Behavior Towards Health Risks:

An Empirical Study Using the "Mad Cow" Crisis as an Experiment

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April 2000
Revised September 2001

*I am grateful to SECODIP, the Observatoire des Consommations Alimentaires, to Christine Boizot for research assistance, to Gary Becker, Russell Cooper, Angus Deaton, Valérie Lechene, Costas Meghir, Jean-Marc Robin, Kip Viscusi and to seminar participants at Boston University, ESEM 98, Harvard University, INRA, INSEE, LSE, University of Bristol, University of Chicago, University College London and University of Toulouse for comments and suggestions. The usual disclaimer applies

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Abstract

This paper investigates the non-monotonic effect of past consumption of risky goods on current consumption behavior. The paper exploits the "Mad Cow" crisis as a natural experiment which exogenously shifts the perceived health effect of past consumption. The paper uses a data set which follows up the consumption of households before and after the crisis. The data set and the sudden crisis allow us to disentangle the effect of past exposure to risk on further risk taking behavior, from non separable preferences over time or prior selection. The paper has two main findings. First, it shows that new health information interacts in a non monotonic way with prior exposure to risks, both in the quantity and the quality dimension. Only consumers with intermediate levels of past consumption decreased their demand and sought higher quality products. Second, as food is usually shared within the household, the decision towards a safer consumption depends on the bargaining power of each of its members. The paper shows that teen-agers are able to influence their parents into risky behavior.

JEL classification: D1, D8, C3.
Keywords: Intertemporal Choice, Health risks, Intra-household Decision.

1 Introduction

In this paper, we use a "natural" experiment to study the non-monotonic relationship between risk taking behavior and past consumption of risky goods. The study is done at the household level, but by contrasting the behavior of households with different composition, we identify the role of different members on the collective behavior towards risk.

The literature on habit persistence (Pollak (1970)) and on rational addiction (Becker and Murphy (1988)) have emphasized the role of non separability in preferences such as the effect of addiction in the case of tobacco consumption. Yet, past exposure can have an effect independent of this channel. For instance, individuals may cut down on smoking because of concerns for their future health. They may estimate that their stock, or cumulative exposure, has grown to a level that puts them to excessive risk later on. A number of papers, following Grossman (1972), model the effect of past consumption through a health stock which affects future utility or mortality. Others have modelled a direct effect of the consumption good on the discount rate such as in Orphanides and Zervos (1995). Becker and Mulligan (1997) also consider a model where the discount rate is endogenous and review a number of facts which are consistent with such a model.

Distinguishing between the effect of non separability of preferences from other sources of dynamics is empirically a very difficult matter, albeit an important one as they have different policy implications. On commonly used panel data, which describe for instance smoking through time, one cannot identify separately the effect of past behavior on utility (such as addiction) and the effect of accumulated risk on concerns about future health, unless one relies on functional form restrictions. As a consequence, the empirical literature has mainly focused on non separability in preferences (see Becker et al. (1994), Chaloupka (1991) or the references in Chaloupka and Warner (2000)).

A second identification problem arises from possible selection into risky behavior. One can argue that individuals who engage in smoking, drinking or chose a risky job usually understand that there is an element of risk. Evaluating the effect of past behavior on current ones will be biased by their possible self-selection into this behavior. This point is also important when it comes to evaluate the impact of other members of the household on risk taking behavior. It is very difficult to distinguish the effect of selection based on

unobservables from a sheer influence of other members. [1]

To identify the exact effect of past behavior and the influence of other members of the household, there is a need for an exogenous and unexpected change in how individuals perceive the effect of past consumption on risk. To be ideal, this experiment should also have two other characteristics. In order to rule out self-selection, the risk should not be known beforehand. Finally, the experiment should involve a large and representative part of the population, so that results can be extrapolated.

This paper uses the French "Mad Cow" crisis as a natural experiment which has all the desirable characteristics. In March 1996, the consumers were informed of a link between Bovine Spongiform Encephalopathy (BSE) and the new variant Creutzfeldt-Jacob disease (nvCJD). This health scare is arguably an exogenous and an unexpected shock to the consumers. The suddenness of the new information is important to rule out self-selection. Before March 1996, nvCJD was totally unknown in the wider public and BSE was still a specific bovine disease, not unlike scrapie, which had affected sheep for more than a century without effects on humans. France is an interesting country to study because 99% of households had eaten beef at least once in the year preceding the crisis. This is because beef is traditionally a central ingredient of French meals. Prior to the crisis, consumers saw beef as a safe and as an important part of their diet. One of the main sources of difference in beef consumption was cultural differences between regions rather than income or occupation. Hence, this is a rare case where one can study the risk taking behavior of a large and representative group of the population.

A second feature of the BSE/nvCJD crisis is that the disease takes several years to incubate and that there is no way to test for it. At the time of the crisis there was a huge uncertainty about the exact contamination mechanism. For the consumers, the only evaluation of the probability of infection was the amount of beef eaten in the past. If consumption prior to the crisis is observed, the econometrician has as much information as the consumer on the exposure to the risk. We have in this case a clear idiosyncratic measure of differences in how much at risk the agents were.

A third feature is that, in France, meals are taken together with the family. Because of tradition and time constraints, only one type of meat would usually be prepared. Thus,

[1] Sacerdote (2001) uses a random assignment scheme to test for peer effects.

the decision regarding further consumption of beef involves all members of the family. The behavior towards risk depends on the different objectives of the household members. By contrasting the behavior of household with different compositions, we are able to document the role of different household members in the joint decision about safer consumption.

The paper uses a unique panel data set which follows up households before and after the crisis. Controlling for non separability in preferences and selection into other risky types of behavior, we show that prior exposure to risk had a non-monotonic effect on behavior, both in the quantity and the quality dimension. Households who had eaten either small or large amount of beef prior to the crisis did reduce their beef consumption significantly less. Others did both decrease their consumption and seek higher quality goods. Consumers reacted mainly on the intensive margin and not on the extensive one, which is surprising given that other types of meat are a close substitute to beef. One possible explanation for these facts is directly linked with the exposure to the risk itself. If contamination only takes place when the individual has been repeatedly exposed to infected beef, consumers with small exposure to the risk might not change their behavior because the marginal gain is low. On the other hand, consumers with large exposure would realize that the risk is already taken, and hence would not change their behavior. Given the "experiment" and the detailed information in the data set, we are able to test and rule out a number of alternative explanations such as time non separability, selection or unobserved heterogeneity.

The paper provides empirical support for several theoretical papers that postulate such behavior. Kremer (1996) or Geoffard and Philipson (1996) model the effect of the prevalence of a disease (such as AIDS) on the behavior of an agent and assume that the population that is the most exposed to the disease has a fatalistic behavior. Our results also provide support for models where agents trade off current utility against an increased mortality risk. Models with endogenous mortality have been studied by Grossman (1972), Cropper (1977), Ehrlich and Chuma (1990) or Ehrlich (2000). There is however very little direct evidence of such behavior. [2] This is because these models are only identified through an exogenous and unexpected change in the weight on future utility. The episode studied in this paper is probably the most relevant to investigate this issue.

