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WHO and for how long? An empirical analysis of the consumers' response to red meat warning

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Abstract

Using data from the Italian Household Budget survey (HBS) this paper investigates consumers' responses to the World Health Organization (WHO) warning about the carcinogenic effect of red meat consumption, released in October 2015. Data collected on a monthly basis allows us to compare household expenditure variations just before and after the WHO warning while accounting for the seasonality of meat consumption in a generalised differences-in-differences framework. We find that the warning caused a reduction which amounts to 6.6%, 10% and 4.7% of the average monthly expenditure in red meat, in carcinogenic meat (*Group 1)* and in probably carcinogenic meat (*Group 2A)*, respectively. However, expenditure reduction is generally found only in the short term, i.e. one month after the warning but was highly heterogeneous across sub-groups both with respect to the magnitude of the effect and to the persistence of the consumption shift. Households with higher education levels and higher health *awareness* exhibited a stable, more accurate -and not just higher- consumption shift in response to the warning. A number of placebo regressions and different approaches to statistical inference support the validity of these conclusions.

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1. Introduction

The increasing incidence of illnesses, of which unhealthy diet is one of the key risk factors, represents one of the main health challenges nowadays. According to the WHO (2014), non-communicable diseases related to a poor diet caused 68% of the deaths globally in 2012. Indeed, the poor eating behaviour of the individuals is associated with a vast array of health issues such as obesity, diabetes and cancer, resulting in detrimental effects on individual well-being and leading to poor economic outcomes. In response to this sort of epidemic, the public authorities have increased the volume of information provided about the consequences of certain food overconsumption. As documented by the Food and Agriculture Organisation of the United Nations (FAO), there have been increased efforts by international organisations, governments, civil society and the private sector to promote healthy diets in the last twenty years, in both developed and developing countries (Hawkes 2013). The main actions have included nutritional education, media campaigns, nutritional labelling and food safety warnings. However, it is quite evident that these initiatives are welfare-improving insofar as they produce a shift in eating behaviours and, more importantly, if they can be found to lead to a stable change in these behaviours which is able to generate significant health gains in the future. Moreover, insofar as promoting equity is also a twin objective of health promotion activities, it is also important that the response to such activities should be as homogenous as possible among the population, i.e. consumption shift should be independent from individual socio-economic background.

This paper, for the first time in the literature, addresses all these aspects together by investigating the consequences on consumers' behaviour resulting from one important health warning released by the World Health Organization's in October 2015 and concerning the carcinogenic effect of red meat consumption. In particular, the WHO warning classified some kind of red meat as *Group 2A*, i.e. probably carcinogenic to humans, and processed red meat as *Group 1*, i.e. carcinogenic to humans. The warning is particularly significant as it concerns highly consumed foods which are included in many daily meals around the world. In fact, the news was rapidly circulated by national health authorities, magazines and mass media, and also the demand for information around the topic was rapidly increasing in the period following the warning. Both factors made "red meat" one of the trending topics on the web in October 2015 around the world, (see Section 2 for more details).

We investigate this issue in the geographical context of Italy using data from the Household Budget survey (HBS) which collects expenditures of a large and representative sample of Italian Households. Italy represents an interesting case study given the long-lasting attention towards food quality associated with the Mediterranean diet. This attention is witnessed, for instance, by a huge amount of related Google searches in the period following the warning; an amount significantly larger than the one observed in almost equally sized countries, such as the UK (see Section 2 for further details). Moreover, available data from Italy includes accurate information on all kinds of expenditure made by a family on a monthly basis and collected on a diary-form from the 2014 to 2016. This is a rare feature of expenditure data which are often available only on a quarterly basis. Monthly data allows us to compare households' expenditure variation just before and after the WHO warning in October 2015 while allowing for the seasonality variations in red meat consumption in a generalised differences-in-differences framework.

The availability of data up until one year after the warning and detailed information around household's characteristics and expenditures allows us to analyse both the short and the long-run effect of the

WHO warning and their variations across different consumer subgroups. In particular, we analyse the response of households differing with respect to average educational level and household health awareness (defined according to the consumption of healthy and unhealthy items, see Section 3). Indeed, when a new piece of health information becomes available, people might respond differently according to their diverse stock of information and ability of processing it as well as to their awareness about the health consequences of certain behaviours. Moreover, households may need some time to absorb the new pieces of information and to adapt their behaviour and this may lead to very different responses in the short *versus* long run.

This analysis makes a number of contributions to different strands of literature. Firstly, there is a large volume of literature exploring the effects of health authorities' announcements on the households' consumption patterns. Seminal papers (Hamilton 1972; Warner 1989) mostly focused on the smoking hazard campaigns. More recent papers, directly relevant to our study, investigate the effect of food safety advisories on both health and economic outcomes. Smith *et al.* (1988) analyse the impact of media coverage of milk contamination in Hawaii and find that negative news had a greater impact than positive news on consumers' behaviour. Rousu *et al.* (2007) use an experimental design to examine the impact of information about genetically modified food on consumers' willingness to pay. Schlenker and Villas-Boas (2009) found that health warnings about mad cow disease significantly reduced beef sales. Other studies (Oken *et al.* 2003; Shimshacka *et al.* 2007; Shimshacka and Wardb 2010) document strong evidence of the effects of the 2001 FDA advisory about mercury–related risks in fish consumption. However, the evidence about the effectiveness of public advisories to improve welfare is mixed. On one hand, evidence shows that consumers may under-respond or distrust the advisory (Burger and May, 1996). On the other hand, several studies (e.g. Viscusi 1997; Fox *et al.* 2002) document an alarmist over-reaction to negative information and that consumers tend to place greater weight on more pessimistic sources of risk information. While these studies advance current knowledge on the reactions of consumer to health warnings, they focus essentially on a short-run effect and do not analyse the heterogeneity in the consumer response. This paper will show that these aspects are, instead, extremely relevant since the response of consumers is actually very heterogeneous across groups both with respect to the magnitude of the effect and to the persistence of the consumption shift.

Secondly, our analysis is linked to the literature exploring the nexus between health information and preventative behaviour. This literature generally suggests that, consistently with the predictions of rational economic actions (Viscusi *et al.* 1986), the provision of health risk information induces individuals to adopt precautionary behavioural changes. However, with few exceptions (Viscusi *et al.* 1986; Carrieri and Wuebker 2016), this relies essentially on observational data. However, the identification of a clear causal link between health information and risk-taking decisions is difficult in a non-experimental setting, due to unobserved individual characteristics (i.e. risk aversion, inter-temporal preferences) which are likely to affect both the outcome and the individual effort to acquire new information. Our quasi-experimental identification strategy allows us to overcome these identification issues and thus to retrieve a causal effect of health information on precautionary behaviour.

Lastly, there is a large body of literature documenting the heterogeneous effects generated by new technology introduction or information availability as a main source of socio-economic status (SES) related health inequalities. In fact, as shown by Contoyannis and Forster (1999), responsiveness to these innovations may vary across socio-economic groups, i.e. a higher take-up rate among the richer or more educated, resulting in a dichotomy between efficiency and equity: average population health and inequalities in health may both increase. As suggested by Deaton (2002) and verified by several empirical papers (Cutler and Lleras-Muney 2006 for a survey, Goesling2007, Conti *et al.* 2010, Clark and Roayer 2013, Brunello *et al.* 2016), education seems to be the key element to disentangle the relationship between socioeconomic status, health outcomes and health innovation uptake. In line with this literature, our paper confirms the beneficial effect of education on responsiveness to health warnings. However, it also finds that education along with the health awareness are the main drivers of a stable, more accurate-and not just higher- consumption shift in response to the warning. This may contribute to a better understanding of the role of education and health awareness on SES-related inequalities.

The remainder of the paper is organised as follows. The following section provides more insights into the WHO warning and its media resonance. Section 3 presents the data. In section 4, we discuss our identification strategy. Section 5 presents and discusses the results. Section 6 reports some robustness checks. The last section summarises and concludes.

2. Institutional setting: the WHO warning

In October 2015, the International Agency for Research on Cancer (IARC) of the WHO published an issue of *The Lancet Oncology* reporting evidence about carcinogenicity of the consumption of red meat and processed meat. In particular, red meat was classified as *Group 2A*, i.e. probably carcinogenic to humans, which refers to evidence from epidemiological studies about the association between meat consumption and developing colorectal cancer. On the other hand, processed meet was classified as *Group 1*, i.e. carcinogenic to humans, which refers to sufficient causal evidence linking red meat consumption and cancer in humans. Red meat refers to all mammalian muscle meat, including beef, veal, pork, lamb, mutton, horse, and goat. Processed meat includes meat that has been transformed through salting, curing, fermentation, smoking, or other processes to enhance flavour or improve preservation (e.g., hot dogs, ham, sausages, corned beef and canned meat). According to the IARC, eating 50 grams of processed meat per day increases the risk of colorectal cancer by about 18%, while red meat consumption is associated with an increased risk of developing colorectal, pancreatic, and prostate cancer. These estimates suggests that about 34,000 cancer deaths per year worldwide are attributable to diets high in processed meat (Global Burden of Disease Project 2016); a number that would increase by 50,000 if the relationship with Group 2A red meat was proven to be causal.

