Risk perceptions, risk-reducing behaviour and willingness to pay: radioactive contamination in food following a nuclear accident.

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Abstract

In this paper, we investigate the links between risk attitudes, risk-reducing behaviour and stated preferences for changes in risk. This is done in the context of an empirical study of "countermeasures" against radioactive contamination of land following nuclear accidents such as Chernobyl. Countermeasures can reduce contamination levels in food crops to "safe" levels, but consumers may require large price reductions before they will consume treated products. How large these reductions would have to be for countermeasures to be effective in terms of consumer attitudes was the focus of a contingent valuation study carried out in Scotland and Norway. Data from this survey allows us to examine whether attitudes to risk or past risk-reducing behaviour are more important in predicting willingness to pay to avoid increases in perceived risk. We also report on which sources of information on food safety are most trusted by consumers.

Key words: Food Risk, Radioactivity countermeasures, Preferences in risk, Chernobyl

1. Introduction

The operation of nuclear power stations gives rise to the risk of nuclear accidents resulting in radioactive fall-out, some times at great distances from the source. A vivid illustration of this was the Chernobyl accident in 1986, where a major leak of radioactive substances to the atmosphere gave rise to contamination of agricultural land. Transfer of deposited radionuclides from soils to plants and animals resulted in contamination of farmed as well as wild foods (such as reindeer and moose) across much of Europe (1). Scotland and Norway were both affected by the accident, and consumers changed their food buying behaviour due to government health advisories. The radionuclide of most concern in Europe was caesium-137, with a half-life of 30 years, while closer to the accident strontium-90, plutonium-239, 240 and others were also present in significant quantities (2). In Norway, a range of measures were undertaken to limit the entry of radiocaesium into the human food chain (3), whilst in the UK the movement of sheep was restricted (4). Fourteen years after the event some areas of Britain and Norway still have restrictions in place preventing agricultural products which exceed government limits from entering the food chain.

"Countermeasures" are steps which can be taken to reduce the radiation dose to humans, to save food from disposal and preserve farm incomes (5). Long-term countermeasures encompass a wide range of options that intervene at the soil, plant or animal level (6). They may target specific radionuclides (i.e. the application of potassium to the soil, which competes for plant root uptake with radiocaesium) or be effective against all radionuclides deposited (i.e. supplying livestock with uncontaminated fodder). Practical applications as well as field and laboratory experiments in the aftermath of the Chernobyl accident have greatly increased our knowledge of the radiological effectiveness of a wide range of countermeasures (7, 8).

However, whilst many steps can be taken which are successful in reducing food contamination below officially safe levels, consumers may be unwilling to purchase treated products from affected areas, if they perceive them as unsafe. There are now many instances of divergences between government advice on what foods are safe to eat, and consumers' attitudes and behaviour (consumer attitudes to genetically-modified food crops being one good example). The purpose of this paper is to investigate the links between attitudes to risk, risk-reducing behaviour and stated willingness to pay (WTP) to avoid perceived risks from "safe" treated products in the context of radiological contamination following a Chernobyl-type accident. We focus on two issues in particular: first, on the magnitude of WTP to avoid perceived risks from "safe" products, when an untreated "safe" alternative is available (such as an imported substitute); and second, whether variations in stated WTP across respondents are better explained using measures of risk perception or measures of risk-averting behaviour. We investigate these issues using a conceptual model put forward by Ajzen and Fishbein (9).

In section 2, the Ajzen and Fishbein model is set out, along with a brief discussion of subjective risk assessment. In section 3, the survey design is described, along with the contingent valuation market used in our survey. Section 4 presents some descriptive results, including estimates of WTP and responses on most trusted sources of information on food safety. In section 5, models relating WTP bids to different proxies for risk perception and risk-averting behaviour are presented. Finally, some conclusions are offered in section 6.

