Title: Exploring influencing factors on meat consumption decisions through probit analysis: The case of fresh meat demand in Belgium

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Exploring influencing factors on meat consumption decisions through probit analysis:

The case of fresh meat demand in Belgium

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Introduction

During the last two decades, Belgium's per capita fresh meat consumption decreased similar as seen in many European and other countries. Changes in consumer taste and preference patterns were often cited as the principal causes (Moschini and Meilke, 1989; Reynolds and Goddard, 1991; Rickertsen, 1996; Piggott et al., 1996). While changing taste and preference patterns may be responsible for long-term shifts, shorter-term consumption decreases in European countries are believed to be specifically linked to media coverage of meat-health issues and communication problems which led to image decline for the meat industry (von Alvensleben, 1995; Burton and Young, 1996; Hoff and Claes, 1997; Verbeke and Viaene, 1998).

Analysis of meat issue television coverage in Belgium during 1995-1997 reveals that more than 90% of the broadcast meat messages contained negative associations between fresh meat safety and human health. The negative associations dealt mainly with growth hormone abuse, residues and the incidence of BSE (*Bovine Spongiform Encephalopathy*) in the case of beef production, as well as with residues of preventive antibiotic's use and outbreaks of *Classical Swine Fever* in the case of pig production. While reports related to hormone abuse and residuals have been in the news at regular intervals during all the last decade in Belgium, the BSE-crisis supplemented additional grounds for negative coverage and is believed to constitute a landmark as related to the decline in overall meat, and more specifically image problems in the beef industry.

The purpose of this paper is to focus empirically on the potential impact from mass media coverage and demographic consumer characteristics on decision-making toward fresh meat. Television is chosen as the mass medium to be investigated, while the potential impact is based on consumer decisions to cut meat consumption. A cross-sectional consumer survey is used as the basis for measuring consumption behavior. Probit models are specified to measure the nature of change in meat consumption and specifically show the extent that media influence the probability of reducing meat consumption. In the following sections, a discrete choice model is specified, estimated and used to predict probabilities of change in consumer behavior over a range of demographics and media attention levels.

Discrete choice in meat consumption

Past meat consumption habits and potential future consumption were measured by asking a sample of consumers to individually indicate whether their meat consumption had decreased since the BSE-crises (March 1996) and whether they expected to change the level in the future (the year following the survey executed in April 1998). Responses were limited to a discrete choice (yes or no), hence the adoption of limited dependent variable models is appropriate to the current problem (Amemiya, 1985; Greene, 1997). To deal with past and future fresh meat consumption decisions, two independent probit models are estimated. First, let the latent response variable y_{1i}* denote the propensity to have cut fresh meat consumption as compared to the BSE-crisis period. Second, consumer intention to cut fresh meat consumption in the future is similarly denoted as y_{2i}*. Hence, the discrete choice is defined as:

$y_{ji} = \begin{cases} 1 \text{ if } y_{ji}^* > 0, \\ 0 \text{ otherwise.} \end{cases}$, with j=1 or 2, or as follows for each of the considered probit models:

$$y_{1i} = \begin{cases} 1 & \text{if fresh meat consumption has decreased since the BSE-crisis,} \\ 0 & \text{if fresh meat consumption has not decreased since the BSE-crisis.} \end{cases} \text{, and}$$

$$y_{2i} = \begin{cases} 1 & \text{if fresh meat consumption is intended to be decreased in the future,} \\ 0 & \text{if fresh meat consumption is not intended to be decreased in the future.} \end{cases}$$

Implicit in the probit model is the assumption that the cumulative distribution function for the error term follows the cumulative normal distribution, denoted as $\Phi_j(\bullet)$ with j=1 or 2, which implies that the probability of the investigated events occurring can be defined as:

$\text{prob}(y_{ji} = 1) = \Phi_j(y_{ji}*)$ and $\text{prob}(y_{ji} = 0) = 1 - \Phi_j(y_{ji}*)$.

