of the independent variable under consideration. When OR<1, the odds of being food secure decrease with a one-unit increase of the independent variable.

Different models were specified. Regressions were performed for a subsample of households included in the lowest disposable income quintile, which is estimated in the survey specifically for each MS.

Goodness of fit tests to compare observed and predicted probabilities were performed. To do so, classification tables were elaborated and from them sensitivity (1 is correctly predicted), specificity (0 is correctly predicted) and the overall rate of correct classification were derived. The model classifies observations into predicted positive outcomes and

predicted negative outcomes depending on whether households are food secure or food deprived — households that are able to access the protein-rich food portion and households that are not able to do so. We had to choose a threshold or cut-off value in order to classify the predicted values into one of the two groups. Predicted values above the cut-off value were classified as positive (being able to access the protein-rich food portion) and predicted values below the cut-off value were classified as negative (being unable to access the protein-rich food portion). The usual is to use a cut-off of 0.5. However when datasets are imbalanced, classification favours the assignment of probabilities into the larger group and this is independent of the fit of the model (Hosmer *et al.*, 2013). In these cases, we need to focus on the aspects that are relevant in the context of the study and optimize sensitivity, specificity or both sensitivity or specificity jointly. The maximum value of the Youden´s ***J*** statistic, defined as $J = sensitivity + specificty - 1$, may be used as a criteria for selecting the optimal cut-off point.

Results

Table 3 shows the parameter estimates of the models specified to explain the evolution of the food deprivation indicator. The table includes regression results for households belonging to the lowest quintile of the MSs income distribution, and account for the possible fixed effects of the different groups of MSs detailed in the previous section. Two regressions are included in Table 3, one which does not include the relative price of food — model (a) — and one including the relative price of food — model (b). Table 4 shows the ORs of the coefficients presented in Table 3 for the different specifications. We recall that in our models the dependent variable takes value 1 if the household can afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day and 0 otherwise.

The parameter estimates of the consumer food price index were negative and significant in both regressions. Therefore, the probability of a household being food deprived appeared to increase with an increase of the consumer food price index. As we can see in Table 4, on average the odds of being food deprived were 0.995 with respect to a unit price increase in model (a) and 0.997 in model (b). This means that the probability of being food deprived increased by 0.5% and 0.3% for a unit increase in the consumer food price index, respectively.

The relative price of food (ratio of food HICP to general HICP) was significant and negative in model (b). Therefore, the probability of a household being

Table 3. Regression results for the lowest income quintile of EU-26 MSs for 2003-2011

	(a)		(b)	
	Coefficient	**SE[1]**	**Coefficient**	**SE[1]**
Equivalised disposable income	0.0000712***	3.26e-06	0.0000715***	3.27e-06
Food HICP[2]	-0.005***	0.00071	-0.003***	0.0009
Equivalised household size	0.184***	0.0145	0.184***	0.0145
Ratio food HICP / general HICP			-0.006**	0.0027
$D_{eurozone}$	1.23***	0.024	1.23***	0.0244
D_{DSU}	1.70***	0.043	1.72***	0.044
D_{urb2}	0.13***	0.027	0.13***	0.026
D_{urb3}	0.09***	0.021	0.08***	0.021
Constant	0.25***	0.092	0.71***	0.229
No. of observations	255973		255973	
Wald chi-square[3]	9714.03 (7)		9737.82 (8)	
Sensitivity (1 is correctly classified)	73%		73%	
Specificity (0 is correctly classified)	70%		70%	
Correctly classified	73%		73%	

Dependent variable: Capacity to afford a meal with meat, chicken, fish (or vegetarian equivalent) every second day (0=No/1=Yes). *p<0.05; **p<0.01; ***p<0.001. Model (a) does not include the variable relative price of food and model (b) includes it. The other non-eurozone dummy variable was omitted because of collinearity. [1]Robust standard error. [2]HICP stands for harmonized index of consumer prices. [3]Degrees of freedom of Wald chi-square statistics in parentheses.

Table 4. Odds ratio of regression results for the lowest income quintile.