2. Risk perception, behaviour and values

According to a conceptual model put forward by Ajzen and Fishbein (9), peoples' responses to changes in risk may be studied at a number of different levels (10). Risk source characteristics and the characteristics of a consumer combine to form a consumer's beliefs about risk. These beliefs include their perceptions towards risky events, and the degree of trust they place in different sources of information. Relevant risk source characteristics have been found to include the severity of the associated health hazard, degree of self-control over

exposure, and familiarity (11,12). Risks associated with nuclear power and associated accidents are fairly extreme in this regard, since they are outside consumers' control (unlike, say, risks of sunbathing), are very unfamiliar, and involve potentially extreme outcomes. In such circumstances, we can expect subjective risk assessments to differ considerably from scientific risk assessments. Consumer characteristics may also be important in the formation of consumer beliefs: relevant characteristics may include age, previous experience, income and education. According to the Ajzen/Fishbein model, consumer beliefs determine attitudes to risk (for example, whether people are in favour of GMO development). Attitudes, mediated by social norms such as the behaviour of others and their expectations regarding the individual, in turn determine intentions. Finally, intentions determine behaviour, although the two are not the same (for example, I may intend never to eat meat, but then get overcome by a desire to eat a hamburger).

Intentions and behaviour are typically the focus of economic analyses of risk. Willingness to pay to avoid an increase in risk can be studied either using stated preference methods, which focus on intentions (13, 14,15); or revealed preference methods, which focus on behaviour. Such revealed preference approaches include hedonic wage models (16) and averting expenditure methods (17). Both approaches have been widely used to estimate the economic costs of risk, and the benefits of reducing risk. In this paper, we use a measure of the value of risk changes based on intentions, in that we seek to estimate peoples' WTP to avoid perceived risks of radioactive contamination from foods, even when countermeasures have been undertaken which reduce scientifically-measured risk to below "safe" levels. We are interested in how large this risk premium is for two different products in two countries, Norway and Scotland, which were both affected by the Chernobyl incident in 1986 although not in identical ways. We are also interested, though, in which serves as a better predictor of variations in risk premia across individuals: a measure of risk perceptions, or a measure of risk-averting behaviour. Two different risk perception and risk-averting proxies are used: one based specifically on radioactivity risks, and one based on more general food risk.

3. Survey design and descriptive statistics

Data was collected in two surveys, using very similar questionnaires, in Norway and in Scotland in 1998. The Norwegian sample was obtained by a mail shot of 2000 randomly-selected addresses. The response rate was 50.6%, giving a sample size of 1003. The Scottish sample was collected by in-person interviews conducted in people's homes by a market research firm, again using random sampling. Owing to higher sampling costs, a sample of only 200 responses was collected[1]. Full details on sample representativeness may be found in Grande et al (18). However, it is important to note here that the Norwegian sample did seem to suffer from a degree of selection bias in terms of sensitivity to food safety/quality issues, for example in a higher than expected representation of consumers buying organic food.

Respondents were first asked to indicate the perceived risk, in terms of the likelihood of suffering ill health, from a number of sources such as traffic accidents and sunbathing. A five-point Likert scale was used, with 5 indicating the highest level of perceived risk. They were then asked how worried they were about suffering ill health from the same sources. Worried-ness could be argued to be a more important cause of risk-averting behaviour than perceived likeliness of a risky event occurring, as it represents an attitude rather than a belief in the context of the Ajzen-Fishbein model. The questionnaire then asked people some general attitudinal questions concerning nuclear power, and their willingness to incur higher food prices in return for higher food safety. Respondents were thus focussed onto the issues of food safety and nuclear power. They were next asked to score the likelihood of suffering ill health from a range of food safety problems, such as chemical additives and genetic engineering; before being asked to score these same issues in terms of how worried they were about them. Five–point Likert scales were again used. The questionnaire then moved on to risk-averting behaviour. Respondents were asked about any change in food buying behaviour which occurred in the immediate aftermath of Chernobyl and over the longer term; and then, more importantly, about the extent to which they had changed their current behaviour in

response to more general perceived food risks (for instance: “In the past twelve months, how often have you avoided buying beef because of BSE (mad cow disease)?”). In the next section of the survey, respondents were asked which sources of information on food safety they trusted most, and how they would prefer to learn about future food safety threats.

Contingent valuation questions

In the last section of the questionnaire, estimates of peoples’ willingness to pay (WTP) for risk reductions were obtained using the contingent valuation method (19). Following a description of countermeasures, respondents were faced with a choice between two substitute products, a treated and an untreated alternative. The “treated” alternative was either milk or lamb from areas affected by fall-out, but which had been treated to reduce radioactivity to within safe levels. The “untreated” alternative was the same product which had been imported from outwith the geographic area affected by fallout (and for which treatment was thus un-necessary). In the Norwegian sample, respondents were asked which of these two alternatives they would prefer when buying lamb; in the Scottish sample, they were asked this question for both lamb and milk (since in Scotland both commodities were affected by Chernobyl, whereas in Norway milk production was un-affected). Having chosen which alternative they preferred, respondents were asked to imagine that this was more expensive to buy than the substitute: they were then asked how great the cost difference could be (between the most-preferred and least preferred option) before they would change their mind. This is an estimate of their willingness to pay to reduce the perceived risk associated with radioactive contamination (even though objectively-determined risk levels might be identical). To aid their responses, people were reminded about the current average price of milk/lamb. A preceding question filtered out those who do not buy lamb or milk at all. The questionnaire concluded by asking questions about respondents’ education, income and occupation.