For convenience of interpretation, the dependent variables are denoted as $DBSE_i \equiv y_{1i}$ for model 1 and as $DFUT_i \equiv y_{2i}$ for model 2, respectively. Independent variables reflect demographic consumer characteristics, fresh meat consumption frequency and attention to television coverage of meat issues. Three demographic variables are included: age (continuous variable, AGE_i) and education (binary, EDU_i, equals 1 for high school or higher education and 0 otherwise) of the respondent, and whether the respondent has children under 12 years of age (binary, $K12_i$, equals 1 in case of young children and 0 otherwise). A fresh meat consumption frequency classification is adopted where $CF1_i$=1 for "daily consumption", $CF2_i$=1 for "several-times-a-week", and $CF3_i$=1 for "once-a-week-or-less", with $CF1_i$ dropped from the model. Dealing with cross-sectional consumer data, the potential impact of television coverage is captured by the attention that consumers claim to have given to television messages about meat issues. A classification with three levels is adopted: $TV1_i$=1 for "low" attention, $TV2_i$=1 for "moderate" attention, and $TV3_i$=1 for "high" attention, with $TV1_i$ dropped from the model. Furthermore, the effects of media may depend on the person receiving the message. One way to differentiate individuals is by age, where one expects the effects of television coverage to be larger with the younger population. The potential interaction between age and attention to television coverage is included in the probit models through the terms *(AGE_i)($TV2_i$)* and *(AGE_i)($TV3_i$)*. With this choice of variables being specified, the complete empirical specification of the probit models follows after including specific variables in the initial equation:

$$\begin{aligned} y_{ji}* = \beta_{j0} + \beta_{j1}AGE_i + \beta_{j2}EDU_i + \beta_{j3}K12_i + \beta_{j4}CF2_i + \beta_{j5}CF3_i \\ + \beta_{j6}TV2_i + \beta_{j7}TV3_i + \beta_{j8}(AGE_i)(TV2_i) + \beta_{j9}(AGE_i)(TV3_i) \end{aligned},$$

then: $\text{prob}(DBSE_i = 1) = \Phi_1(y_{1i}*)$; $\text{prob}(DBSE_i = 0) = 1 - \Phi_1(y_{1i}*)$,

and: $\text{prob}(DFUT_i = 1) = \Phi_2(y_{2i}*)$; $\text{prob}(DFUT_i = 0) = 1 - \Phi_2(y_{2i}*)$.

Data were collected through a questionnaire-based survey with at-home interviews of 320 individuals. Sampling was based on a quota sample method with respondent age and gender as quota control variables. The sample was representative to the Belgian population in terms of household size, location and education level. After excluding cases with missing values, a total of 291 observations were useable for estimation.

Probit estimation

Before estimating the probit models, the independent variables were tested for detecting multicollinearity in the sample. No substantial degree of covariation between any pair of the selected independent variables was found. Table 1 presents the results of the probit analysis for the $DBSE_i$ model. Except for EDU_i and $CF3_i$, all of the individual parameter estimates are significant at the 95% or higher level and for a one-tail test these are also statistically significant. The resulting signs of the estimates corroborate with previous findings and expectations. Even for the two marginally significant variables the signs of the estimates are as expected. The positive sign of the highly significant parameter AGE_i clearly points to an increase in decision-making to cut fresh meat consumption as age increases. Similarly, fresh meat consumption was cut more among those households with younger children. The probability that fresh meat consumption was cut compared to the BSE-crisis period was significantly larger for consumers who consume fresh meat on a "several-times-a-week" or "once-a-week-or-less" basis. That is, the less frequent users are more likely to reduce their meat consumption versus the daily meat consumers. Estimates for the parameters quantifying potential television impact are positive, with a higher estimate and larger t-value for $TV3_i$ as compared to $TV2_i$. This finding confirms the hypothesis that consumers who paid high levels of attention to television coverage related to fresh meat are more likely to have decreased fresh meat consumption since the BSE-crisis than consumers who claim lower attention levels. The estimates of the interaction terms between age and television are negative and significant, thus confirming the expectation that media impact differs across age groups. The marginal impact of television decreases with increases in the consumer's age, e.g. $(\Delta y^* \mid TV2=1) = 2.394 - 0.044AGE$.