Following the evaluation from IARC, the WHO gave health recommendations to prevent the risk of cancer associated with the consumption of meat, inviting individuals to moderate their consumption of meat, particularly processed meat, to reduce the risk of developing cancer. Since the publication of the WHO report in October 2015, the news of the WHO warning had a huge echo across the mass media and was rapidly spread through social networks. To give an idea of this resonance, Figure 1 shows the Google trends for both the search engine hits (as a proxy of the *demand* of information) and the volume of news (the *supply* of information) related to red meat in Italy from 2004 to 2017.

[Figure 1 around here]

As can be seen, both lines representing the relative frequencies, reach their peak in correspondence of October 2015, which is by far the month with the highest volume since 2004 (the first year in which data are available). In Italy, the news had even more echo if compared to countries with a similar population size. For instance, according to the volume data provided by Google AdWords, the term "carne rossa", in Italy, has been searched around 49500 times in October 2015, while its English corresponding "red meat" has been searched only 9600 times in the United Kingdom (a country with an even slightly larger population) in the same period. Interestingly, Figure 1 also shows the presence of other peaks for what concerns the news supply, starting approximately around the middle of 2011. This is attributable to the diffusion of the research outcomes of the first studies exploring the link between the consumption of red meat and some kind cancers, i.e. especially colorectal and prostate cancer (Punnen *et al.* 2011; Takachi *et al.* 2011). However, if in the other cases there was only a consequent negligible increase in the number of search hits by the consumers, the 2015's official warning by the WHO generated by far the highest frequency for both the supply and the consequent demand of information around the health effects of red meat consumption. More importantly, as will be shown in the following sections, this has also caused a significant reduction in the red meat consumption.

3. Data and Variables

Our data come from the Italian Household Budget Survey, which is a cross-sectional survey carried out once a year by the Italian National Institute of Statistics (ISTAT). In agreement with EUROSTAT, the survey is based on the harmonised international classification of expenditure voices (Classification of Individual Consumption by Purpose - COICOP) to ensure international comparability and it is included in the National Statistical Program, i.e. it is used to compute official indicators used by the governments for many purposes such as official relative and absolute poverty thresholds. The survey provides detailed information about the monthly expenditure of the household for goods and services destined for household consumption, alongside a number of demographic and socioeconomic information. Data are collected using a dual system, i.e. a diary followed by a face-to-face interview. In fact, every sampled household receives a diary every month where they are asked to record the daily expenditure sustained by all the household's components, the consumption of goods produced by the household and the place of purchase of goods and services. This information is then validated during the interview in which all other kind of information are also collected. Data are finally made public every year with expenditures listed on a monthly basis. As stressed in the introduction, this is a rare feature of household budgetary survey and it will be particularly useful to carefully identify our effects of interest.

In this paper, we use data from 2014 to 2016. Our sample thus consists of about 17,000 observations per wave. Data before 2014 were collected in a different fashion and thus they are not directly comparable to the last two waves. However, information on main aggregates of expenditure are still comparable and we will use them for placebo regressions and to illustrate the validity of the common trend hypothesis (see Section 6 for more details)[1].

Our outcomes, following the IARC's report, refer to the expenditures for the different kind of meats grouped according to their risk classification. Thus, the variable *Group 2A* includes expenditure for

[1] Since the 2014, the ISTAT have changed the purpose of the survey, collecting data about expenditures instead of consumption. Moreover, many demographic and socio-economic variables are collected in a very different fashion. As a result, data collected in the waves before 2014 are not directly linkable to the last two waves as explicitly indicated in the data-release documentation.

beef, pork, lamb and goat; *Group 1* includes cured meat, sausages and canned meat and the variable *Red Meat* includes meats from both groups. Expenditures are expressed in Euros and VAT included.

In the baseline specification, we include the total amount of food expenditure as a control variable. This is in line with the literature about household expenditure (Deaton, 1997) and it is useful to take into account variations over time and between households in the general level of household consumption. As robustness, we also consider a larger set of variables including household demographic and socioeconomic variables: household size, the age range of the household reference person (available in three categories: 18-34, 35-64, 65+), a dummy to indicate whether the household includes migrants and a dummy indicating whether there is at least one graduate in the household. Information about the presence of migrant is useful for taking into account cultural-related food preferences and fasting periods related to religion while the presence of a graduate in the household is useful to take into account both the availability and the ability to process information, which may influence the dietary choices of the entire household. Finally, in order to take into account heterogeneity in regional consumption due to the high local food tradition in Italy, we also include regional fixed effects.

Concerning subgroup analysis, we analyse heterogeneous effects across households with a different level of education and of *health awareness*. Concerning education, we analyse the differential response by households composed by at least one graduate *vs* households with no graduates, while, to assess the role of health awareness, we follow Shimshack *et al.* (2007; 2010) and we consider as *health aware*, the households with a low consumption of unhealthy items such as alcohol and tobacco. Moreover, in order to assess *health awareness* for what concerns dietary choices explicitly, we also present separate estimates for households with a high *vs* low consumption of healthy foods such as fruit and vegetables. For both cases, we define households with high (low) consumption, as those for which expenditure in these items is in the top (bottom) two quintiles of the expenditure distribution[2]. A complete description of all these variables along with some descriptive statistics is provided in the next Section.

3.1 Descriptive statistics

Table 1 shows descriptive statistics of all variables employed in our empirical analysis. Concerning our outcomes, we find that an Italian household spends on average about 78 Euros per month on red meat, while the monthly expenditure for meat included in Group 1 and Group 2A amounts to 34 and 44 Euros, respectively. These expenditures represent 17%, 7%, and 10% of the total expenditure for food, respectively. This confirms the relevance of these items for the Italian household budgets.

[Table 1 around here]

However, average data masks two important features of the expenditure for these items in Italy. These are instead highlighted in Figure 2,which reports the non-parametric distribution of these expenditures. First, we find that the distributions are highly right-skewed. This indicates the presence of very few households consuming high quantities of red meat per month. Second, we find that there is a non-negligible share of households which did not report any expenditure for red meat (about 12% for Group 1 and 18% for Group 2A). Both features are generally common to all households' expenditure data and will be taken into account in our empirical model through the use of a Tobit estimator (see Section 4 for more details).

[2] We also perform some sensitivity across this threshold and results are substantially unchanged (available upon request)

[Figure 2 around here]

Concerning the other variables used in our analysis, Table 1 shows that households spend on average 456 Euros per month on food and this represents about the 20% of the total monthly expenditure. In about 20% of the households in our sample there is at least one university graduate and 4% of the households consist of migrants. We also find that households reporting high consumption in healthy foods such as fruits and vegetables (i.e. in the top two quantiles of the expenditure for these items) spend on average 175 Euros per month for these foods, while their counterparts spend 38 Euros, on average. Conversely, households reporting low consumption for unhealthy items such as tobacco and alcohol (i.e. in the bottom two quantiles of the expenditure for these items) spend on average 0.90 Euros per month for these items while their counterparts spend 102 Euros.

Table 2 reports other features of the expenditure on red meat in Italy. First, it highlights the presence of a high regional heterogeneity in the expenditure. Regions in central Italy show higher monthly expenditure in red meat, exceeding by approximately 10 Euros red meat expenditure of Northern and Southern regions. In particular, due to the culinary traditions, Northern regions show higher monthly expenditure in Group 1 meat, while Group 2A meat is more highly consumed in the Southern regions. This heterogeneity confirms the need to control for regional fixed effects in our estimates. Interestingly, Table 2 also shows that households reporting low consumption on unhealthy items (alcohol and tobacco) spend less on red meat, i.e. 40 Euros less than their counterparts.