Finally, we are able to document how individual behavior differed from household behav-

[2]Becker and Mulligan (1997) survey a number of empirical facts that are consistent with a model where an agent endogenously chose the weight on future utility.

ior. If individuals have different views on how to respond to the crisis, they had to come up with some kind of agreement on the optimal quantity to consume within a household. We show that families with teenagers, and especially with boys responded less to the crisis. The most likely explanation is that these children did not care about the crisis, and influenced their parents into buying a potentially unsafe product. We are able to test and reject alternative hypothesis such as selection or heterogeneity in tastes. To our knowledge, this is the first paper to document the bargaining power of teenagers within a family and to document how a group of individuals decide collectively on the attitude towards health risks. This is probably due to lack of data. Yet, it is likely that household members have an influence on each other, for instance when considering driving, drinking or smoking. Understanding these interactions are important in order to design efficient public policies.

Section 2 presents the data set and analyzes the heterogeneity in the response to the crisis. Section 3 investigates the determinant of the decrease in beef consumption and tests different explanations of the effect of the stock of beef consumed prior to the crisis. Section 4 investigates the role of the composition of the household on behavior towards risk. Section 5 concludes and proposes further avenues of research.

2 Data and Descriptive Statistics

This section provides a description of the data set and some summary statistics.

2.1 The Data Set and Aggregate Consequences of the Crisis

The panel data set has been collected by SECODIP, a French firm which gathered data for marketing purposes, and recorded all expenditures for a sample of 2798 French households, week by week, between January 1, 1995 and June 24, 1996 (76 weeks). [3]

Each week, the household reported each item bought with a detailed description of the product, the quantity and the expenditure. The items under consideration are all purchases on meat, fish, eggs and dairy products. The information about the product is quite detailed, describing the particular cut of meat or the type of fish.

[3]The consumers learn about the crisis on March 20, 1996, so their reaction to the news are observed during 13 weeks. This is enough to study their immediate reaction but not longer term behavior.

In addition, in 1995 only, the data recorded all purchases of alcohol on a weekly basis. The data set also reports details on the composition of the family, the age of all the members, their occupation and education level, the household income, the region of residence and the size of the city. The data set also reports anthropometrical measures for all the household members such as height and waist circumference. All these household characteristics are reported at the start of the period, so we observe no variation during these 76 weeks.

Table 1 presents summary statistics. On average, the consumption of beef fell sharply as households learned about the crisis. This can be seen as well in Figure 1 which presents the aggregate per capita quantity of beef consumed each week. There is a clear structural break when the consumers learn about the news. The Figure also reports in dotted lines the standard deviation, calculated from the 1995 expenditures. This indicates that the week to week movements before the crisis or after the announcement are not specific to the year 1996, but is normal variability due to end-of-month effects or the effect of changes in weather, for instance. A more formal test of the significance of the crisis can be done by running a simple regression of budget shares or quantities for beef on a dummy equal to one during the crisis, controlling for total expenditure, prices and seasonal effects. The results are displayed in Table 2, which also reports the same regression for total expenditure on animal protein. [4] The data has been aggregated up at a quarterly frequency, in order to avoid zero expenditures due to infrequent purchases. This leaves six periods, the crisis starting at the beginning of the last quarter.

From Table 2, the households responded to the crisis by reducing their expenditures on beef significantly. However, the households did not significantly change their total expenditure on animal protein, which is slightly higher during the last period. This means that they substituted within the groups under consideration.

2.2 Heterogeneity in Consumption Changes

These statistics give only an aggregate view of the behavior during the crisis. We now study the heterogeneity in the responses to the information, using the cross-section dimension of the data set.

Figure 2 displays a measure of the change in quantities between two periods (quarters). If

[4] All expenditures on beef, veal, lamb, horse, pork, poultry, fish and eggs are considered.

q_t^h is the per capita quantity consumed in quarter t, the measure is $d_t^h = (q_t^h - q_{t-1}^h)/(q_t^h + q_{t-1}^h)$, which is bounded between -1 and 1. Two distributions are displayed, before and after the announcement.

Before the announcement, the change in consumption is centered around zero with a roughly symmetric distribution. The distribution after the announcement is different and interesting for two reasons. First, the distribution is centered to the left and asymmetric, because most households have decreased their consumption. Second, there is a strong heterogeneity in households' responses in terms of consumption changes. There is a *continuous* distribution over the consumption changes. Some households have decreased their consumption by 20, 50 or 80%. This means that the households were not faced with a discrete decision, either stop consuming beef or ignore the risk. This result is not only due to the aggregation of different behavior inside the household, as it holds also for single person households. The decrease in beef consumption is the result of consumers purchasing less often and fewer quantities. Even the average quantity of beef purchased conditional on purchasing some has decreased significantly.

About 8% of the sample stopped consuming beef altogether. This figure is higher than the 3.5% in the preceding periods, but still relatively low with regard to the crisis, as the households could substitute to other types of meat or animal protein. Note that some households have increased their consumption, despite the crisis. However, when compared to the results before the crisis, the increase does not appear to be very significant. Part of the increase could also be explained by relative price variations, as the price of beef slightly decreased after March 1996.

The distribution of total expenditure on animal protein does not change as a consequence of the crisis. In particular, there is no evidence that some households became vegetarian.

3 Determinants of Behavior Across Households

In this section, we investigate the determinants of the change in consumption across households. We first start with an analysis of variance to single out the important determinants. We then analyze the role of past consumption on the behavior during the crisis. Next, we investigate the robustness of the results and different possible explanations.

3.1 Analysis of Variance

We start by decomposing the variance in the changes in beef consumption between the first and the second quarter of 1996, as the crisis takes place during the second quarter. We use as explanatory variables the age, the occupation and education of the head of the household, the size of the household, the total family income, the region of living the size of the city, and the average quantity of beef consumed during 1995. We also included risk taking behavior such as alcohol consumption and overweight.

Figure 3 decomposes the explained variance into the contribution of all the variables. A major determinant in the changes in behavior during the crisis is the quantity of beef eaten prior to the crisis. There is a clear difference with pre crisis behavior. A second important determinant is age. Education, occupation and income plays a very small role. Given the importance of past consumption, next sub section investigate in more details its effect on behavior at the time of the crisis.

3.2 Effect of Quantities of Beef Eaten Prior to the Crisis

Let $S_t^h = \sum_{j=0}^{T} q_{t-j}^h$ be the total quantity (in kilograms) consumed during the last T periods and let I_{crisis} be a dummy equal to one during the crisis. We model the expenditure on beef in period t, x_t^h, as:

$$\begin{aligned} x_t^h &= u^h + \gamma_1 \ln p_t^h + \gamma_2 \ln y_t^h + \alpha_0 I_{crisis} \\ &\quad + \alpha_1 S_t^h + \alpha_2 (I_{crisis} * S_t^h) + \alpha_3 (I_{crisis} * Z^h) + \varepsilon_t^h \end{aligned} \tag{1}$$

where u^h is an individual fixed effect, which takes into account differences across households such as tastes, family size, regional location, education, occupation... The regression controls for price and total expenditure movements; p_t^h is a household specific price and y_t^h is the household's total expenditure on animal protein. Z^h is a set of dummies controlling for fixed characteristics such as occupation, education, size of city, region and family characteristics. These variables interacted with a dummy for the crisis take into account regional differences in risks, or different perception of the risk by education levels. As past consumption might influence current consumption even without the crisis, equation (1) controls for the stock at each period before the crisis through the coefficient α_1. Given the exogenous change in the

perception of the level of health risks, we are able to separate the effect of non separable preferences and the direct effect of the crisis.