4. Descriptive statistics

With regard to all (food plus non-food) risks, the highest perceived risk in the Scottish sample was from bacteria infected food, and in Norway from chemical additives in food. Radioactive contamination from food was scored at or below the mean level of all listed risks in the two samples, whilst radiation leaks were scored even lower. When looking at food risks only, chemical additives were again given the highest risk rating in the Norway sample, with bacterial infection the highest rated in Scotland. Radioactive contamination was rated lowest by Scots and second lowest by Norwegians in terms of how likely people were to suffer ill health. In general terms, the Scottish sample gave higher score to likeliness of ill health rather than to being worried about ill-health from all sources mentioned in the survey. This pattern is reversed for Norwegians: Scots therefore seem less concerned about food health risks.

Turning to risk-reducing behaviour, Scots showed the greatest response in terms of avoiding buying beef due to fear of BSE. This was followed by buying bottled water rather than tap water, and buying organic milk. However, levels of averting behaviour were in general low (in that, for example, even for avoiding buying beef, nearly half the sample said they did not and had not). Norwegians showed higher levels of averting behaviour for all products except drinking water, with the greatest extent of averting behaviour being shown with respect to avoiding buying lamb due to fear of radioactive contamination or scrapie (even although it is very rare and has no proven health effect on people); and in buying organic milk. Regarding responses to Chernobyl, Norwegians showed a greater response than Scots in terms of both short term and long term reductions in consumption of farmed and wild meat. Milk consumption was most affected amongst all listed food products in Scotland.

Regarding willingness to pay for risk reductions, the Scottish sample had a significantly higher level of agreement than the Norwegian sample with the statement ”I would be willing to accept a tax increase next year if I knew the money would be spent on a programme to impose stricter food safety regulations”. In the actual willingness to pay questions, results were as shown in Table 1. As may be seen, Willingness to Pay (WTP) to avoid perceived risk

was positive in all cases, implying that people discriminated between the treated and un-treated alternatives, even though both were explained to be safe. Mean WTP for untreated lamb was between +29-+37% of the average current product price in Scotland and Norway. For milk, WTP to reduce perceived risk was higher at 60% of the product price. Put another way, this implies that milk from dairy herds subject to countermeasures with radioactivity levels within safe limits would need to be discounted at no less than 60% if such countermeasures are to be economically effective.

Which sources of information do people most trust when it comes to food safety issues? In our samples, highest degrees of trust were found for information provided by health authorities and "experts" (researchers and scientists). Lowest levels of trust were placed on politicians and the food industry. Rankings of sources of information in terms of degree of trust were in fact very similar between Norway and Scotland, with the greatest degrees of difference being lower levels of trust in the food industry in Norway, and higher levels of trust in "experts" in Scotland.

5. Explaining the variation in willingness to pay to reduce risks

One of the main aims of this paper is to investigate empirically whether risk perceptions or risk-averting behaviour are better predictors of willingness to pay for risk reduction. From the contingent valuation survey described above, three data series of WTP are available: for lamb in Norway, and for lamb and for milk in Scotland. Two alternative indexes of risk perceptions and of risk-averting behaviour were constructed. For risk perceptions, the variable RPI was constructed based on responses to questions concerning people's views on perceived food and health risks related to radiation and nuclear power. The variable RPI2 was, in contrast, constructed from ratings of perceived risk relating to food consumption in general (for example, including pesticides and BSE). Similarly, the variable RBI was constructed using responses on actions taken to reduce risks connected with radiation in food, such as reducing long-term consumption of food types affected by Chernobyl, whist the variable RBI2 related

to more general risk-reducing behaviour, such as avoiding eggs for fear of salmonella, or avoiding eating beef for fear of BSE contamination. Full details on the construction of these four indices is given in Appendix 1 at the end of this paper.