[Table 2 around here]

Figure 3 shows a last interesting feature of the red meat expenditure in Italy, i.e. an high seasonality. In particular, it emerges that the expenditure is higher in the second and fourth quarter and lower in the first and third quarter of the year. This is likely due to two factors. First, higher expenditure is coincident with the two important Catholic holidays such as Easter and Christmas. In these periods, Italian households cook traditional meals based on red meat, in particular lamb and cured meat, and this explains the peak in consumption during these periods. Second, lower consumption during the summer time (June-September) is likely to be due to the hot temperatures, which make fresh meals based on fruits and vegetables more desirable. An interesting feature of this pattern is that it is pretty constant across years. Indeed, Figure 3 shows that monthly and seasonal variations in red meat expenditure are substantially the same in the last two pre-treatment years, i.e. 2013 and 2014. Similar patterns emerge also for other health behaviours such as smoking (Del Bono and Vuri 2017)and it represents a useful source of identification of the causal effects of the WHO warning, as we will show in the next Section.

[Figure 3 around here]

4. Identification strategy

The identification of the effect of the warning on red meat consumption in our setting requires us to address two main challenges. The first challenge is the possible presence of a long-term trend in red meat consumption. Such a trend -especially if negative- would lead to an overestimate of the impact of the warning in a simple before-after framework, as it would confound the effect of the warning with the "natural" trend in red meat consumption. In principle, our data released on a monthly basis should allow us to control for this issue since we might compare expenditure variation over a very small window around the time of the release of the warning (i.e. one month before and after the warning) and thus deal with eventual long-term trend effects. However -and this represents the second identification challenge - this strategy might also lead to biased estimates of the effect of the warning if there is a seasonal pattern in red meat consumption. As already documented in Section 3, this seems to be the case in Italy due to the higher consumption during the Catholic holidays and lower consumption during the summer time.

In order to deal with these two challenges, we employ a generalized differences-in-differences framework in which variations in red meat expenditure over a small window around the release of the WHO warning (October 2015) are compared with the variations in the same period of the previous year. A similar identification strategy –but using a larger window around the event- has already been employed in other policy-evaluation frameworks dealing with seasonal effects (i.e. Del Bono and Vuri 2017). More formally, our empirical model can be expressed as follows:

$$\mathrm{Meat}_{my} = \mathrm{T}_{my}\beta + \theta_m + \gamma_y + u_{my} \quad (1)$$

Where Meat_{my} represents household's expenditure on red meat, Group 1 or Group 2A meat in the month m of the year y, respectively. θ_m are month fixed effects capturing monthly variations in expenditure- independently of the year of the interview- while γ_y are year fixed effects capturing variations across years in expenditures. T_{my} is our treatment variable and β is the corresponding coefficient measuring the impact of the warning on red meat expenditure. As discussed in the introduction, we also aim to distinguish short *vs* long run effects of the warning. The T_{my} is thus accordingly adapted in different specifications to consider from 1, 2, 5 months and up to one year after October 2015, respectively[3].

In our baseline specification, we also include the total amount of food expenditure as control in equation (1). Alternative specifications includes a larger set of variables, i.e. the household size, the age category of the head of the household, the presence of at least a university graduate in the household and whether the household includes, as discussed in Section 3. Finally, following empirical literature on the analysis of expenditure data (e.g. Donkers *et al.* 2017, for charity expenditure; Tansel and Bircan 2006, for education expenditure; and Cai 1998, for food expenditure) we use a Tobit estimator to deal with the excess of zeros problem. However, for comparison, we also estimate equation (1) using OLS estimator and we obtain qualitatively similar results.[4]

The main identifying assumption to interpret β as the causal effect of the warning is the existence of a common trend in red meat expenditures over the same periods in the pre-treatment years. In other terms, this requires to assume that –in absence of the warning- the expenditure variations in the periods just before and after the October 2015 warning would be the same observed in the same period of the previous year. Figure 3 discussed in Section 3 already anticipated that this assumption can be credibly maintained in our setting since seasonal variations in red meat expenditures exhibit a very similar pattern across years. To check this assumption more carefully, in Figure 4 we compare variations in

[3]For this reason we opted to illustrate our estimation equation using a more flexible generalized diff-in-diff formula.
[4] These results are available upon request.

expenditure in November (one month after the warning) with average expenditures in the period January-October in pre-treatment years, i.e. in the 2014 and 2013. Figure 4 shows that these variations are effectively "parallel" , i.e. very similar in 2014 and 2013 and this is found for both kinds of red meat (Group 1 and Group 2A) and also when expenditure for all kinds of red meat is jointly considered. By contrast, significant deviation to this pattern are found in 2015 -the treatment year- as a result of the warning release. This anticipates the existence of a negative and significant consumer response to the WHO warning.

[Figure 4 around here]

In order to further check the validity of this identification assumption, we also perform several placebo regressions using fake warning periods of different length and we implement randomization tests based on simulated placebo warnings for non-parametric inference. Results are reported in Section 6 and further support the validity of our identification strategy.

5. Results

5.1 Short-term effects

Table 3 reports the results of the Tobit estimates of the generalized DiD model described in Equation (1) for Red meat, Group 1 and Group 2A meat, respectively. All estimates refer to the short-term effect of the WHO's warning, i.e. one month after the warning took place. In columns 1-3 we report the estimates of the treatment effect without controls, while in columns 4-6 we report the estimates of the treatment effect with control variables. For all the outcomes of interest, we report estimates that include standard errors clustered at month level that are robust to correlated monthly shocks in red meat expenditure. However, in Section 6 we demonstrate that our results are robust also to different approaches to statistical inference (block-bootstrap and randomisation tests based on simulated placebo warnings).

[Table 3 around here]

A comparison between columns 1-3 and 4-6 demonstrates that the estimates of the average treatment effect are substantially unchanged when covariates are included. This gives further confidence to the validity of our quasi-experimental design. Table 3 shows that the WHO's warning had a strongly significant impact on consumers' behaviour in the short-term. In fact, in the first month after the treatment, consumers responded to the warning by reducing red meat expenditure by about 5.24 Euros, which amounts to the 6.7% of the average monthly expenditure on red meat. Interestingly, the reduction for probably carcinogenic meat (Group 2A) was higher than the one observed for carcinogenic meat (Group 1), i.e. 4.5 *versus* 1.6 Euros amounting to the 10% and 4.7% of the average monthly expenditure for these meats, respectively. This pattern is likely due to the fact that the news was mainly conveyed through mass-media as a generic "red meat danger" and this induced consumers to reduce especially the consumption of the most known red meats such as beef, pork, lamb and goat. However, as will be shows in the next sub-section, this pattern is highly heterogeneous across households as more educated and health aware families interpreted the warning more correctly, especially in the long-run.

The coefficients of the Tobit model encompass both changes in the probability of having positive expenditure on red meat and changes in red meat expenditure for those with a positive expenditure in red meat. Thus, in order to obtain further insights into the effects of the warning we apply the decomposition method suggested by McDonald and Moffitt (1980) which allows us to assess the relative weight of these two effects. We find that 73% of the total change in expenditure on red meat was generated by marginal changes in the value of positive expenditures, whereas 27% was generated by changes in the probability of spending anything at all for red meat. This is consistent with the contents of the WHO warning which was that of reducing rather than eliminating red meat consumption. These effects are 65% and 35% for Group 1 and 60% and 40% for Group 2A, respectively.[5] Interestingly, this indicates that warning seems to have increased more the proportion of consumers who do not consume any quantity of less dangerous red meat (Group 2A) than carcinogenic meat (Group 1). This confirms the common misinterpretation of the generic "red meat danger" previously discussed.

With respect to the control variables, we find that larger households are associated with higher expenditure on red meat, as expected; while, households with at least one university-graduated member spend on average about 11, 4 and 8 Euro less than less educated households on red, Group 1 and Group 2A meat, respectively. This might be due to a preliminary knowledge around the dangers caused by an excess of red meat consumption which is strengthened by the first research outcomes reporting a correlation between red meat consumption and some kinds of cancer available since 2011 (see the discussion in Section 2). Concerning age, we find that households with an older head of the household spend more on red meat, and in particular for cured meat on which they expend, on average, about 7 euro more than their counterparts. This might be indicative of some cohort effects in red meat consumption. Lastly, as expected, we find that households with migrants are associated with a lower expenditure on red meat and this is likely due to different dietary habits and possibly also related to religious beliefs for some sub-groups of migrants, e.g. Muslims.

5.2 Long-term and heterogeneous effects

In Table 4, we report the estimates of the long-term effect of the warning on households' red meat expenditure. Estimates are based on the same equation described in equation (1) and include the same set of controls but employs a longer post-warning observational period including estimates at two months, five months and one year after the WHO warning, respectively.