As the data set starts in the beginning of 1995, an accurate measure of the stock can only be constructed at the end of the survey, in March 1996 for example, where more than a year of consumption data is available. For the preceding periods, the stock measures would be less and less accurate. However, by differencing equation (1), the equation to estimate gets simpler as $\Delta S_t^h = q_{t-1}^h$. The only stock measure that is needed is the one just before the start of the crisis, in order to compute $\Delta(I_{crisis} * S_t^h)$. We use as a proxy for the stock the total quantity of beef consumed since January 1995. The differentiation also gets rid of the fixed effect, but introduces an MA(1) component:

$$\begin{aligned} \Delta x_t^h &= \gamma_1 \Delta \ln p_t^h + \gamma_2 \Delta \ln y_t^h + \alpha_0 \Delta I_{crisis} \\ &\quad + \alpha_1 q_{t-1}^h + \alpha_2 \Delta(I_{crisis} * S_t^h) + \alpha_3 \Delta(I_{crisis} * Z^h) + \Delta \varepsilon_t^h \end{aligned} \tag{2}$$

Equation (2) can be estimated by two stage least squares to control for the correlation between ε_{t-1}^h and q_{t-1}^h and the endogeneity of total expenditure. Potential instruments are lagged prices and lagged total expenditure.

The estimation results are displayed in Table 3, columns 1 and 2. At the time of the crisis, the geographical location dummies do not come out significant, nor the dummies for education or for occupation. The reference group for occupation is farmers, and there is slight evidence that they have decreased less than others. The size of the city has a significant effect on behavior at the time of the crisis. Households living in rural areas decreased less their consumption than those in large cities. This might reflect a difference in information on local prevalence of BSE.

The coefficient of the age of the head of the household is significant and negative. Older households have decreased their consumption more. This is somehow surprising as CJD takes several years to incubate, so one would expect older households to respond less to the crisis. One reason might be that the new variant CJD has a shorter incubation time (even teen-agers have died from the disease). The second reason could be that older individuals, although closer to their life horizon, become increasingly cautious. This feature is not so different from the fact that older individuals do not engage in risky behavior such as smoking or drinking. A related feature is the puzzle in the savings literature where elder people appear

to accumulate much more precautionary savings than a standard finite life model would predict.

The size of the household significantly affect the behavior during the crisis with larger households reducing less their consumption. We analyze this in more details in section 4.

Prices do not come out significant, because we are relying on (moderate) time and regional variations. The effect of total expenditure on animal protein on expenditures on beef is very precisely estimated as we have variations across households and time.

Even after controlling for taste differences, for prices and income effects, as well as differences in education, occupation and geographic location, the stock of beef comes out significant. It is indeed one of the most precisely estimated coefficient. Moreover, the effect is non linear. The relation is U-shaped. For low *and* high values of the stock, the households reduce less their consumption than those with a medium value. This non monotonicity can be interpreted in many ways. Fortunately, the data set allows us to test a number of them. For instance, the upward part of the U shape effect could simply be the consequence of extrapolating the quadratic function of the stock too far. Figure 4 displays a non parametric regression of the change in expenditure on the stock, using a grid with fifty points. Here, we see that this U-shape is still present. The figure plots the response of all households in the sample as well as single person households. A second concern could be that this U-shape is spurious and is the outcome of aggregation of different responses within the household. As Figure 4 indicates, the effect of beef on changes in behavior at the time of the crisis is even more pronounced for individuals than for households. Similar results are displayed in Table 3, columns 5 and 6. For singles, the other explanatory variables such as the size of the city, the region or the occupation have similar effects on the behavior during the crisis.

3.3 Robustness of the Results

To check the robustness of the results, three extensions to the basic model have been tested. Table 4 displays the additional results. First, the model in section 3.2 has not taken into account the truncation at zero, as expenditures cannot be negative. Consumers with a small stock might have little scope to reduce their consumption, which might explain why they respond less to the crisis. The first columns in Table 4 presents the results for a tobit model where the truncation at zero is explicitly modelled. The results are comparable to the one

in Table 3.

Second, we allow for some inertia in the consumption behavior, by introducing lagged expenditure in equation (1). Consumers with high expenditures in the previous period might respond less to the crisis. This could occur with habit formation for instance. Again, the effect of the stock of beef is unaltered. Apart from the coefficient α_1 associated with the level of the stock in equation (1) which becomes positive, the other parameters are not very sensitive to the inclusion of lagged effect of consumption. However, the lagged effect of consumption is only significant at the 10% level.

Finally, to make sure the results are not driven by measurement errors, functional specification or any form of endogeneity not controlled for, we estimate equation (1) on pre crisis data only, pretending the crisis took place in the first quarter of 1996 (I_{crisis} takes a value of one at that date). The last columns of Table 4 displays the results. The coefficients in front of the stock of beef are reduced by a factor 3, and insignificant at any conventional level. This shows that the behavior of the households are being influenced by previous quantities, *once* the crisis is known. It is hard to find a reason based on measurement errors or endogeneity to explain why the stock of beef comes out significant for one quarter and not the other. This means that there must be a behavioral response which drives these results. We now proceed to explore economic explanations for these facts.

3.4 Adjustment Costs?

Both high and low stock consumers could face a high cost of adjustment. Habit formation or addiction could be important for high stock consumers. On the other side of the spectrum, low stock consumers could have a taste for variety, which makes them reducing or stopping beef consumption difficult.

The hypothesis of a heterogenous cost of adjustment can be tested on the pre-crisis data. If agents face different costs of adjustment, they should react differently to price or total expenditure movements. The idea is to check whether price or total expenditure elasticities differ between households with different pre-crisis levels of consumption, before the crisis. If some groups face higher costs of adjustment, they should have lower price and total expenditure elasticities (in absolute values).

The elasticities are estimated on the pre-crisis data, by fitting an almost ideal demand

system (Deaton and Muellbauer (1980)). Five independent regressions are run for each quintile of the stock. The regression uses the panel structure and allows for a fixed effect in levels. Total expenditure is instrumented by income and lagged expenditures. The results are displayed in Table 5.

The price elasticities range between -1.9 to -1.22, without any clear gradient. In fact, given the standard errors, the elasticities for each quintile are not significantly different from the overall elasticity. The total expenditure elasticities range between 0.67 to 0.95. As they are more precisely estimated, the elasticities are different across groups. However, the groups which have the highest elasticities are the lowest and highest stock groups. If anything, the low and high stock consumers appear to face a lower cost of adjustment, as they appear to be more willing to adjust their consumption to total expenditure or price movements. When the crisis comes along, they should be able to decrease their consumption more than average, but the data suggests the opposite. Hence, adjustment costs do not explain the features found in section 3.2.

3.5 Prior Selection into Beef Consumption?

In many countries, information on coronary heart diseases (CHD) has led consumers to reduce their consumption of red meat over the last decades. If this is the case, then high stock consumers might reduce less their consumption, because they care less for their future health in the first place.