Table 1. Probit analysis results model j=1: dependent variable $DBSE_i$.

Parameter	Estimate	Standard error	t-statistic	p-value
Constant	-4.6107	0.8349	-5.5221	0.000
AGE_i	0.0588	0.0158	3.7215	0.000
EDU_i	0.2991	0.1981	1.5099	0.131
$K12_i$	0.5474	0.2158	2.5362	0.011
$CF2_i$	0.8073	0.1916	4.2126	0.000
$CF3_i$	0.6772	0.3925	1.7254	0.084
$TV2_i$	2.3937	0.9613	2.4900	0.013
$TV3_i$	3.5492	0.8891	3.9919	0.000
$(AGE_i)(TV2_i)$	-0.0440	0.0207	-2.1227	0.034
$(AGE_i)(TV3_i)$	-0.0529	0.0188	-2.8181	0.005

Restricted log likelihood value, ln L_{10} = -174.28
Maximum unrestricted log likelihood value, ln L_1 = -129.56
Log likelihood $\chi^2_{(df=9)}$ = 73.01(p<0.001)
R^2 (McFadden, 1973) = 0.256; R^2 (Estrella, 1998) = 0.247; % of correct predictions = 77.0

Note: estimates are unstandardized coefficients.

Results for the $DFUT_i$ probit analysis are reported in Table 2. Current consumption frequency significantly impacts the intention to cut fresh meat consumption in the near future with the effects of $CF2_i$ and $CF3_i$ being significant at the 95% or higher level. This estimates show that daily consumers are less inclined to reduce their consumption level, whereas the less frequent consumers show a greater propensity to reduce their fresh meat consumption. The estimate for $TV3_i$ is significant and positive while that for $TV2_i$ is not. A meat consumer who paid high attention to television messages is more likely to decrease consumption in the near future than consumers who paid low or moderate attention to the media. Contrary to the model with reference to consumption decrease since the BSE-crisis, the estimates of the interaction terms $(AGE_i)(TV2_i)$ and $(AGE_i)(TV3_i)$ are not significant with reference to the future. Furthermore, none of the included demographic variables appears to significantly affect intentions to cut fresh meat consumption in the near future.

Table 2. Probit analysis results model j=2: dependent variable $DFUT_i$.

Parameter	Estimate	Standard error	t-statistic	p-value
Constant	-1.7578	0.5108	-3.4414	0.001
AGE_i	0.0155	0.0104	1.4877	0.137
EDU_i	0.1000	0.1767	0.5663	0.571
$K12_i$	-0.0382	0.1922	-0.1989	0.842
$CF2_i$	0.3680	0.1667	2.2075	0.027
$CF3_i$	0.8508	0.3218	2.6437	0.008
$TV2_i$	0.4457	0.6844	0.6512	0.515
$TV3_i$	1.5651	0.6342	2.4677	0.014
$(AGE_i)(TV2_i)$	-0.0045	0.0157	-0.2891	0.772
$(AGE_i)(TV3_i)$	-0.0183	0.0145	-1.2590	0.208

Restricted log likelihood value, ln L_{20} = -180.79
Maximum unrestricted log likelihood value, ln L_2 = -165.93
Log likelihood $\chi^2_{(df=9)}$ = 29.72(p<0.001)
R^2 (McFadden, 1973) = 0.082; R^2 (Estrella, 1998) = 0.101; % of correct predictions = 72.2

Note: estimates are unstandardized coefficients.

Simulation of probabilities

The most important benefit of probit models is the ability to establish the probability of various events occurring under a given set of conditions or range of explanatory variables. Figure 1 displays the probabilities across age for both $DBSE_i$=1 and $DFUT_i$=1 under the assumptions of low education (EDU_i=0), absence of children aged less than 12 ($K12_i$=0), daily fresh meat consumption frequency ($CF2_i$=0 and $CF3_i$=0), and low attention to television ($TV2_i$=0 and $TV3_i$=0). Given the signs of the estimates shown in Table 1 and Table 2, these "base" values lead to the lowest predicted probabilities.