[Table 4 around here]

Remarkably, we find that the treatment effect coefficients are negative but never statistically significant at conventional levels in the following months after the release of the warning. This result is consistent across all our outcomes. It is important to observe that testing for the effect up to one year after the warning and accounting for seasonality allows us to reduce any concern about the fact that this result might be influenced by festivity bias and new year's resolutions which might play a role in the adoption of any kind of health behaviour, as already shown by other papers (e.g. Del Bono and Vuri 2017 for

[5] Mc Donald and Moffit (1980) decompose the total effect of a determinant X_i in a tobit model as: $\delta Ey/\delta X_i = F(z)(\delta Ey^*/\delta X_i) + Ey^*(\delta F(z)/\delta X_i)$, where $F(z)$ is the share of observations with non-zero expenditures, $\delta Ey^*/\delta X_i$ is the impact of the determinant on the expenditure above zero, $Ey^*$is the average positive expenditure and $\delta F(z)/\delta X_i$ is the impact of the determinant on the probability of any expenditure. In the case of red meat, the decomposition is $5.24 = (0.93 * 3.9) + (80.9 * 0.02)$. Thus, the first term (0.93*3.9)/5.24) accounts for 73% of the final coefficient, while the remaining 27% is explained by the second term (80.9*0.02/5.24). Same procedure was applied for the other outcomes.

smoking). Moreover, for sake of brevity, we report in Table 4 only results for two, five months and one year after the warning but additional analyses exclude the presence of any significant treatment effect from two months and up to one year after the release of the warning (results available upon request). Overall, this indicates the presence of a negative causal effect of the warning limited to one month after its release while levels of expenditure in red meat came back to before-warning average levels just two months after its release.

However, these results apply only for the average household and they are indeed extremely heterogeneous across different sub-groups of households, as shown in Tables 5-7. In these Tables, we report both the short and long term estimates of the treatment effects of the WHO's warning for different types of households characterized by a different educational level and *health awareness*. In particular, in the first two rows of each table we report treatment effect estimates for households with at least one university-graduated component *versus* households with no graduate member. As a short-hand we refer to these groups as High-educated *versus* Low-educated households in the Tables. In the third and fourth columns of Tables 5-7 we report estimates for households with a high *versus* low health awareness (High-aware and Low-aware as a short-hand in the Tables), i.e. households in the top *versus* bottom two quintiles of unhealthy items expenditure such as and alcohol and tobacco. Lastly, in the last two rows of Tables 5-7 we compare the response by households with bad *versus* good dietary habits (Bad-diet *vs* Good-diet as short-hand in the Tables), i.e. households in the top *versus* bottom two quintiles of expenditures in fruits and vegetables. For the sake of brevity, we report in Tables 5-7 only the coefficient measuring the treatment effect. Estimates are based on the same specification discussed so far and includes the same set of controls with the obvious exception of the variables used for sample stratification (i.e. education in the case of comparison between high *vs* low educated households).

[Tables 5, 6, 7 around here]

Concerning education, we find that high-educated households had a stronger and more stable response to the warning. Our estimates suggest that these households reduced the expenditure on red meat by about 13.7 Euros in the first month after the warning, as indicated in Table 5. This reduction is found to be fairly stable over time being equal to about 10 Euros in a span that covers up to one year later the release of the warning. This pattern suggests a sort of permanent shift in red meat consumption for these households. Furthermore, a comparison of results reported in Tables 6 and Table 7 suggests that while in the first month after the warning the reduction was higher for Group 2A meat- in line with the "average household" (as discussed in Section 5.1)- the pattern changes quite substantially when considering long-term effects. Indeed, consumption shifts points towards a higher and stable reduction of carcinogenic Group 1 meat (about 5 Euros in a span that covers up to one year later) and non-significant variations for group 2A meat expenditure. This suggests that high-educated families took time to go deeper into the warning and were able to process the information accurately. This has led to a stable reduction in the more dangerous meat especially in the long run in a way which is consistent with the contents of the WHO warning. This result is not found for low-educated families who instead reduced the generic red meat consumption only in the first month and returned to before-warning expenditure levels just two months after the release of the warning, as shown in the second row of Table 5.

A similar pattern emerges from the comparison of the effects of the warning between households with a different degree of *health awareness*. In order to explore the pure role of health awareness on consumers' response we include household's education level (i.e. the presence of a university graduate in the household) among the set of controls in these estimates. Table 5 shows that Low-aware households had a large reduction of red meat expenditure only in the first month after the warning (about 9 Euros), in line with the average household. On the other hand, High-aware households had an enduring reduction in red meat expenditure, i.e. a constant monthly reduction of about 3 Euros in a span that covers up to one year following the release of the warning. Interestingly, reduction for High-aware households was mostly concentrated on the meat labelled as carcinogen by the WHO (Group 1), as indicated in table 6. Conversely, Low-aware households exhibit a higher reduction among more generic and less dangerous red meat (group 2A) and this is found also in the long run (see Table 7). This indicates, in line with what we observed for education, that health awareness had an impact not only on the magnitude and the stability of the consumption shift but also on the correct adherence to the WHO suggestions.

The comparison of responses between households with Bad *versus* Good diet confirms substantially the latter results but with some interesting differences. Indeed, in line with the effects discussed above, we find that households with a good diet reduced expenditure especially for dangerous red meat (Group 1) and over a long time span, as reported in Table 6. On the contrary, households with bad diet reduced mostly generic and less dangerous red meat (Group 2A) but not the more dangerous meat (only in the first month, as shown in the last row of Table 6). However, we also found that short-term responses to the warning were substantially similar among these households for overall red meat expenditure (last two rows of Table 5) and stable over time among households with a bad diet for Group 2A meat (Table 7). These results seem to indicate an important heterogeneity in the short *versus* long run effects of the warning among these households: a similar response in the short-run but a divergent response in the long-run which is compatible with a long-run equilibrium in which households with bad diet tending to consume a relatively more dangerous bundle of red meats and households with good diet tending to consume a relatively healthier bundle. The persistence of reduction in probably carcinogen meat expenditure among households with a bad diet may also depend on the presence of some compensation effects induced by the new piece of information around red meat. Unfortunately, our results indicate that this reduction was wrongly oriented towards the relatively less dangerous red meat bundle.

6. Robustness checks

In this section, we perform a number of checks to test the validity of our identification strategy. As a first check, we focus on the plausibility of the common trend assumption. Figure 3 reported in Section 3 already has shown a seasonality in meat consumption, which was constant across years. A direct consequence of this pattern is that expenditure variations between November and previous months of the year are effectively parallel across pre-treatment years, as shown in Figure 4 of Section 4. Graphical analysis then leads us to be confident about the credibility of common trend assumption in our setting. However, to give even more credence to this assumption, we also replicate the estimates of our Diff-in-Diff regression based on the specification introduced in equation (1) but with "fake warning" periods. In Table 8 we report placebo DiD estimates assuming a fake warning occurred in October 2014, i.e. exactly one year before the real warning, and using the same post observational period employed for short and long term treatment effects reported in Section 5. We, thus, basically compare the red meat expenditure in the months before the fake warning with periods of up to one year later than the fake warning while accounting for seasonality in red meat expenditure. As expected, the DiD estimates in Table 8 show that treatment variable are never statistically significant alongside all our outcomes and, interestingly, for all post observational period considered (one, two, five months and up to one year later). The coefficients of the control variables are instead very comparable to the ones found in the main regressions reported in Section 5.

We also repeated the same exercise dating the fake warning to two years before, i.e. October 2013, and using a post-observational period of the same length, i.e. up to one year later than the fake warning. Also in this case we do not detect any statistically significant treatment effect. Moreover, we do not detect any significant effect also when performing placebo DiD estimates on the subgroup of households considered for heterogenous treatment effect estimates as in Section 5.2. (Results are available upon request).

As a second check, we explore the robustness of our results to assumptions about the structure of the error distribution. Indeed, inference in DiD setting might be problematic especially in the presence of a small number of clusters (Bertrand et al., 2004; Donald and Lang, 2007). In our analysis, given the seasonality of the red meat expenditure, the month seems to be the most appropriate level at which to cluster the standard errors. This is the strategy we effectively adopted for the regressions shown in Section 5. Technically, these standard errors are consistent provided that there is a sufficiently large number of clusters. Despite the literature does not offer conclusive evidence around the sufficient number of cluster do draw credible inference, 12 clusters might be effectively "at the boundary". In Table A1 in the Appendix, we show that our results are statistically significant at conventional levels also when based on bootstrapped standard errors clustered at the monthly level (with 200 replications). However, even non-parametric inference based on bootstrapped standard errors might not be entirely reliable with only 12 clusters. To rule out any possible concern, we thus follow Bertrand et al. (2004) and we implemented a randomization test based on placebo warnings. Essentially, we randomly select a set of different periods (month x year) for simulating the treatment effect of "fake warnings" and estimate our generalised DiD by using the placebo fake warnings in place of the real one. This process is repeated 2000 times and the estimated coefficients from permutation tests based on Monte Carlo simulations are stored in order to plot the non-parametric distribution of placebo warnings. The main assumption behind this test is that, on average, the fake warning should not generate any effect on the households' red meat expenditure, since the months of treatment effects are randomly chosen.