In France, the prior selection is probably less important than in many other countries. France has the lowest rate of CHD in the world together with Japan. The rate is about 3 times lower than in the US, and 4 times lower than in the UK. As a whole, the awareness of a link between beef, cholesterol and CHD is very low. [5]

However, it might be the case that high stock consumers come from a population with

[5] As pointed out in Lennernas et al. (1997) or in Babayou (1995), French consumers did not perceive beef to be a threat to health, before the crisis. Both studies use data from a representative sample of French consumers in 1995 (prior to the crisis), and find that beef has a very high status, even in terms of nutritional properties. It is rather seen as a good source of protein, iron, vitamin A and C. In a list of 27 products, only 2.5% of the surveyed individuals wants to avoid beef as a source of cholesterol and 0.8% as a source of fat. Among all the European consumers, the French appeared to be the less preoccupied by a healthy diet. This results also hold when broken down by education level.

risky habits such as drinking, poor diet and little exercise. If this is the case, it would not be surprising that these consumers do not care about additional risks from BSE. It is thus important to control for risky behavior when we analyze the response to the "Mad Cow" crisis. We use two sources of information from our data on drinking and on overweight. We construct a measure of alcohol consumption by averaging all alcohol purchases over the 52 weeks of 1995 and by scaling it by the number of adults in the household. We then break down this variable into three dummies at the 33rd and 66th percentile. We also construct a ratio between waist circumference and height to measure overweight. We break down this variable into three dummies in the same way as alcohol consumption.

We now take into account these variables when studying the change in behavior during the crisis. We augment equation (2) with measures of alcohol and overweight and interact these variables with a dummy for the crisis. Table 3, columns 3/4 and 7/8 displays the results for all households and for single person households.

Households with an overweight head reduced their expenditure less during the crisis. However, alcohol consumption did not appear to be correlated with the change in behavior at the time of the crisis. More importantly, the effect of the stock of beef consumed prior to the crisis is unaltered. Hence, the data does not appear to support an explanation of the U shape effect based on a prior selection of individuals with risky habits in France. [6] This is why studying the crisis in this country is particularly interesting.

3.6 Demand for Quality

High and low stock consumers could appear reluctant to change their habits if in fact they are reacting to the crisis in another dimension. These consumers could switch to better quality beef, which might be safer, and keep the consumed quantities of beef unchanged. We test here this hypothesis.

The data set reports physical quantities, expenditure per item and the nature of the beef cut (18 different cuts of beef are reported). The country of origin of the beef was not

[6] A previous version of the paper tests the effect of new information linking beef and cholesterol on aggregate beef consumption between 1966 and 1995. Contrary to the US (see Kinnucan et al. (1997)), the aggregate demand for beef did not appear to be correlated with new health information before the "Mad Cow" crisis.

recorded, because, up to 1997, it was not legal to reveal the country of origin to the consumer for "fear of distortions" on the beef market. Yet, shortly after the crisis, the French retail industry set up a label on domestic beef, which was assumed to be safer than foreign beef. In April 1996, the consumer had then the choice between French and foreign beef, but the precise origin of the foreign beef was not indicated. At the time of the crisis, French cows had also been diagnosed with BSE, so it is not clear whether the label was very meaningful. There is no indication that the introduction of this label changed the aggregate demand for beef. Hence, in France, the main quality differentiation was the cut of the beef.

We analyze in more detail how the demand for beef changed as a result of the crisis. The data on quantities and expenditure per item were used to compute unit prices. The variation in prices paid by the household reflects both time and regional variations but also the quality of the product.

In response to the crisis and to the fall in aggregate demand, the relative price index of beef fell slightly in 1996, by a modest 1.6% with in fact very little monthly variation. From the aggregate price index, the crisis is barely noticeable. This may be the effect of the EU policy of price stabilization. In our data set, we find the same pattern for a given cut of beef. However, the *average* price of beef paid by households in the data set increased sharply as a result of the crisis, by about 10%. This indicates that the households went out for more expensive cuts of beef after March 1996. From the data, the market share of low quality cuts of beef did sharply decrease during the crisis, while the demand for high quality cuts of beef increased.

Thus the crisis triggered both a decrease in the consumption of beef and an increased demand for higher quality. This increased demand for quality within beef consumption was not uniform across households. Table 6 displays the change in the demand for quality between the quarter preceding the crisis and the quarter after the announcement as a function of the stock of beef. We regress here the change in the unit prices paid for beef between two consecutive quarters. We control for regional effects, the size of the city and household characteristics such as occupation, education and family composition. As evident from the two first columns, households with intermediate levels of stock had a significant increase in the demand for quality. The average price paid by these households went up by 1.9 French francs compared with the highest stock group. Both for low and high stock consumers, the

demand for quality was significantly lower than the middle group. Before the crisis, the effect of the stock is insignificant and has no clear pattern (last two columns). This inverse U shape mirrors the U shape response in quantities. It confirms that low and high stock consumers did not alter their behavior because of the crisis, even in the quality dimension.

3.7 Prior Exposure to nvCJD?

We have found a number of determinants to the household behavior when they learn about the link between BSE and nvCJD. One of the main determinant was the amount of beef consumed before the crisis. The effect was U shaped, with low and high stock consumers reacting less to the crisis. This is true despite controlling for time non separability and for self-selection based on differences in attitudes towards risks. We were also able to rule out the role of heterogeneity in the cost of adjusting consumption levels, or changes towards better quality of beef for consumers with high and low consumption prior to the crisis.

Given the nature of the crisis, an explanation of the effect of the quantity of beef eaten prior to the crisis is its correlation with the exposure to nvCJD. Individuals might evaluate the risk of nvCJD already taken and might consider new consumption of beef with its implication on further exposure. Given the U shape response in the data, this explanation is only valid under a certain shape of the dose-response relationship.

If the nvCJD can be contracted by eating only one piece of infected beef, whatever its size, the optimal behavior of an agent would be to abstain totally from beef if prior exposure is low. Conditional on eating, the size of the piece of beef on the plate would be irrelevant for the risk of further exposure. [7] This is clearly not supported by the data.

It might be the case that the nvCJD can only be contracted after a cumulative exposure to infected beef. For instance, the prion responsible for the nvCJD might only become toxic beyond a certain threshold. If this is the case, then the optimal strategy would be a U shape profile as seen in the data. Individuals with a low stock are too far away from the threshold to worry and those with a high stock might not care anymore. This fatalistic behavior does not imply that the individual think that the probability of dying from nvCJD is high, but rather that the marginal effect of future consumption on the risk is zero. Individuals with a

[7] If there is some habit formation, the optimal strategy, conditional on eating, would be to consume fewer and larger pieces of beef.

medium stock might realize that they are getting close to this threshold and reduce or stop their beef consumption. This could also explain the differential demand for quality seen in section 3.6.

The precise shape of the dose-response relationship has not been established in the medical literature yet. [8] At the time of the crisis, no such information was available to the consumer. Consumers might have had in mind the example of other consumption goods such as alcohol and cigarettes, or indeed poor diet, which requires repeated exposure to have an effect on health.

4 Household Behavior versus Individual Behavior

The results presented in section 3.2 showed that the size of the household had a significant impact on the behavior during the crisis. Households with a larger number of individuals decreased their consumption less.

In France, in most of the cases, meals are taken by the whole family together and one type of meat would be prepared. Because of traditions and time constraints it is doubtful that different types of meat would be prepared for different members of the households. Hence, what is consumed and purchased must be the outcome of some form of a collective decision. For a single person household, this decision can be easily taken. How is this decision taken when more than two individuals are present? This crisis can help to understand how decisions towards health risks depend on the composition of the household. We can try to investigate who has the most influence on the decision to move towards safer habits.