Tables 2-5 show the results. In all cases, we use a Tobit estimator to take account of the censored nature of the dependent variable. As may be seen with the pooled-across-countries WTP data, in Table 2, risk perceptions are in general a stronger predictor of WTP than risk-reducing behaviour. The model contrasting risk behaviour/perception for radiation-specific factors is similar to that comparing perception and behaviour in relation to general food risks, in respect of both the significance of socio-economic variables (eg income significant, family status not significant) and the relative significance and size of risk perception and risk averting behaviour. Income is in both cases a strongly significant determinant of the risk premium, but neither family status or the "worried" variables are significant.

For Norwegian consumers (Table 2), risk perceptions are significant when radiation specific risks are used, but risk averting behaviour is not significant. When general food risks form the indices, risk perceptions are still more important, but risk averting behaviour is now significant at the 90% level. This result on risk-averting behaviour may be due to the rather long time lag since Chernobyl. The Scottish-only data for lamb yields similar although poorer results, mainly due to the small sample size. Risk perceptions are significantly related to WTP when radiation-specific indices are used (RPI and RBI), but it is risk-averting behaviour that significantly affects WTP when general food risks indices are used instead (RPI2 and RBI2). For milk, Table 5 reveals poor results, again perhaps due to a small sample size. Only family status is significant.

6. Conclusions

Results from our data set show that people care about risks that "scientific opinion" does not recognise. Respondents in our two samples from Norway and Scotland were willing to pay

significant premiums for a (hypothetical) product which had no higher objectively-measured risk than an otherwise identical alternative. This is entirely rational given the Ajzen and Fishbein conceptual model of attitudes and behaviour towards risky alternatives, and confirms findings in many other branches of the literature that subjective measures of risk are more relevant to policy over health and safety than objective measures. The policy implication is that authorities may be wasting resources if, following a distant nuclear accident, they engage in countermeasures aimed at making affected food supplies and agricultural production systems "safe". However, we do not know from this data how long this risk premium persists after such an event.

We also found that risk perceptions were more important in determining how much people were willing to pay as a risk-reduction premium than previous risk-averting behaviour. This may, in a sense, seem an odd contrast to make, since risk perceptions should be closely related to risk-averting behaviour. In fact, in our sample, the correlation between the two were quite low: 0.12 between RPI and RBI, and 0.24 between RPI2 and RBI2. From a policy perspective, this finding is however, encouraging, since it implies authorities could increase the acceptability of "safe" products by changing peoples' risk perceptions. In this regard, the findings from our study on most trusted sources of information are important. These showed that information from "experts" and health authorities are most trusted, with information from politicians and the food industry being least trusted. However, previous research (20) has suggested that prior beliefs may have a bigger impact on perceived risks than new information, so that the ability of authorities to increase the acceptability of treated, safe products may be fairly limited in the short term.

Table 1: Willingness to Pay estimates

	Lamb		Milk
	Scotland	**Norway**	**Scotland**
N (valid, > 0)	158	684	172
Given price	£2.50/pound	NOK 50 /kg	£0.40/pint
Mean WTP (extra for preferred product)	£0.72	NOK 18.00	£0.24
As % of original price	29%	37%	60%
95% ci for WTP	0.563 – 0.892	16.77 – 19.22	0.199 – 0.272
Standard deviation	1.048	16.32	0.241

Table 2 WTP Tobit regressions for lamb, combined Scotland and Norway data

	Radiation-specific risks		**Food risks generally**	
	Coeff.	*t-stat*	*Coeff*	*t-stat*
Constant			-1.5677	-0.673
RPI	4.282	4.219	**	**
RPI2	**	**	2.038	3.776
RBI	-0.366	-1.315	**	**
RBI2	**	**	0.967	1.678
Income	0.0002	7.03	-0.0001935	6.748
Worried	0.493	0.876	0.6629	1.201
Family	1.446	1.056	1.2928	0.942

N= 842

RPI, RPI2, RBI, and RBI2 are defined in Appendix 1.

Income = Stated annual gross household income

Worried = Likert scale from 1 to 5 (not at all worried …somewhat worried …very worried) measuring degree to which respondent was worried about suffering ill health from radioactive contamination.

Family = Dummy variable if respondent has children and/or partner.