Figure 5 shows the kernel density distributions of the coefficients generated by the simulation process explained above for our outcomes of interest: red meat, Group 1 and Group 2A meat. As it is possible to observe, the means of the distributions are virtually zero, which implies that estimator of placebo effect is unbiased. More importantly, average treatment effects we estimate for the real WHO's warning (5.2 for red meat, 1.6 for Group 1 and 4.5 for Group 2A as shown in Section 5) fall in the very extreme tails of the distribution of placebo effects. This provides further confidence that the effect we estimated was not observed by chance and therefore reduces any concern about the fact that our results might be incorrect due to invalid assumption on the standard errors distribution.

[Figure 5 around here]

7. Conclusions

In this paper we have investigated the consequences on consumers' behaviour of World Health Organization's warning concerning the carcinogen effect of the red meat consumption released in October 2015. We investigated this topic in Italy due to its the long-lasting attention towards food quality and Mediterranean diet but also for the availability of good data collecting expenditures for a large and representative sample of Italian Households on monthly basis and with rich information on household characteristics. Monthly-based data allows us to compare households' expenditure variation just before and after the WHO warning while accounting for the seasonality of red meat consumption in a generalized differences-in-differences framework. This allows to retrieve the causal effect of the warning on red meat expenditure under the hypothesis of common trend in expenditure over the same period of the year, which seems to be largely supported in our case. Additionally, the availability of data up until one year after the warning and detailed information around household's characteristics and expenditures allows us to analyse both the short and the long-run effect of the WHO warning and their variation across different consumers' subgroups.

Using the Household Budget Survey (HBS), our analysis leads to three important findings. Firstly, we find that WHO's warning had a strongly significant impact on consumer's behaviour but only in the very short-term. In fact, we find that in the first month after the warning, consumers reduced their expenditure on red meat by around 6.6%, 10% and 4.7% of the average monthly expenditure in generic red meat, in carcinogenic meat (*Group 1)* and in probably carcinogenic meat (*Group 2A)*, respectively. However, expenditures on red meat returned to pre-warning levels just two months after its release. Secondly, we find that only some subgroups, such as the more educated and health aware changed their eating behaviours in the long run, i.e. over a one year post-warning observational period. On the contrary, poor-educated and less health-aware households reduced the consumption in a less significant manner and only in the very short-term. Thirdly, we also find that these groups differ significantly with respect to the correct interpretation of the warning. More educated and health-aware households reduced especially the consumption of carcinogenic meat (Group 1) while their counterparts reduced mostly the consumption of relatively less dangerous meat (Group 2A). This pattern is likely due to the fact that the news was mainly conveyed through mass-media as a generic "red meat danger" and this induced these kinds of consumers to reduce particularly their consumption of the most common but relatively less dangerous red meats such as beef, pork, lamb and goat.

These results contribute to three different strands of the literature and offer potentially very relevant implications around the design of food warning policies. Firstly, we contribute to a large volume of literature exploring the effects of health authorities' announcement on households' consumption patterns. We add to this literature by demonstrating that the effect of an announcement might be very different in the short *versus* long run and highly heterogeneous across subgroups of consumers. Secondly, we report causal evidence on the effect of health information on risk-taking decisions in a quasi-experimental setting. This topic has been addressed by other papers based on observational data which however cannot tackle the endogeneity between the consumers' efforts to acquire information and their behaviours. Thirdly, we contribute to the literature exploring the distributive consequences of new technology introduction or information availability. In line with this literature, we confirm that education plays a significant role in the responsiveness to health warnings. This indicates that both the stock of information and the ability to process it are factors which contribute to shaping health inequalities in a substantial way. However, and this is a new result for the literature, we also find that education along with the health awareness are the main drivers of a stable, more accurate -and not just higher- consumption shift in response to the informational shock. This offers a perhaps more pessimistic view on the possibility of contrasting health inequalities through educational campaigns especially when the aim is to change behaviours in a permanent way.

In terms of policy, our paper has a number of implications for the successful design of health advices. Firstly, the fact that the consumers - on average- only responded in the immediate short-term suggests that successful health information policies should be designed in a way that expose the individual to a constant flow of information. This is likely to be more beneficial compared to the "one-shot" warnings. A real-world example of these policies is represented by the anti-smoking advice campaigns, which are delivered quite constantly, and through different formats. Secondly, the misinterpretation of the warnings by some subgroups suggests the importance of re-designing the health warnings in a simpler and more accessible way. This might have the effect of reducing the information gap between more and less educated. In this respect, a higher involvement of GPs in dissemination of health warnings might be beneficial. Finally, our findings confirm the strategic role played by education for health. Other than to reduce the well-known health gap, our finding indirectly suggests also that education is able to increase the health returns on investments in health campaigns and health educational activities since the latter are misinterpreted by low educated individuals and produce only short-term effects among them. In a general equilibrium perspective, higher investments in education are then likely to bring both equity and efficiency gains to the health production process.

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Tables and Figures

Table 1. Summary statistics

Variable	*Description*	*Mean*	*Std. Dev.*
Dependent variables			
Red Meat	Monthly expenditure on Red meat	78.29	69.98
Group 1	Monthly expenditure on Group 1 meat	34.00	32.73
Group 2A	Monthly expenditure on Group 2A meat	44.29	49.48
Controls/Subgroups			
Food expenditure	Monthly expenditure on food	456.54	304.48
HH size	Household size	2.35	1.22
High-Educated	At least one graduate in the household (share)	0.21	0.40
Age	Age category of the household's respondent	18-34 (7%) 35-64 (55%) >64 (38%)	
Migrant	At least one migrant in the household (share)	0.043	0.20
High-aware	Average expenditure of households in the bottom two quintiles of Tobacco and Alcohol expenditure	175.48	82.17
Good diet	Average expenditure of households in the top two quintiles of Fruit and Vegetables expenditure	0.90	2.03

All expenditure values are expressed in Euros

Table 2. Meat expenditure by subgroup: mean values

	Red Meat	Group1	Group 2A
All	78.29	34.00	44.29
North	76.68	35.46	41.22
Centre	85.42	36.11	49.31
South	75.74	30.73	45.00
High Education	82.79	36.37	46.42
Low Education	77.12	33.38	43.73
High-aware	99.16	42.68	56.47
Low-aware	58.11	25.48	32.63
Good diet	113.09	47.79	65.39
Bad diet	45.41	20.76	24.64

All values expressed in Euros

Table 3. DiD estimates of the effect of the warning on meat expenditure: short-term effects

	(1) Red	(2) Group 1	(3) Group 2A	(4) Red	(5) Group 1	(6) Group 2A
Treatment	-5.2422***	-1.5935***	-4.5289***	-5.2399***	-1.5936***	-4.4777***
	0.6589	*0.3308*	*0.6252*	*0.6626*	*0.3224*	*0.6351*
Food Exp.	0.1900***	0.0772***	0.1267***	0.1866***	0.0736***	0.1257***
	0.0032	*0.0010*	*0.0028*	*0.0034*	*0.0012*	*0.0029*
H Size				2.8256***	2.0995***	1.5702***
				0.3935	*0.1896*	*0.3487*
High-Educ.				-11.5601***	-4.5525***	-8.7707***
				1.1091	*0.5947*	*0.7335*
HH Age 35-65				1.4057*	-0.0541	2.8215**
				0.8123	*0.5713*	*1.1145*
HH Age>65				2.8809**	-1.9694**	7.4073***
				1.1220	*0.7709*	*1.0503*
Migrant				-10.0946***	-9.6441***	-3.5916***
				1.1461	*0.8863*	*0.9479*
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
N	30852	30852	30852	30852	30852	30852

Tobit estimates of Equation (1). Clustered standard errors at month level in *italics*. ***, **, * indicate significance at 1%, 5% and 10%, respectively.