With age on the bottom axis, Figure 1 illustrates the impact of aging on fresh meat consumption decisions. Clearly, the response since the BSE-crisis is profoundly related to age differences. At the selected base values, the probability of having cut fresh meat consumption since the BSE-crisis ranges from nearly zero for a 20-year old person to about 23% for a 66 year old person. For consumers under 40 years of age, the predicted probability of cutting their meat consumption since the BSE-crisis is fairly low, being less than 1%. Beyond the age of 40 however, this likelihood increases exponentially.

Intention to decrease fresh meat consumption in the near future displays a positive pattern over the same age range. A major difference pertains to the lower extreme for $DFUT_i$=1, where the minimum probability that a person will cut fresh meat consumption in the near future is at least 7%. Across the entire sample there is a clear intention to reduce the intake of fresh meat in the future. For each additional two years of age below the age of 40, the probability of cutting fresh meat consumption increases with about 0.4 percentage points, holding all other variables at their selected values. Beyond the age of 40, this probability increases with about 0.8 percentage points for each additional two years of age. Note however that the age-variable in the DFUT-model is not as significant as seen for the change from the BSE-period. Also, for the older population, the probabilities related to past actions and intended future behavior are nearly equal. Whereas, among the younger population, indicated future behavior is not consistent with past changes. Younger consumers indicate they plan to change their meat intake in the future, but historically from the BSE-period they showed less willingness to cut their meat consumption.

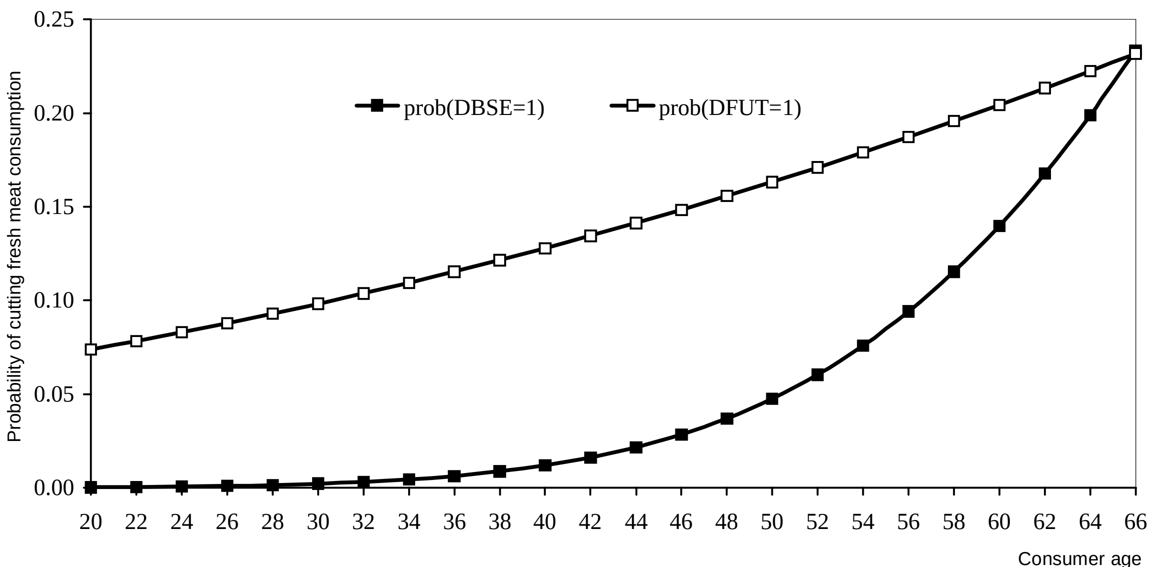

Figure 1.
Probability of cutting fresh meat consumption across age, given base assumptions on other variables

The combined impact of education, children, consumption frequency and attention to television is analyzed at the mean of age (40.7 years). Changes in probabilities from the "base" likelihood (0.013 for $DBSE_i=1$ and 0.13 for $DFUT_i=1$) are displayed in Figure 2 and Figure 3. The bars indicate changes in the probability of cutting meat consumption per unit change in each explanatory variable while holding the other variables at their "base" values. The relative magnitudes are important since they provide a clear picture of what drives the probabilities.