The reaction of a household with several members can differ from the reaction of a single individual for several and not necessarily exclusive reasons. Household members might react in the same way, but heterogeneity in prior exposure might lead to an aggregation bias. Another possibility is that conditional on the stock, different members respond in different ways. This can arise if some individuals are more reluctant to vary their consumption levels, or if their concern about safety differs.

[8] From a study of hamsters, Diringer et al. (1998)) find a concave probability: for a low exposure, the risk is virtually inexistent, for a higher exposure, the marginal increase in the risk is increasing with the exposure and then decreases.

4.1 Aggregation Bias?

The household size effect could be the result of the aggregation of different decisions within the household. From Figure 4, the main difference between the response of individuals and households is the magnitude of the decrease for medium values of the stock. It might be the case that all the members of the household are reacting in the same way, but that heterogeneity in the stock of beef could blur the aggregate response. On average, adult men eat more than women, so one might expect that men have a higher stock of beef, even if meals are taken together. Could differences in exposure between members of the family explain the difference between individual and aggregate responses?

For a stock of about 0.6 kilograms, a single individual decreases expenditures on beef by about twelve Francs. For a larger household, this decrease is only about five Francs. Suppose a household with two members have a stock of 0.6 kilogram per capita, how far apart should the individual stocks be to explain an aggregate drop in consumption of (roughly) -5 French Francs? From the single person household response in Figure 4, the individual stocks would have to be at least 0.4 and 0.8 kg (which would lead to an aggregate stock of 0.6 kg per capita). At that range, a single individual would roughly decline its expenditure by five francs. Thus, individual consumption levels, within a household, have to be at least 66% different. This figure appears to be rather high. It is possible that some of the attenuation in the aggregate response is due to pure aggregation bias, but more is clearly needed. For instance, different members of the family might have different responses to the crisis, conditional on the stock.

4.2 Household Composition

The fact that larger households decrease their consumption less is, at first glance, rather surprising. Larger households are very likely to be families with several children. These households are usually thought to be more cautious and less likely to engage in risky behavior compared with single-person households.

Table 7 displays the effect of the size of the household at the time of the crisis and breaks down the size into different age categories. The first line reports the same coefficient as in Table 3. Larger households decrease their consumption less on average. Next, we look at an effect for households which are not single person households. For these, the size effect remains the same. In row 3, we performed the regression on all households with no members

younger than 18. The magnitude of the effect decreases by about 25% compared with the effect for all households and is not significant anymore. Hence, larger households decreases less their beef consumption when children are present. It might be that households with children care less about health issues. This would be rather surprising, given that we have controlled for education, occupation, income and age of the head of household. If anything, households with children are thought to be more cautious about health issues. Another explanation is that even after controlling for a number of factors, households with children do not believe in the crisis as much as other households. If this is the case, this would be true whatever the age of the children, given that the timing of the crisis is exogenous. Rows 4 and 5 of Table 7 break down the effect of the size by age categories. The number of infants of age 0 to 4 have little effect on how the households responded. However, the number of children of age 5 to 9 and especially of age 10 to 17 comes out strongly. It is hard to argue that households with teenagers believed less in the information about nvCJD than households with young children. Row 6 also controls for the number of teenage boys. The effect is quite strong in magnitude and significant.

These results indicate that families with teenagers are more reluctant to change their behavior. Several reasons could be put forward. First, children eat less than adults and would have lower stocks than their parents. The presence of children could attenuate the response of the family leading to an aggregation bias as discussed previously. However, girls eat even less than boys, so one would expect families with teenage girls to reduce less their consumption, which we do not observe.

Second, it might be the case that families with children in that age group are less prone to switch from beef to chicken or lamb for instance, even before the crisis. Parents might think that beef is important for the well being of teenagers and that this concern outweighs the concern about nvCJD. Given that we observe the behavior of these households for more than a year before the crisis, we are actually able to evaluate the importance of this "cost of adjustment". The idea is similar to the test in section 3.4. We investigate whether families with teenagers have lower total expenditure elasticities. This would indicate that these households are less susceptible to switch from beef to another category of meat or fish. We computed the total expenditure elasticity by estimating a demand system for beef and for all other types of animal protein. The total expenditure elasticity for beef is 1.05 (0.01)

for all households and 1.01 (0.30) for households with teenagers. The latter elasticity is not estimated very precisely, given the smaller number of observation, so we cannot reject a different elasticity for these families. Moreover the point estimates are quite close. We also computed this elasticity for households with younger children and found a total expenditure elasticity of 1.02 (0.03).

Before the crisis, families with teenagers did not appear to have a rigid diet. They were as likely as others to substitute to other types of meat. The reason for this rigidity must come from the nature of the crisis itself. One explanation could be that teenagers were less concerned about the crisis than other age groups. This may indicate that this age group has a lower discount rate, especially for boys. That young males engage in risky habits and care less for their future health has been documented in the literature before (see Gruber (2000) for instance). At that age, a number of them starts smoking, experiments with drugs and drives motorcycles.

What is more surprising is that teenagers affect the behavior towards health risks of the whole household. It is doubtful that children of that age go out and buy beef on their own. This means that they must influence their parents into buying a potential unsafe product. That they are able to influence the behavior of the whole household is a new and interesting finding. The literature on intra household behavior usually emphasizes the role of the distribution of resources within the family or of threat points in explaining the bargaining power of individual members, as in McElroy (1990), Browning and Chiappori (1998) or Bourguignon (1999). As teenagers have virtually no income and cannot split from the household, these models would predict that they have no bargaining power. Yet, they have an influence on household behavior towards risks. [9]

This pattern of behavior could also arise if children had no bargaining power but if parents care for the *instantaneous* utility of their children, rather than their life time utility. Parents might be myopic when deciding the level of risk for their children. However, when it comes to their own decision, adults do not appear to behave in a myopic way.

Families have to decide on a number of actions which involves a collective health risks. For instance, consumption of cigarettes affects not only the smoker but also the whole household. It is very probable that the decision to smoke is not entirely taken individually and that the

[9]However, the fact that parents cannot split from their teenagers gives these children some bargaining power.

spouse or children influence this decision. Other risky actions include drinking, driving, or poor diet for instance. Risky habits also originate within the family, as child and parent smoking are correlated. The interaction between different members of a household when dealing with risk is important for the design of public policies, but from lack of appropriate data, has not been addressed in the literature before.

5 Conclusion

Past consumption can be correlated with current behavior for a number of reasons. Preferences can be non separable over time because of habit formation or of addiction. Selection and unobserved heterogeneity are also able to generate such a correlation. Finally, in the case of goods which have an effect on health, past consumption may influence the behavior of the consumer through the effect of the accumulated risk on future health. On commonly used data set, it is very difficult to disentangle all these effects. First, individuals usually know about the risk beforehand and it is very difficult to escape the selection problem. Second, most risky goods are also addictive. The only way to separate out these effects and to demonstrate the role of accumulated risk on further risk taking behavior is to rely on an exogenous shift on the perceived effect of accumulated risk.