	(a)	(b)
Equivalised disposable income	1.000071***	1.000071***
Food HICP	0.995***	0.997***
Equivalised household size	1.20***	1.20***
Ratio food HICP / general HICP		0.994**
$D_{eurozone}$	3.42***	3.44***
D_{DSU}	5.45***	5.57***
D_{urb2}	1.14***	1.14***
D_{urb3}	1.09***	1.09***

Based on coefficients presented in Table 3.

food deprived appeared to increase with an increase of the relative price of food. In this way, food deprivation appeared to be associated not only with food prices but also with the extent to which food prices run above general prices. On average for EU consumers, the odds of being food deprived were 0.994 with respect to a unit relative price increase. This means that the probability of being food deprived increased by 0.6% for a unit relative price increase.

The parameter estimates of the equivalised household income were significantly positive in the models presented in Table 3. The odds of being food deprived were 1.00007 with respect to a unit income increase in both models. This means that the probability of being food deprived decreased by 0.007% for a unit increase in the household disposable income.

The equivalised household size had a significant and positive impact in explaining food deprivation among EU consumers. Therefore, the probability of being food deprived decreased with a unit increase of the equivalised household size. Larger households seemed to be less vulnerable to food deprivation.

When considering the dummy variables eurozone and DSU, both estimated coefficients were significantly positive. This shows the considerable differences in food deprivation that exist across groups of MSs. Thus, food deprivation appeared to be more severe in the MSs that belong neither to the DSU group nor to the eurozone group. This result was already identified in the descriptive statistics included in Table 1. Taking into account the findings included in Table 1, we may also say that the recently acceded EU MSs that do not belong to the eurozone may have achieved some convergence toward the MSs belonging to the EU prior to 2004.

We found differences in the degree of urbanization too. Households in both thinly populated areas and intermediate areas had less probability of experiencing food deprivation than households in densely populated areas.

Models taking into account the entire sample —including all income quintiles— were also specified. These models have not been included in Tables 3 and 4 due to the fact that the goodness of fit specificity tests´ results were lower. Even so the parameter estimates of the models not including the relative price of food were significant and the results for the entire sample were consistent with those obtained for the lowest income quintile. For a unit increase in the consumer food price index, the probability of being food deprived increased more in households belonging to the lowest income quintile than in the entire sample. This is consistent with arguments that recognize the large differences existing across the share of income spent on food and across income classes between EU MSs and between income classes within each MS respectively (EC, 2008).

We did not test for the difference in the 2007-08 period relative to the period after the price increases by separating the model into two subsamples in order to test for structural breaks because the sample was not large enough. However, a dummy variable that captures the food crisis —years 2007 and 2008— was not statistically different from zero. Therefore, we found no clear evidence of an increase of food deprivation following the 2007-2008 food crisis.

As for the goodness of fit tests, a cut-off of 0.5 to generate the classification variable performed poorly, missing true negative cases (food deprived units). According to Hosmer *et al.* (2013), classification is sensitive to the distribution of the two component groups and always favours classification into the larger group. This is independent of the fit of the model. To overcome this, a cut-off of 0.85 was used instead of 0.5, for which the maximum value of the J statistic was obtained.

Discussion

The aim of this paper was to test whether increasing food prices had an impact on EU consumers' food deprivation during the period 2003-2011, which coincided with the increase in agricultural commodities prices occurred in 2007-2008 and 2010-2011. Increasing food prices were immediately followed by the economic crisis which resulted in the increase of unemployment rates and the fall of households' real disposable income. These facts were confirmed by our results. We found a significantly negative relationship between the probability of being less food deprived and the consumer food price index, whose level increased

around the world after the food crisis. Even if the relationship was significant, the quantitative effect was not large. We also found a significantly positive relationship between the probability of being less food deprived and household disposable income and that households in densely populated areas were more vulnerable to food deprivation.

Households belonging to the more recently acceded EU MSs that do not belong to the eurozone appeared to be more sensitive to food price increases and therefore more vulnerable to food deprivation. The significant differences in the level of food deprivation across EU MSs could be due to differences in disposable income, food price transmission and varied economic situations across them. Further research could be performed to explain these differences by regressing the food deprivation indicator on other MSs-level variables that account for the socio-economic and food markets situation of each MS. These were not considered in the analysis —except for consumer food prices and the relative price for food and for the group the MS belongs to.