Table 4. DiD estimates of the effect of the warning on meat expenditure: long-term effects

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		Red			Group 1			Group 2A	
	2-month	5-month	1-year	2-month	5-month	1-year	2-month	5-month	1-year
Treatment	-0.2560	-0.2384	-2.3744	-2.3264	-2.0380	-0.2208	-2.4476	-2.4182	-2.2937
	0.9461	*0.9496*	*1.9082*	*1.5160*	*1.8172*	*0.9132*	*1.9368*	*1.9407*	*1.5071*
Food Exp.	0.0730***	0.0724***	0.1802***	0.1257***	0.1255***	0.0714***	0.1861***	0.1851***	0.1217***
	0.0010	*0.0010*	*0.0023*	*0.0027*	*0.0025*	*0.0011*	*0.0030*	*0.0028*	*0.0020*
H size	2.2034***	2.1375***	3.1477***	1.6072***	1.6111***	2.2007***	2.9656***	2.9233***	1.7736***
	0.1737	*0.1749*	*0.3010*	*0.3691*	*0.3509*	*0.1699*	*0.3893*	*0.3958*	*0.2762*
High-Educ.	-4.8199***	-4.8813***	-11.6018***	-8.8061***	-9.0256***	-5.0085***	-11.8136***	-12.0569***	-8.4525***
	0.5319	*0.5091*	*0.8819*	*0.6933*	*0.6799*	*0.4744*	*1.0469*	*0.9947*	*0.6637*
HH Age 34-64	1.8966*	1.8364*	1.9498**	0.0864	-0.0541	0.1844	3.3435**	2.8215**	3.2293***
	1.1086	*1.0246*	*0.9735*	*0.5895*	*0.5713*	*0.5447*	*1.3214*	*1.1145*	*1.2208*
HH Age>65	3.4627**	3.4894***	3.6089***	-1.8700**	-1.9694**	-1.8834***	8.0750***	7.4073***	8.1415***
	1.4235	*1.2920*	*1.0858*	*0.7732*	*0.7709*	*0.7210*	*1.3456*	*1.0503*	*1.2142*
Migrant	-9.4579***	-9.0642***	-9.4323***	-3.0564***	-2.9819***	-8.9267***	-9.4804***	-9.1176***	-3.6226***
	1.0277	*0.9969*	*0.7955*	*0.8538*	*0.7659*	*0.7060*	*1.3141*	*1.1654*	*0.6937*
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	32782	35814	45837	32782	35814	45837	32782	35814	45837

Tobit estimates of Equation (1). Clustered standard errors at month level in italics. ***, **, * indicate significance at 1%, 5% and 10%, respectively.

Table 5. DiD estimates of the effect warning on red meat expenditure: heterogeneous effects

	(1) 1-month	(2) 2-month	(3) 3-month	(4) 4-month	(5) 5-month	(6) 1-year
High-Educ.	-13.7214***	-10.0816***	-10.1140***	-10.0305***	-10.1029***	-10.1035***
	1.3328	*2.6003*	*2.5926*	*2.5823*	*2.5934*	*2.6419*
Low-Educ.	-3.3365***	-0.5725	-0.5533	-0.5472	-0.5393	-0.4107
	0.7961	*1.9920*	*1.9929*	*1.9972*	*1.9989*	*1.9629*
Low-aware	-9.5992***	-4.8597	-4.8504	-4.8468	-4.8586	-4.893849
	1.2404	*2.9910*	*2.9795*	*2.9689*	*2.9563*	*2.8555*
High-aware	-3.2889***	-3.6638***	-3.6379***	-3.6373***	-3.6173***	-3.5749***
	0.7005	*0.7051*	*0.7038*	*0.6956*	*0.6883*	*0.7026*
Good-diet	-3.1134***	-0.5140	-0.5174	-0.5363	-0.5427	-0.5056
	1.2080	*2.1375*	*2.1263*	*2.1465*	*2.1319*	*1.9980*
Bad-diet	-5.8289***	-2.6869	-2.6840	-2.6824	-2.6853	-2.718012
	0.7345	*2.1077*	*2.0979*	*2.0974*	*2.1053*	*2.1326*

Tobit estimates coefficients of treatment effect of Equation (1). Full set of controls included. Clustered standard errors at month level in *italics*. ***, **, * indicate significance at 1%, 5% and 10%, respectively.

Table 6. DiD estimatesof the effects warning on Group 1 meat expenditure: heterogeneous effects

	(1) 1-month	(2) 2-month	(3) 3-month	(4) 4-month	(5) 5-month	(6) 1-year
High-Educ.	-3.7050***	-5.1995***	-5.2075***	-5.1736***	-5.1946***	-5.1841***
	0.8317	*1.3180*	*1.3170*	*1.3176*	*1.3169*	*1.3394*
Low-Educ.	-1.1886***	1.0306	1.0452	1.0414	1.0480	1.0985
	0.3667	*1.5172*	*1.5192*	*1.5304*	*1.5262*	*1.4854*
Low-aware	-2.5563***	-0.9477	-0.9406	-0.9473	-0.9546	-0.9040
	0.7202	*1.2112*	*1.2048*	*1.1977*	*1.1843*	1.1483
High-aware	-1.5279***	-1.4315***	-1.4058***	-1.4069***	-1.4024***	-1.3963***
	0.3618	*0.3395*	*0.3434*	*0.3540*	*0.3503*	*0.3410*
Good-diet	-1.3914**	-1.0361*	-1.0342*	-1.0494*	-1.0407*	-1.0230**
	0.5503	*0.5673*	*0.5656*	*0.5756*	*0.5633*	*0.5151*
Bad-diet	-0.8520**	0.5410	0.5506	0.5388	0.5426	0.6236
	0.4037	*0.9606*	*0.9611*	*0.9594*	*0.9632*	*0.9537*

Tobit estimates coefficients of treatment effect of Equation (1). Full set of controls included. Clustered standard errors at month level in *italics*. ***, **, * indicate significance at 1%, 5% and 10%, respectively.

Table 7. DiD estimates of the effect of the warning on Group 2A meat expenditure: heterogeneous effects

	(1) 1-month	(2) 2-month	(3) 3-month	(4) 4-month	(5) 5-month	(6) 1-year
High-Educ.	-12.2431***	-5.9241	-5.9422	-5.8908	-5.9601	-5.9251
	1.1146	*4.1256*	*4.1062*	*4.1075*	*4.1185*	*4.1651*
Low-Educ.	-2.7227***	-1.5483	-1.5489	-1.5378	-1.5357	-1.4607
	0.6969	*1.0510*	*1.0473*	*1.0400*	*1.0455*	*1.0451*
Low-aware	-8.3624***	-4.6228**	-4.6192**	-4.5990**	-4.6091**	-4.6913**
	0.9784	*2.3086*	*2.3007*	*2.2982*	*2.3062*	*2.2354*
High-aware	-2.5382***	-2.6187***	-2.6215***	-2.6265***	-2.6054***	-2.5570***
	0.7871	*0.8044*	*0.8067*	*0.8115*	*0.8140*	*0.8415*
Good-diet	-1.6017	0.6780	0.6648	0.6563	0.6316	0.6853
	1.1092	*1.8795*	*1.8651*	*1.8698*	*1.8608*	*1.7949*
Bad-diet	-5.9908***	-3.3618*	-3.3700*	-3.3583*	-3.3625*	-3.4718*
	0.5411	*1.7375*	*1.7290*	*1.7271*	*1.7350*	*1.7818*

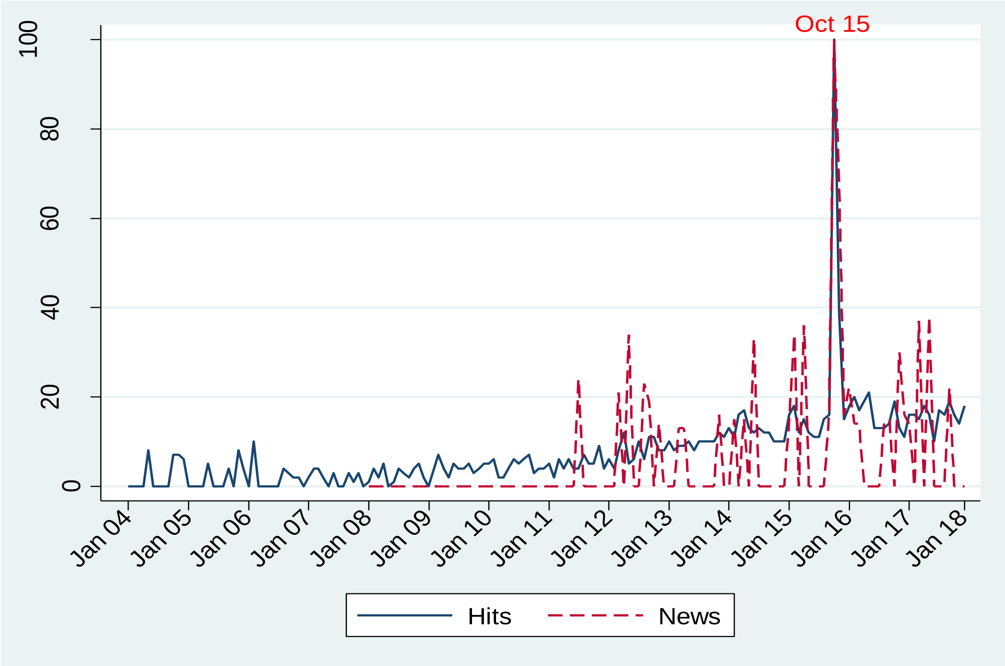
Tobit estimates coefficients of treatment effect of Equation (1). Full set of controls included. Clustered standard errors at month level in *italics*. ***, **, * indicate significance at 1%, 5% and 10%, respectively.