The "Mad Cow" crisis is a unique episode which can be used as a natural experiment. Due to the nature of the crisis, past behavior are crucial in determining the degree of exposure to this risk, but the consumers did not know this until March 1996. We exploit this feature to show that consumption of beef prior to the crisis was one of the main determinants of the response of the consumers. This effect is non linear and U-shaped. Consumers who had previously eaten small or large quantities of beef did not change their behavior. Those with medium levels did significantly decreased their consumption. This is still true, despite controlling for non separable preferences over time and for prior selection into risky behavior.

Few data sets contain information on the quality of the good (such as the nicotine content of cigarettes). Using our detailed data set, we show that past behavior affects current risk taking behavior in a non-monotonic way not only in the quantity dimension but also in the quality one.

The effect of past behavior and the non-monotonicity both in the quality and quantity dimension points to, or at least is not contradicted by, a model where the discount rate is

a function of the exposure to the risk, once the risk is known. A number of authors have studied models with endogenous discount rates or endogenous mortality in the case of risky goods, as Grossman (1972), Cropper (1977), Ehrlich and Chuma (1990) and Ehrlich (2000). Becker and Mulligan (1997) review a number of facts outside the health literature which supports these models, such as the correlation between consumption growth and income or schooling. However, direct tests or empirical evidences are very scarce. [10]

Taking advantage of the natural experiment, the paper also investigates how the composition of the households affects its behavior towards risks. We show that teenagers, and especially boys, had an effect on household behavior towards health risks. The most likely explanation is that teenagers cared less about the crisis and that they were able to influence their parents into buying a potential unsafe product. The previous literature on intra household allocation has not studied the role of children as decision takers. It is usually assumed that they have no bargaining power. Probably from lack of data describing joint household decisions about risks, the literature on risk taking behavior has concentrated mostly on how single individuals behave. Little is known or documented on how a group of individuals decide collectively about health risks. Yet, most of the risk taking behavior involve not only the individual him-self, but also other surrounding family members. This is the case for smoking and its passive implication or driving for instance. Understanding these issues are important to design efficient policies. Clearly more research and evidence is needed in this field, but this paper takes a step towards it.

[10] Adda and Lechene (2001) develop and test a model with rational addiction and endogenous mortality and shows that the model is able to explain the heterogeneity in smoking across individuals.

Table 1: Descriptive Statistics

	Before Crisis	During Crisis
Quantity of beef	0.19 (0.19)	0.14 (0.20)
Quantity of beef, conditional on buying	0.40 (0.47)	0.35 (0.37)
Number of Purchases of beef, week 12-24	5.9 (3.5)	4.9 (3.5)
Expenditure on beef	10.9 (10.6)	8.6 (10.5)
Total Expenditure on Animal Protein	41.7 (31.9)	43.0 (32.4)
Mean age of head	53.6 (14.9)	
Household Size	2.84 (1.35)	
Percentage Households with Children	0.36 (0.48)	
Head Farmer	0.05	
Head Self-Employed	0.06	
Head Manager	0.17	
Head White collar	0.27	
Head Blue collar	0.41	
Head no activity	0.04	
College Degree	0.04	
Live in Village	0.34	
Live in Medium Town	0.18	
Ethanol purchase in 1995 (liter per capita, per week)	0.11 (0.17)	
Height, adult women (meters)	1.61 (0.62)	
Height, adult men (meters)	1.73 (0.65)	
Waits circumference, adult women (meters)	0.98 (0.09)	
Waits circumference, adult men (meters)	0.92 (0.09)	

Note: Standard deviations in parenthesis. All quantities are expressed in kilograms per capita and per week. All expenditures are expressed in French Francs per capita and per week.

Figure 1: Average Consumption of Beef in France Weekly, From January 1, 1996 to June 24, 1996

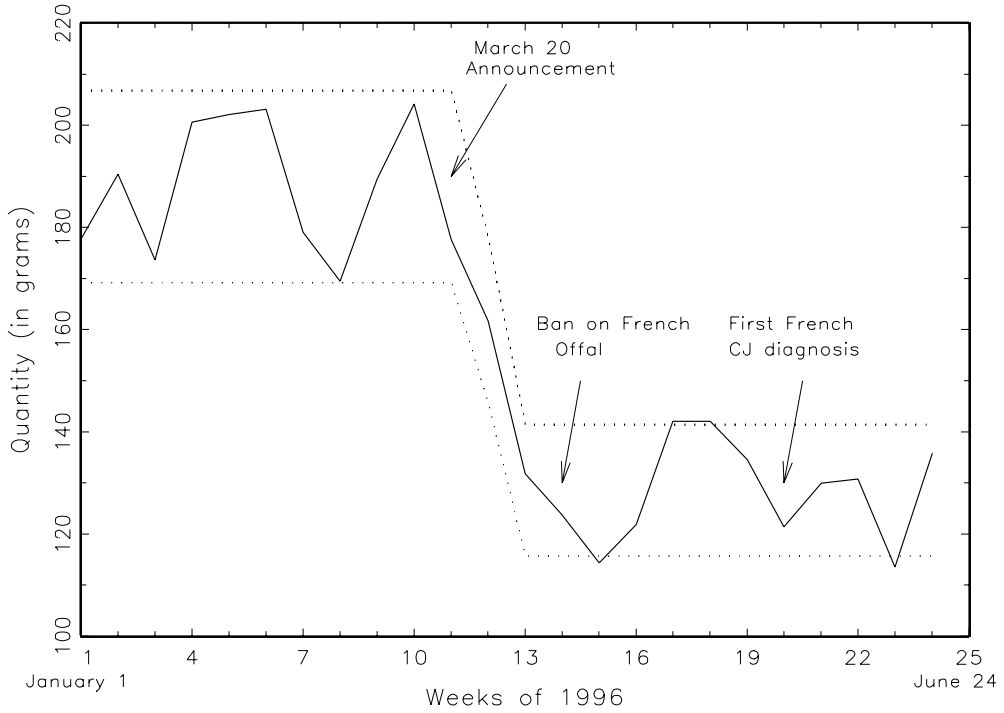

Table 2: Effect of Crisis on Behavior

		Mean	D crisis		Mean	D Crisis
Beef:	Budget share	0.25	-0.047 (-15.0)	Quantity	0.18	-0.03 (-8.3)
Total Expenditure		38.4	0.60 (1.7)			

Notes: t-stat in parenthesis. D crisis: Dummy for crisis. The regressions also included a fixed effect, prices, total expenditure and seasonal dummies. Heteroscedastic corrected standard errors were computed.