High versus low education doubles the probability while the presence of young children more than triples the probability of cutting fresh meat consumption. For households consuming fresh meat “several-times-a-week” or “once-a-week-or-less”, the probability of having cut their consumption since the BSE-crisis increased by seven and five percentage points respectively. Moderate attention levels to television coverage increase the prob($DBSE_i$=1) to around five percent with all other variables set to the “base”. With a high level of attention to television coverage, the probability of having cut fresh meat consumption since the BSE-crisis rises to near 21%, which illustrates the profound effect of attention to television coverage. Setting binary independent variables with a positive estimate to their maximum and the dummies with the largest estimates to one, upper probabilities of cutting meat consumption of 0.77, 0.80 and 0.83 are obtained for the ages 23 (5th percentile), 40.7 (mean), and 60 (95th percentile), respectively.

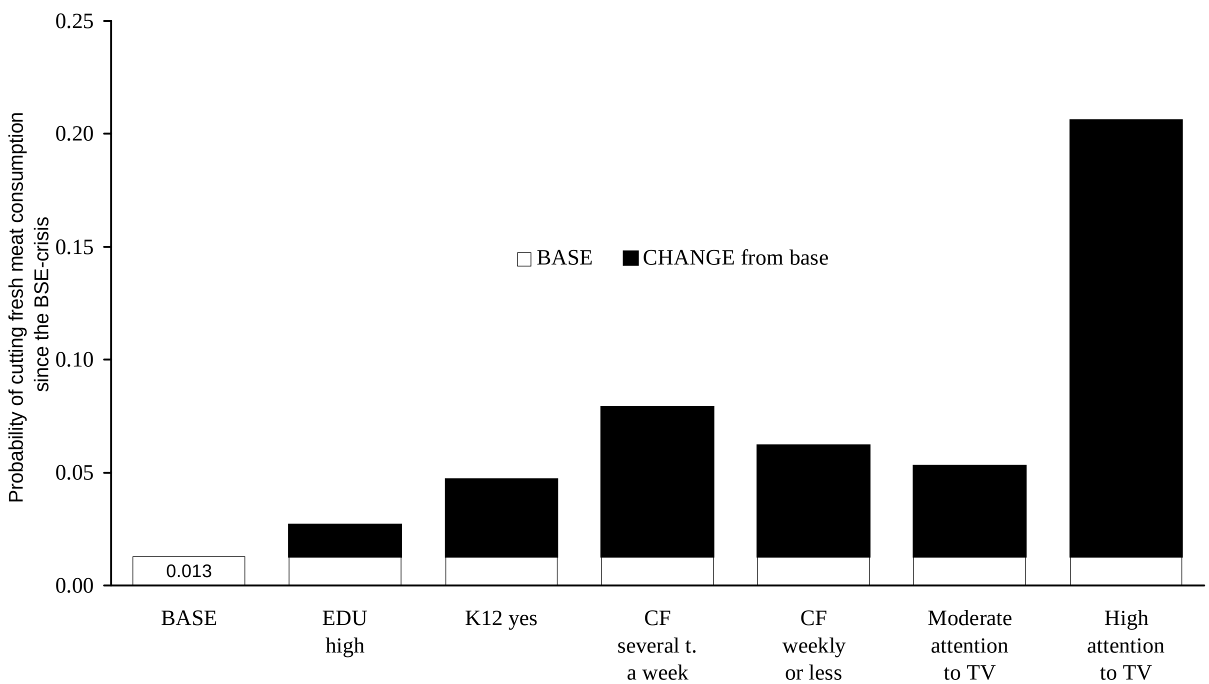

Figure 2.
Impact of education (EDU), presence of young children (K12), consumption frequency (CF), and attention to television (TV) on the probability of cutting fresh meat consumption since the BSE-crisis