Figure 8. Robustness checks. Placebo tests for fake warning periods

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	Red meat				Group 1				Group 2A			
	1-month	2-month	5-mont	1-year	1-month	2-month	5-mont	1-year	1-month	2-month	5-mont	1-year
Treatment	-0.3019	-0.7645	-0.8443	-0.8649	0.4521	-0.4162	-0.4286	-0.4152	-0.7022	-0.4578	-0.5231	-0.5528
	0.5648	*0.6598*	*0.6609*	*0.6868*	*0.3649*	*0.7613*	*0.7467*	*0.7275*	*0.6500*	*0.6679*	*0.6564*	*0.6417*
Food Exp.	0.1770***	0.1779***	0.1777***	0.1764***	0.0587***	0.0594***	0.0596***	0.0602***	0.1350***	0.1351***	0.1343***	0.1319***
	0.0020	*0.0023*	*0.0022*	*0.0023*	*0.0009*	*0.0012*	*0.0010*	*0.0010*	*0.0019*	*0.0019*	*0.0017*	*0.0017*
H Size	2.7198***	2.6944***	2.7660***	2.8314***	2.0205***	1.9972***	2.0060***	2.0565***	1.4068***	1.4324***	1.5027***	1.5607***
	0.3341	*0.3219*	*0.3084*	*0.2848*	*0.1159*	*0.1192*	*0.1097*	*0.1256*	*0.4104*	*0.4003*	*0.3632*	*0.3152*
High Educ.	-4.5158***	-4.6507***	-5.2723***	-6.0535***	-0.8945**	-0.7710**	-0.9784***	-1.4455***	-4.6356***	-4.9817***	-5.5163***	-5.8945***
	0.7711	*0.7187*	*0.7104*	*0.7284*	*0.3478*	*0.3435*	*0.3534*	*0.3543*	*0.6985*	*0.6447*	*0.5434*	*0.5977*
HH Age 35-64	0.7193	1.0866	1.1110	1.4232**	0.2502	0.3749	0.2981	0.5507	1.2867	1.6009*	1.7596**	1.9381**
	0.8398	*0.9026*	*0.8015*	*0.6048*	*0.6723*	*0.7002*	*0.6317*	*0.4689*	*0.9532*	*0.9426*	*0.7620*	*0.8864*
HH Age>65	3.3598***	3.7333***	3.5972***	3.6722***	-1.4132**	-1.1953*	-1.3451**	-1.0846**	6.5660***	6.8102***	6.8166***	6.8360***
	0.8871	*0.9242*	*0.8496*	*0.6706*	*0.6320*	*0.7181*	*0.6835*	*0.5505*	*1.1620*	*1.1168*	*0.9591*	*0.9335*
HH Migrant	-12.8240***	-12.5878***	-12.8982***	-10.6922***	-12.2827***	-11.5587***	-11.7374***	-10.9874***	-5.2703***	-5.5784***	-5.5574***	-3.1873***
	1.6641	*1.5172*	*1.1197*	*1.1429*	*0.8945*	*1.0992*	*1.0465*	*0.8049*	*1.6855*	*1.5549*	*1.1575*	*1.0874*
N	36095	37421	41414	50351	36095	37421	41414	50351	36095	37421	41414	50351

Tobit estimates of Equation (1) for fake warning (October 2014). Full set of controls included. Clustered standard errors at month level in *italics*. ***, **, * indicate significance at 1%, 5% and 10%, respectively.

Figure 1. Google trends for "carne rossa" (red meat) in Italy, 2004-2018



Own elaboration on Google trends data. Google trends data for News are only available from 2008.