Figure 2: Percentage Change in Beef Consumption, Before and After the Announcement

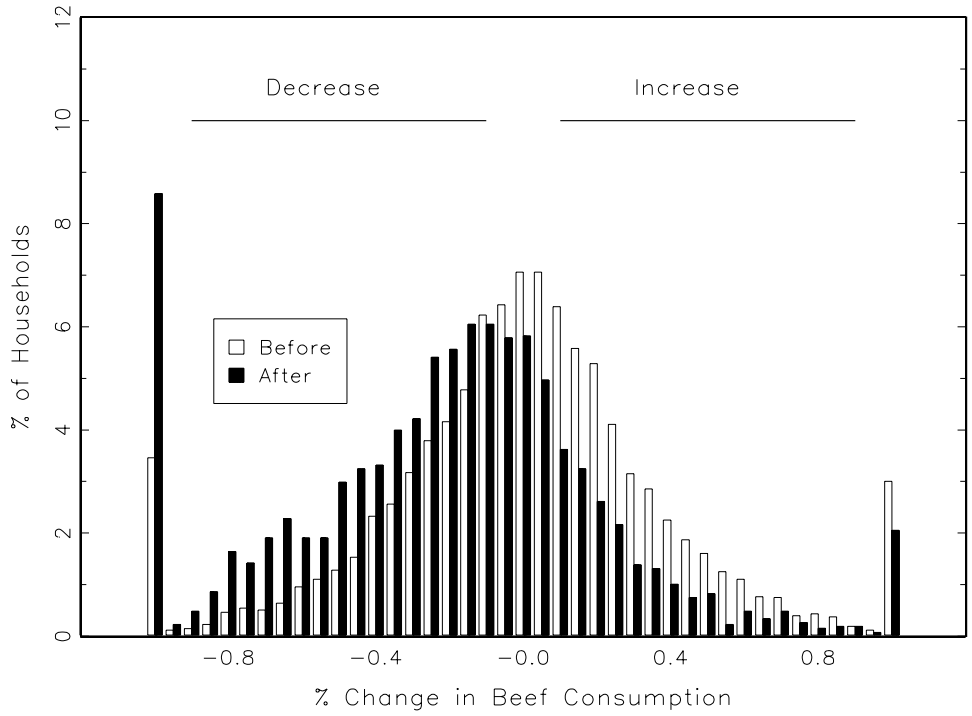

Figure 3: Main Determinants of Changes in Consumption

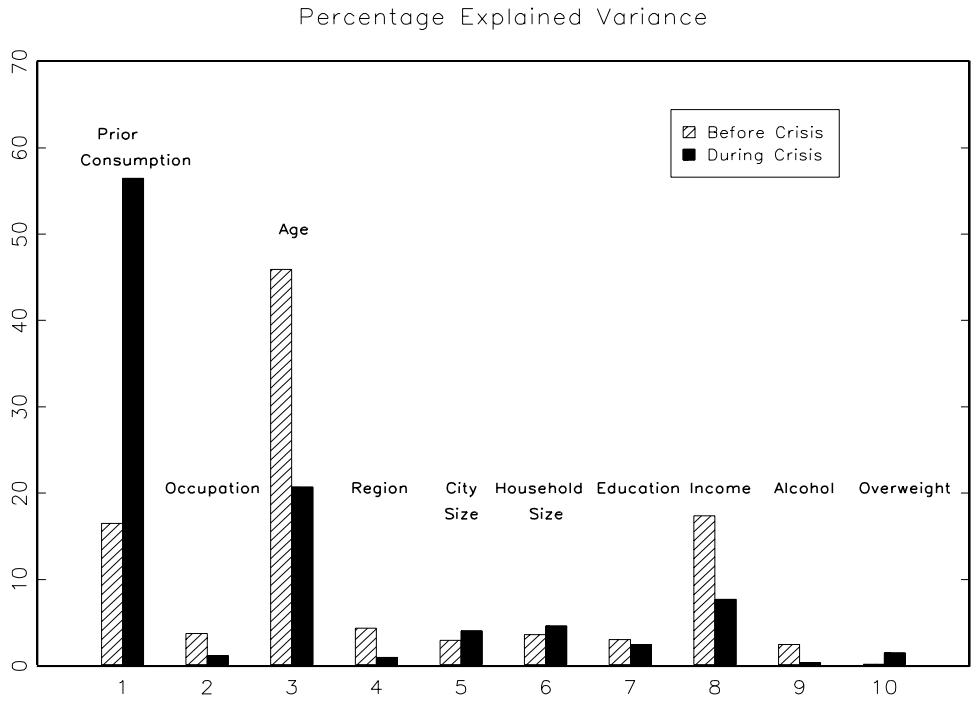

Table 3: Determinants of Change in Consumption

	All Households				Single Person Households			
Variable	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat	Coef.	t-stat
q_{t-1}	-3.6081	(-2.68)	-4.6901	(-3.20)	-3.084	(-2.10)	-2.5930	(-1.63)
$\mathrm{I}_{Crisis} * S_t$	-12.34	(-3.16)	-12.673	(-2.46)	-18.46	(-3.08)	-19.199	(-2.94)
$\mathrm{I}_{Crisis} * S_t^2$	14.702	(2.33)	16.971	(2.05)	14.779	(2.99)	14.887	(2.93)
Log Total Expenditure	5.9590	(11.62)	5.6395	(10.88)	5.5641	(5.76)	5.9203	(5.94)
Log Price	-1.1026	(-0.29)	-2.7906	(-0.70)	-3.7738	(-0.31)	-2.0697	(-0.14)
Size of Household	-.01559	(-0.29)	-.01871	(-0.31)				
Dummy First Quarter	.01162	(0.01)	-.40197	(-0.34)	-.38166	(-0.11)	.09946	(0.02)
Dummy Second Quarter	-.1430	(-0.30)	-.17063	(-0.34)	-1.0167	(-0.66)	-.72863	(-0.40)
Dummy Crisis	-.98203	(-0.81)	-.59274	(-0.40)	-.44493	(-0.15)	.4465	(0.12)
I_{Crisis}*Size of Household	.42452	(3.32)	.48204	(3.21)				
I_{Crisis}*East	.0844	(0.16)	-.02773	(-0.05)	.1147	(0.06)	.53987	(0.31)
I_{Crisis}*North	.09077	(0.11)	-.46940	(-0.56)	-3.4438	(-1.32)	-2.86	(-0.98)
I_{Crisis}*West	-.09340	(-0.14)	-.45506	(-0.68)	.46196	(0.21)	.86024	(0.37)
I_{Crisis}*Center	.39820	(0.77)	.29141	(0.52)	-.48554	(-0.27)	-.24644	(-0.12)
I_{Crisis}*South East	.1011	(0.21)	.01758	(0.03)	-.61824	(-0.38)	-.53453	(-0.30)
I_{Crisis}*South West	-.47526	(-0.63)	-.54836	(-0.69)	-2.41	(-0.97)	-2.4499	(-0.86)
I_{Crisis}*Village	1.3192	(3.91)	1.4333	(3.96)	3.196	(2.63)	2.797	(2.13)
I_{Crisis}*Medium City	.78602	(2.36)	.88023	(2.49)	2.8706	(2.73)	2.8673	(2.50)
I_{Crisis}*Self-employed	-.49152	(-1.05)	-.59993	(-1.42)	-1.5430	(-1.00)	-1.9546	(-1.19)
I_{Crisis}*Managers	-.56752	(-1.25)	-.68693	(-1.74)	-1.4167	(-1.01)	-1.5369	(-1.05)
I_{Crisis}*White Collar	-.29196	(-0.66)	-.37916	(-0.98)	-.28297	(-0.20)	-.47836	(-0.32)
I_{Crisis}*Blue Collar	-.09662	(-0.22)	-.17652	(-0.46)	-.30886	(-0.24)	-.49207	(-0.36)
I_{Crisis}*No Activity	-.05298	(-0.09)	.08019	(0.14)	-.37476	(-0.26)	-.23873	(-0.15)
I_{Crisis}*Foreigner	-.17424	(-0.19)	-.65407	(-0.56)				
I_{Crisis}*College Degree	.19797	(0.67)	.48752	(1.58)	6.3446	(0.47)	15.64	(0.86)
I_{Crisis}*Age of head	-.02381	(-2.08)	-.02906	(-2.09)	-.00291	(-0.09)	-.00757	(-0.20)
age of head	.00525	(0.90)	.00545	(0.86)	.01066	(0.63)	.0106	(0.55)
constant	.4497	(0.62)	.55398	(0.71)	-.31487	(-0.14)	-.37663	(-0.14)
Body Mass Low			.00850	(0.04)			-.19351	(-0.12)
Body Mass Medium			.08428	(0.44)			.39941	(0.68)
I_{Crisis}*Body Mass Low			-.72900	(-1.68)			2.8601	(0.75)
I_{Crisis}* Body Mass Medium			-.57217	(-1.37)			-1.4220	(-1.02)
Alcohol Low			-.14709	(-0.76)			.15511	(0.21)
Alcohol Medium			.06765	(0.36)			.49453	(0.68)
I_{Crisis}*Alcohol Low			-.25684	(-0.67)			-.23505	(-0.16)
I_{Crisis}* Alcohol Medium			-.44188	(-1.12)			-.1196	(-0.07)