Both Headey (2013) and Verpoorten *et al.* (2013) coincided in the fact that the format used to formulate the question that measures a variable in surveys determines to a great extent the answer. For example, respondents may answer subjectively depending on what they understand with meat, chicken, fish (or vegetarian equivalent) and how it suits their diet. In this specific case, the questions were clear and interviewed subjects could easily respond to questions about affording a certain type of meal (EU-SILC). According to EU-SILC documentation, in the case of the EU's food deprivation indicator, the question refers to affordability, in contrast to not having food due to other reasons. It is addressed to the household and defines a non-monetary deprivation variable which is directly linked to current income (Fusco *et al.*, 2010). It is a basic need and refers to severe food deprivation (Carney & Maître, 2012).

Apart from the limitations that may arise with the use of subjective data (Headey, 2013), there were other drawbacks of the EU deprivation indicator. On the one hand, as Carney & Maître (2012) pointed out, the survey variable does not account for the potential uneven distribution of food within households or for some groups that are vulnerable to food deprivation, such as homeless or people living in or being supported by institutions. On the other hand, the indicator does not refer to the nutritional quality of the food that the household can afford, providing the issue of food deprivation with a quantitative perspective rather than a qualitative one (Carney & Maître, 2012). Despite its overall drawbacks, the EU-SILC indicator appears to be a convenient tool for analysis due to several reasons, such as the regularity, high quality, large sample, annual execution and large coverage both in countries and time period of the survey, which permits comparability between MSs.

Despite the limitations, results are consistent with other studies. Antentas & Vivas (2014) found reductions in the consumption of all items, and significant changes in the composition of the diets among Spanish households. But their work was also capturing the effects of the economic crisis, hurting especially low income households, unemployed adults, and pensioners. Huang & Wu Hang (2012) found that an increase of 20% of the price of food and energy would increase the per capita compensated expenditure by US 795$, which would be equivalent to 14% of the disposable income of a household in the lowest income quintile. Gregory & Coleman-Jensen (2013) found statistically significant effects of increases of food insecurity among the poorest US households resulting from an increase of food prices by less than one standard deviation.

Based on the importance given by many authors to the percentage of food expenditure, it is clear that increasing food prices must have had notable impact in the households within the lowest income quintile in Romania, Lithuania, Bulgaria, Malta, Poland, Slovakia and Estonia, reaching possibly to the median income household in Romania. Average households spending more than 20% of disposable income in food and non-alcoholic beverages in 2012 are only found in Romania and Lithuania (Schoen & Lang, 2014).

The health consequences of food price increases are difficult to qualify. Jones *et al.* (2014) clearly showed that healthy food items are more expensive than unhealthy ones, but that does not mean that poor households would switch to unhealthier products in result to price increases. Ligon (2008) conjectures that households may switch away from preferred diets to more basic foodstuffs. Antentas & Vivas (2014) suggest that increased food prices may have had a positive health impact because of reduced food-away-from and more home cooking of legumes, and larger consumption of fruits and vegetables. Schoen & Lang (2014) reported British 78% consumers in 2013 as being worried about the increasing cost of food, and 41% claiming the cost of food as a source of stress. Beatty (2010) found that the poorest households in the UK pay less because they benefit more on quantity discounts, but households without a car or sufficient storage space at home may end up paying more. As to the nutrition and health consequences of quantity discounts, Beatty (2010) did not offer any conclusion.

There is still significant uncertainty about how people actually change their eating and consumption

habits in response to changes in food prices. Do they waste less food when it becomes more expensive? Does food waste at home vary across products? How do they respond to discounts? Are there ethnic differences in food deprivation? From a policy perspective, it is important to delve also into the retailers' strategies too, learn more about how the poorest urban consumers make use of the wide food choice they can find in all EU cities, and evaluate the food assistance programmes in compensating the negative effect of increasing food prices. Our findings provide basis to conclude that more expensive food does have an impact in the poorest households of the poorest EU MSs in affording a meal with meat, chicken, fish (or vegetarian equivalent) every second day.

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