Table 2 WTP Tobit regressions for lamb in Norway

	Radiation-specific risks		**Food risks generally**	
	Coeff.	*t-stat*	*Coeff*	*t-stat*
Constant	4.2958	1.14	5.63	2.02
RPI	3.01	2.72	**	**
RPI2	**	**	1.87	3.09
RBI	-0.364	-1.20	**	**
RBI2	**	**	0.867	1.39
Income	0.00000499	1.45	0.00000443	1.29
Worried	0.904	1.46	0.95	1.57
Family	1.36	0.88	1.23	0.80

N= 684

Table 4. WTP Tobit regressions for lamb in Scotland

	Radiation-specific risks		**Food risks generally**	
	Coeff.	*t-stat*	*Coeff.*	*t-stat*
RPI	0.331	1.75	**	**
RPI2	**	**	0.0986307	1.17
RBI	0.0526176	1.04	**	**
RBI2	**	**	0.16407	1.91
Income	0.0000028	0.36	0.0000026	0.34
Worried	-0.03063	-0.321	-0.02021	-0.221
Family	0.0986	0.489	-0.01282	-0.063

N = 158

Table 5 WTP Tobit regressions for milk in Scotland

	Radiation-specific risks		**Food risks generally**	
	Coeff.	*t-stat*	*Coeff*	*t-stat*
RPI	0.0222	0.545	**	**
RPI2	**	**	0.00258	0.013
RBI	-0.00845	-0.749	**	**
RBI2	**	**	0.0159	0.809
Income	0.00002067	1.132	0.0000229	1.27
Worried	0.0326	1.554	0.032	1.491
Family	0.0916	2.007	0.08894	1.907

N = 172

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Appendix One:

Construction of risk indices

Risk Perception Index for Norway – Mean based on the scores given to:
Likelihood of suffering ill health caused by radioactive contamination in food
Agree or disagreement with the statement 'I would be willing to let my family and I eat food that has been treated against radioactive contamination'
Likelihood of contracting a serious disease caused by Chernobyl accident through food consumption
How safe or unsafe it is to eat lamb
How safe or unsafe it is to eat game
Agreement/disagreement with statement "The health risk associated with radioactivity is considerably exaggerated"
Agreement/disagreement with statement "Preventive measures against radioactivity in food do not make the food as safe for consumption as the experts claim"

Risk Perceived Index for Scotland – Mean based on the scores given to:
Likelihood of suffering ill health caused by radioactive contamination in food
Agreement or disagreement with statement 'I would be willing to let my family and I eat food that has been treated against radioactive contamination'
Likelihood of getting a serious disease caused by Chernobyl accident through food consumption
How safe or unsafe it is to eat lamb
How safe or unsafe it is to eat beef
Agreement/disagreement with statement "The health risk associated with radioactivity is considerably exaggerated"
Agreement /disagreement with statement "Preventive measures against radioactivity in food

do not make the food as safe for consumption as the experts claim”

Risk Behaviour Index for Norway – Mean based on scores given to
How often the respondent has avoided buying lamb due to fear of radioactivity in the meat
Long term reduction in consumption of wild mushrooms due to Chernobyl
Long term reduction in lamb consumption due to Chernobyl
Long term reduction in consumption of venison (game) due to Chernobyl
Short term reduction in lamb consumption due to Chernobyl
Short term reduction in wild mushrooms consumption due to Chernobyl
Short term reduction in game consumption due to Chernobyl

Risk Behaviour Index for Scotland – Mean based on scores given to
How often the respondent has avoided buying lamb due to fear of radioactivity in the meat
Long term reduction in consumption of wild mushrooms due to Chernobyl
Long term reduction in lamb consumption due to Chernobyl
Long term reduction in consumption of beef due to Chernobyl
Short term reduction in lamb consumption due to Chernobyl
Short term reduction in wild mushrooms consumption due to Chernobyl
Short term reduction in game consumption due to Chernobyl

Risk Perceived Index 2 – Mean based on the scores given to:
Likeliness of suffering ill health caused by sunbathing/too much sun
Likeliness of suffering ill health caused by chemical additives in food
Likeliness of suffering ill health caused by bacteria infected food
Likeliness of suffering ill health caused by pollution from industry
Agreement or disagreement with: "I am willing to accept a tax increase next year, if I know the money will be spent on a programme that would impose stricter food safety regulation on the food processing industry"

Risk Behaviour Index 2 – Mean based on the scores given to:
During the previous 12 months how often avoided buying poultry or eggs because of fear of salmonella
During the previous 12 months how often avoided buying / eating beef because of BSE (mad cow disease)

END NOTES

[1]We did not use a mail shot in Scotland due to a worry over low response rates