Note: Two Stage Least Squares estimates. instruments: q_{t-2}, $\ln p_{t-1}$, $\ln p_{t-2}$, $\ln y_{t-1}$, $\ln y_{t-2}$, S_{t-1}. Heteroscedastic corrected standard errors were computed.

Figure 4: Effect of Stock of Beef on Change in Consumption

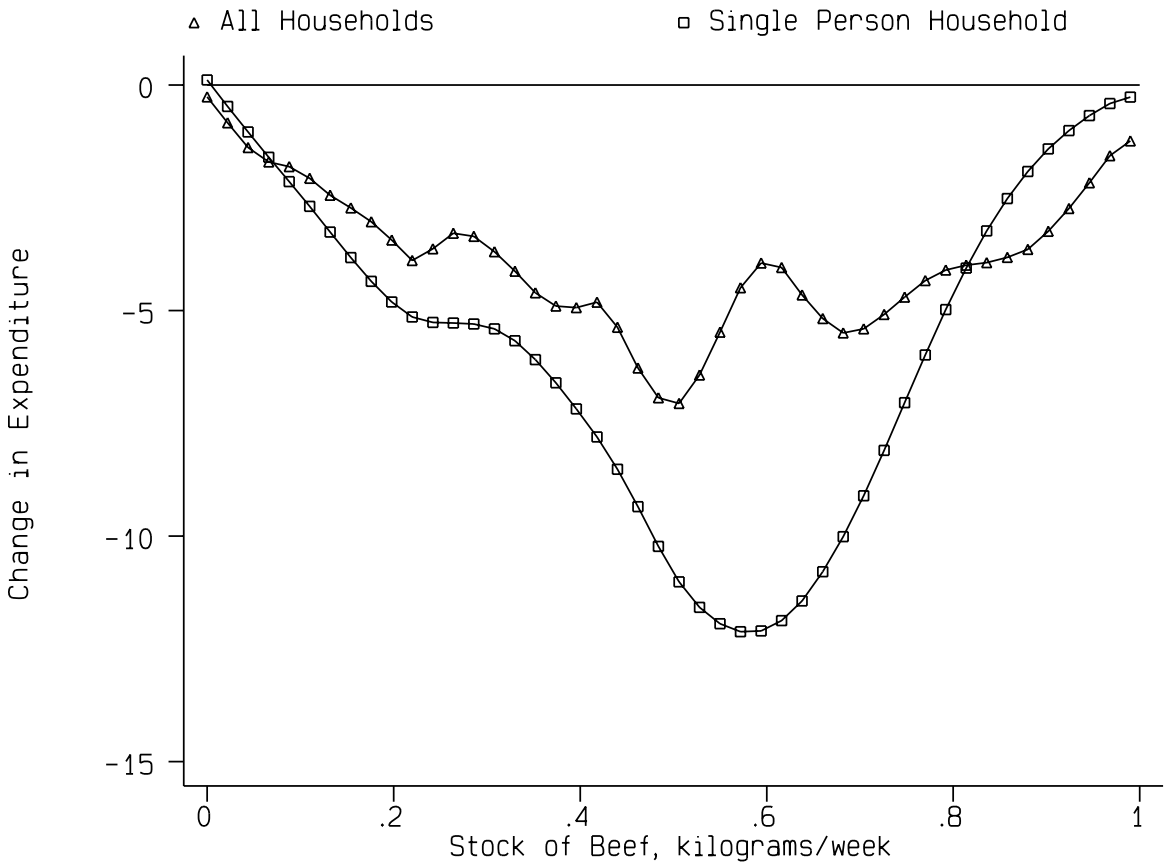

Table 4: Robustness Check: Determinants of Changes in Consumption

	Tobit		Lagged Effect		Pre Crisis	
Variable	Estimate	t stat.	Estimate	t stat.	Estimate	t stat.
$I_{crisis} * S_t$	-12.58	-9.1	-16.6	-4.0	3.1	1.3
$I_{crisis} * S_t^2$	15.07	12.3	15.1	2.4	-2.6	-1.2
q_{t-1}			0.83	0.5	-2.4	-1.9
Δx_{t-1}^h			0.06	1.7		

Notes: The regression controls for prices, total expenditure, seasonality, age and includes dummies for geographical location, occupation and education. Heteroscedastic corrected standard errors were computed.

Table 5: Price and Total Expenditure Elasticities, Prior to the Crisis

Stock Quintile	1 (lowest)	2	3	4	5 (highest)	All
Price Elasticity	-1.46	-1.9	-1.74	-1.22	-1.33	-1.37
standard dev.	.44	.25	.19	.18	.13	.09
Total Expenditure Elasticity	0.93	0.67	0.79	0.85	0.95	1.05
standard dev.	.03	.02	.02	.02	.02	.01

Note: Estimations performed on 14025 observations on data prior to the crisis. An individual fixed effect was included.

Table 6: Effect of Stock on Changes in the Demand for Quality

	During Crisis		Before Crisis	
Variable	Estimate	t stat	Estimate	t stat
Stock [0,20%]	0.04	0.0	0.77	1.1
Stock [20%,40%]	1.89	1.9	-0.41	-0.8
Stock [40%,60%]	1.92	2.0	0.28	0.6
Stock [60%,80%]	0.37	0.4	-0.21	0.5

Note: Heteroscedastic corrected standard errors were computed. Regression also controls for lagged changes in quality, region of living, size of city, occupation, education, family size and income.

Table 7: Effect of Size of Household on Behavior during the Crisis

	Household Size				
All Households	0.42 (3.32)				
All Households, Size≥2	0.41 (2.9)				
All Households, no children under 18	0.32 (1.2)				
	Number of Individuals of Age				
	[0,4]	[5,9]	[10,17]	[18,100]	[10,17], Males
All Households	0.08 (0.4)	0.38 (1.7)	0.52 (3.2)	0.40 (2.2)	
All Households, Size≥2	0.22 (0.9)	0.45 (1.9)	0.58 (3.3)	0.30 (1.6)	
All Households, Size≥2	0.26 (1.0)	0.50 (2.0)	0.28 (1.3)	0.35 (1.8)	0.64 (1.9)

Note: t-stat in parenthesis. Regressions control for size of stock, region of living, size of city, occupation of head, education level, income, prices and total expenditure. Robust standard errors were computed.

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