A similar analysis of the impact of demographics, consumption frequency and television on prob($DFUT_i$=1) is presented in Figure 3. High versus low education and presence versus absence of younger children have a negligible influence on the intention to cut fresh meat consumption in the near future, which was already reflected by the highly insignificant estimates in Table 2. A shift from "daily" to "several-times-a-week" consumption frequency and from "low" to "moderate" TV attention levels increases the prob($DFUT_i$=1) from 13% to 22% and 19%, respectively. Shifts from the "base" likelihood values toward "once-a-week-or-less" consumption frequency and "high" attention to television coverage cause the prob($DFUT_i$=1) to rise to around 40% holding all other variables at their "base" values. Upper extreme probabilities of cutting fresh meat consumption in the near future equal 76%, 74% and 72% for the 5th percentile age, mean age and 95th percentile age, respectively.

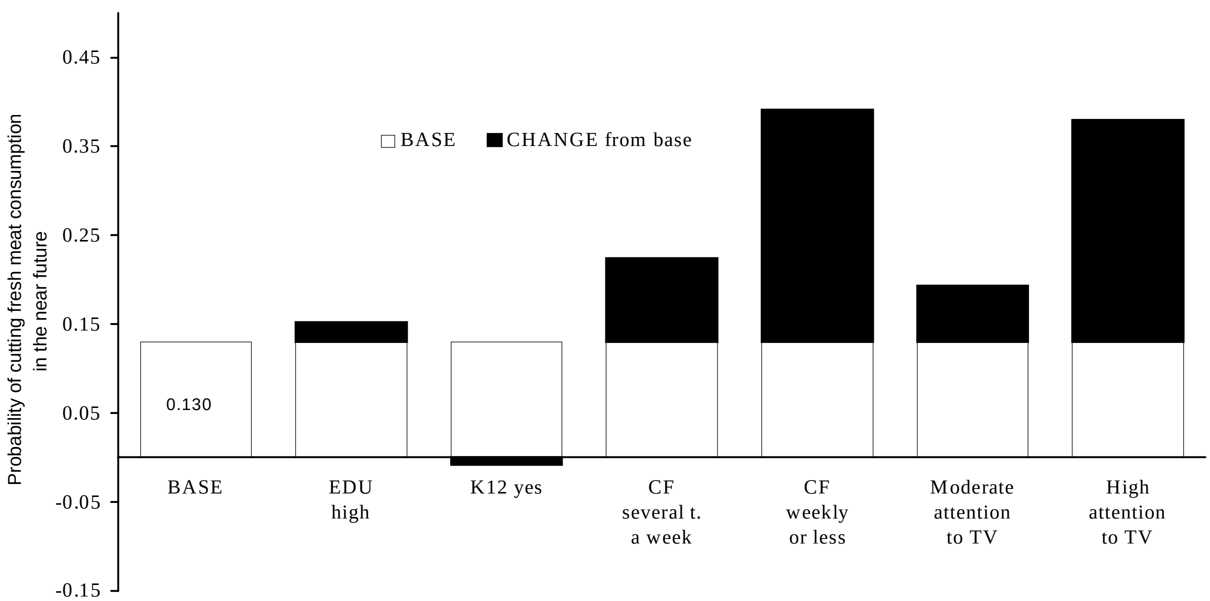

Figure 3.
Impact of education (EDU), presence of young children (K12), consumption frequency (CF), and attention to television coverage (TV) on the probability of cutting fresh meat consumption in the near future

Interaction "age" and "attention to television"

The interactions for both television intensities and age were shown to be significant with respect to consumption decreases since the BSE-crisis (Table 1), but insignificant with respect to the future (Table 2). The meaning of the interaction term with respect to DBSE has a clear interpretation. In Figure 4, the predicted probabilities for $DBSE_i$=1 are graphed against age with each level of claimed attention to television represented by a curve, and by holding EDU_i=1 (higher education), $K12_i$=0 (no children aged less than 12), and $CF2_i$=1, $CF3_i$=0 (consumption frequency "several-times-a-week").