Figure 2. Kernel density estimate of monthly expenditure on red meat

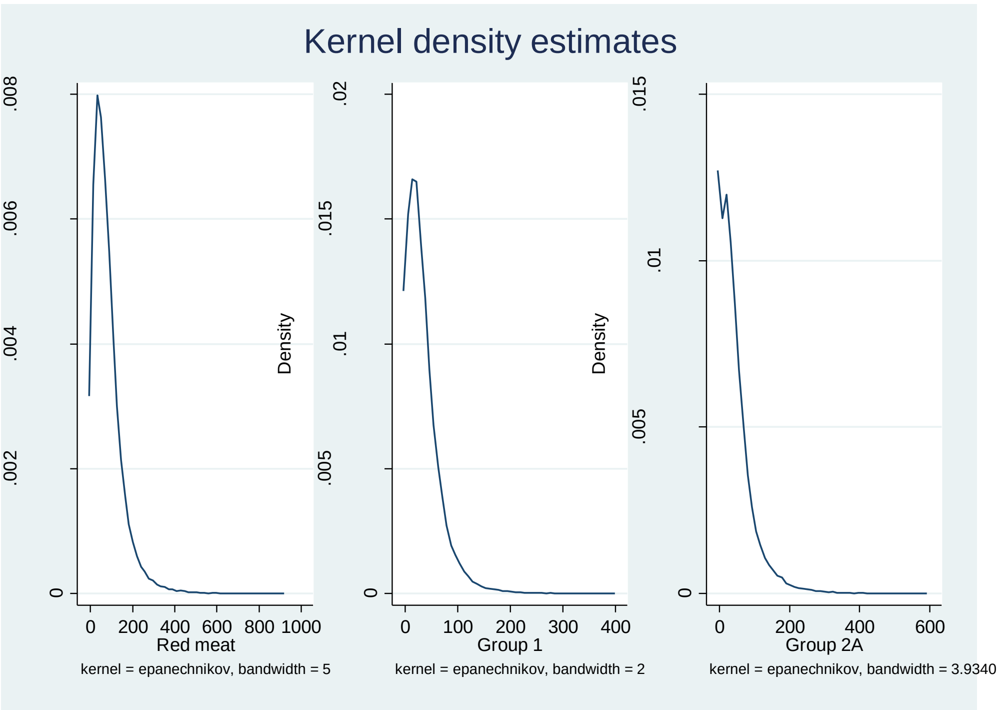


Figure 3. Share of red meat expenditure by month and quarter, 2013 and 2014

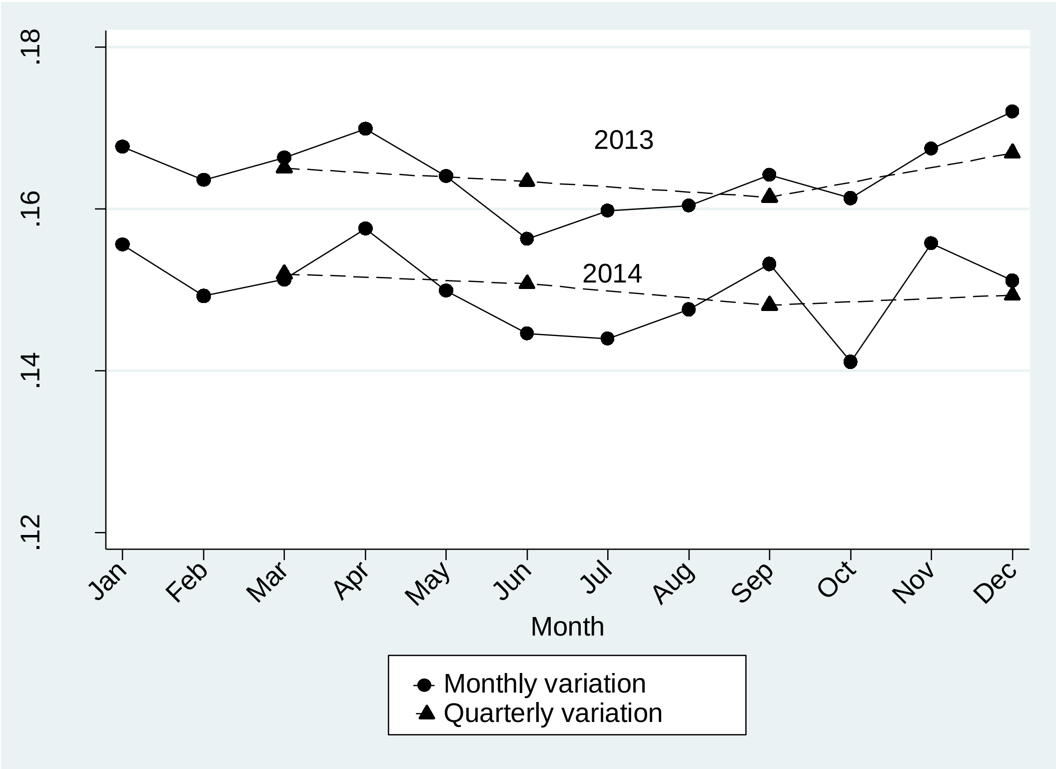


Figure 4. Common trends in red meat expenditure

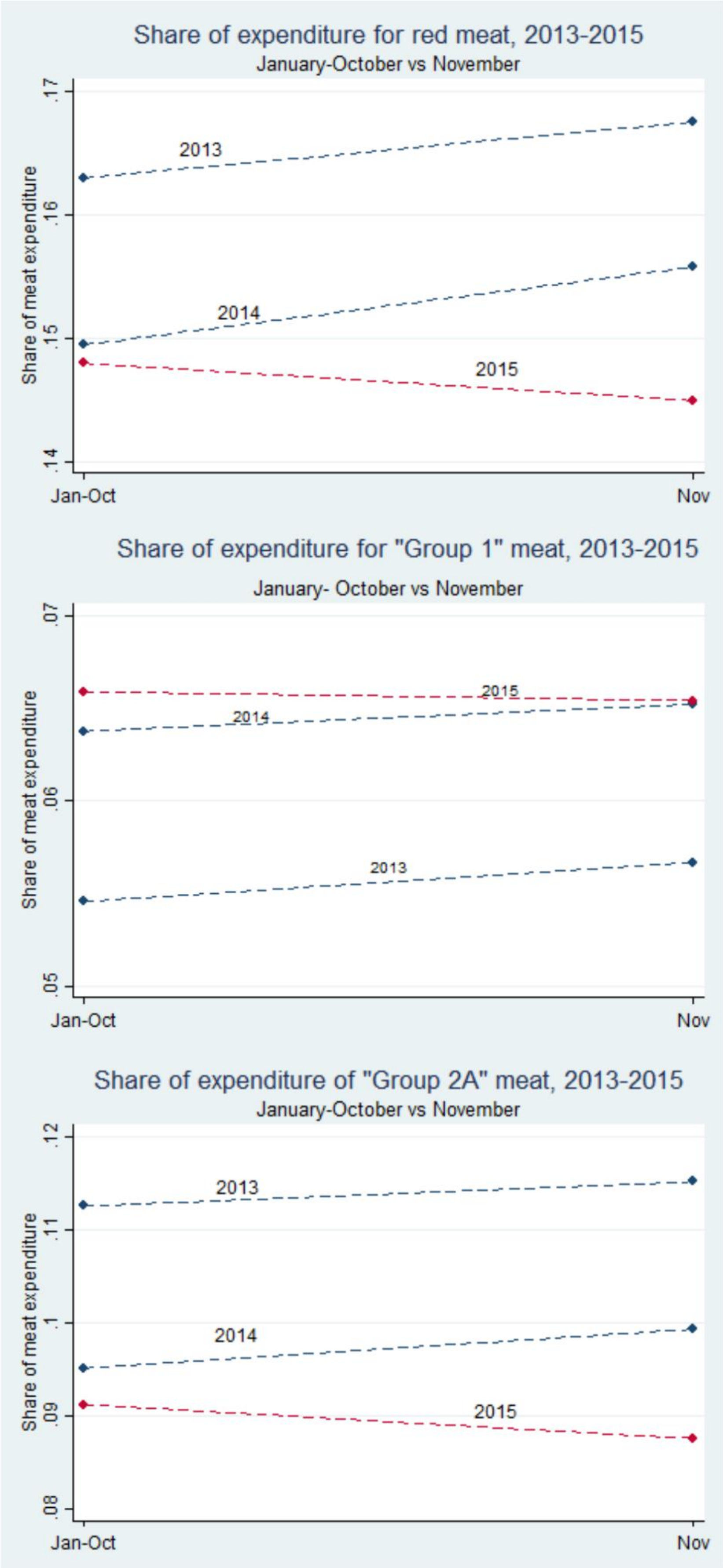
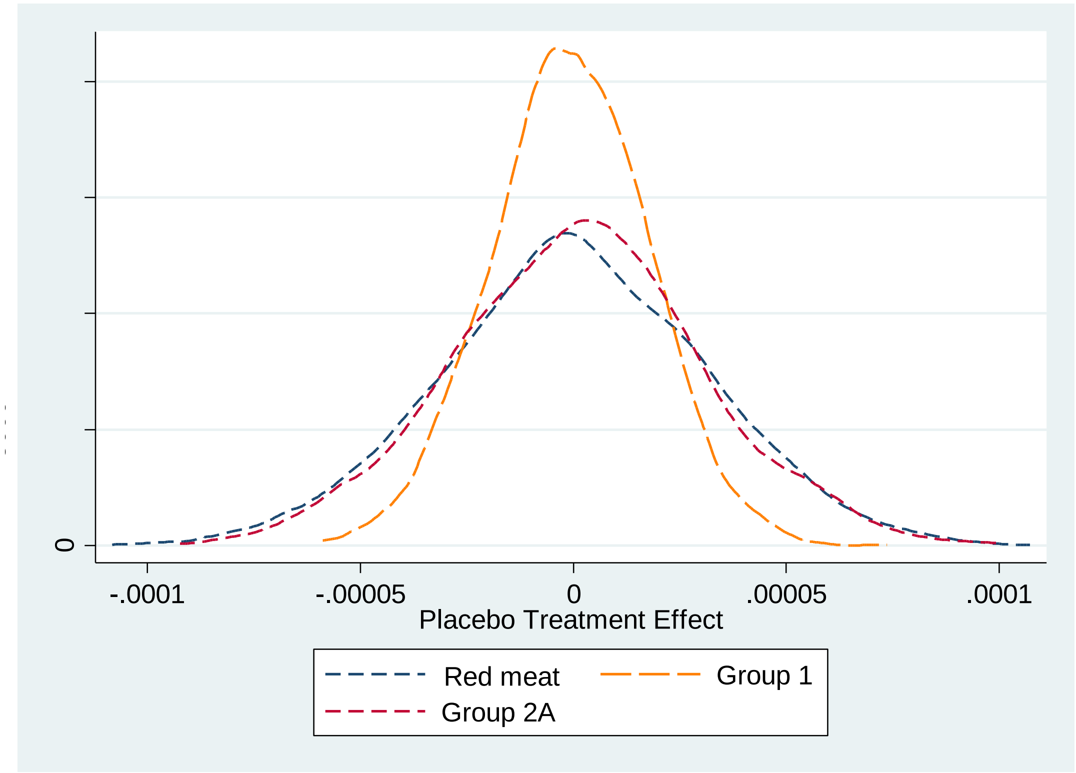


Figure 5. Kernel density estimates for placebo warnings



Appendix

Table A1. DiD estimates of the effect of the warning on meat expenditure: short-term effects (Bootstrapped standard errors)

	(1) Red	(2) Group 1	(3) Group 2A	(4) Red	(5) Group 1	(6) Group 2A
Treatment	-5.2422***	-1.5935***	-4.5289***	-5.2399***	-1.5936***	-4.4777***
	0.6248	*0.3268*	*0.5691*	*0.6294*	*0.3607*	*0.6222*
Food Exp.	0.1900***	0.0772***	0.1267***	0.1866***	0.0736***	0.1257***
	0.0029	*0.0009*	*0.0024*	*0.0026*	*0.0012*	*0.0023*
HH size				2.8256***	2.0995***	1.5702***
				0.2887	*0.1689*	*0.2838*
High Educ.				-11.5601***	-4.5525***	-8.7707***
				0.8155	*0.5869*	*0.6469*
HH Age 35-65				1.4057**	-0.0541	2.8215***
				0.6920	*0.5168*	*0.9627*
HH Age>65				2.8809***	-1.9694***	7.4073***
				0.9438	*0.7028*	*0.8413*
Migrant				-10.0946***	-9.6441***	-3.5916***
				1.0352	*0.7697*	*0.9000*
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
Region FE	Yes	Yes	Yes	Yes	Yes	Yes
Month FE	Yes	Yes	Yes	Yes	Yes	Yes
N	30852	30852	30852	30852	30852	30852

Tobit estimates coefficients of treatment effect of Equation (1). Full set of controls included. Bootstrapped standard errors clustered at month level based on 200 replications in *italics*. ***, **, * indicate significance at 1%, 5% and 10%, respectively.