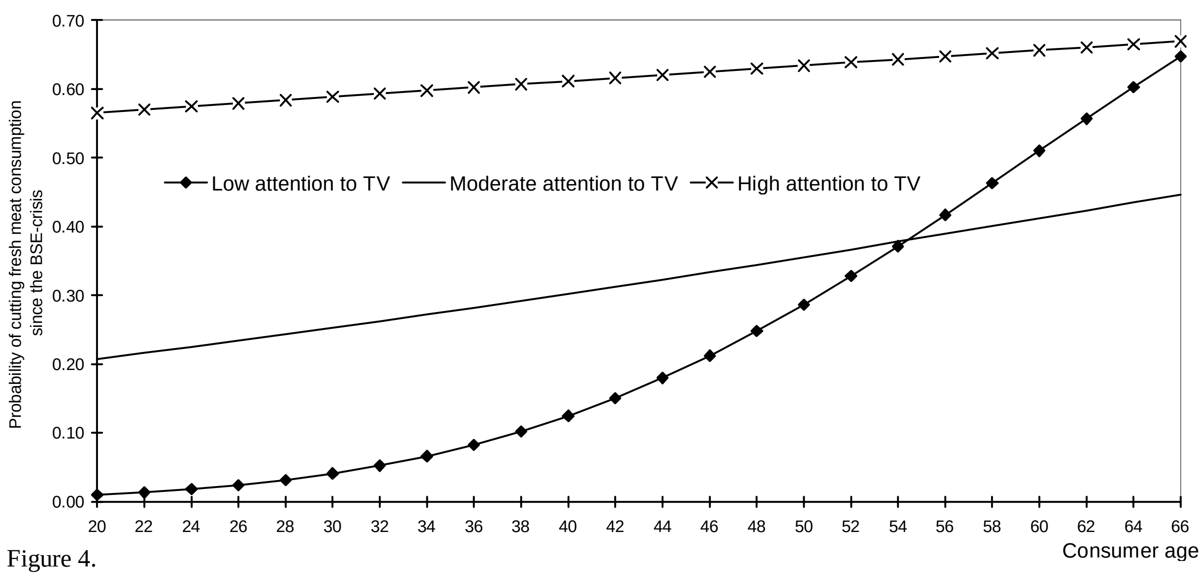

Figure 4.
Probability of cutting fresh meat consumption since the BSE-crisis; across age, given the level of attention to TV

Age has an overall positive effect on the probability to have cut fresh meat consumption since the BSE-crisis. As one ages, the probability of reducing meat consumption increases without any media effect. However, when consumers claim to have paid considerable attention to television coverage of meat issues, their probabilities of reducing meat consumption get pushed up near a maximum adjustment level. That is, for this group of demographics excepting age, the upper level of change in the probability of reducing meat intake is around 65%. When paying a high level of attention to television coverage, consumers reach this probability very quickly at a much younger age. A much closer similarity in the consumption behavior across ages is a direct result of the level of attention given to the television messages. Likewise, differences in the age responses are very pronounced when the television message is minimally attended to.

Conclusions and implications

This paper examined factors of influence on consumer decision making toward fresh meat consumption in Belgium through estimating discrete choice models with cross-sectional data input. Significant demographic variables include the presence of young children in the household and the age of the consumer. The presence of young children in the household increases the probability of reducing fresh meat consumption. Aging is also found to limit favorable decision making related to meat consumption. Mass media, and more specifically in this research television coverage, is found to have a highly negative impact on consumer decision making toward fresh meat both from the past and in the future. Probabilities to cut consumption were boosted as consumers reported to have paid considerable attention to the media coverage during periods preceding the survey. A new element consists of the investigated interaction between television attention and consumer age. Looking to the future, it is reasonable to expect a further decrease of the consumption of red meats in Belgium from April 1998. Taking away the grounds for negative press emerges more than ever before as the key attention point for the future of the meat industry. Finally, given that reactions to negative press differ across age, future communication strategies appear having to be clearly targeted in order to be successful.

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