Food Policy 41 (2013) 112–123

Contents lists available at SciVerse ScienceDirect

Food Policy

journal homepage: www.elsevier.com/locate/foodpol

How many bad apples are in a bunch? An experimental investigation of perceived pesticide residue risks

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ARTICLE INFO

Article history:
Received 28 May 2012
Received in revised form 19 April 2013
Accepted 29 April 2013
Available online 5 June 2013

Keywords:
Subjective risk
Internal validity
Pesticide residue
Apple

ABSTRACT

Subjective risks of having contaminated apples elicited via the Exchangeability Method (EM) are examined in this study. In particular, as the experimental design allows us to investigate the validity of elicited risk measures, we examine the magnitude of differences between valid and invalid observations. In addition, using an econometric model, we also explore the effect of consumers' socioeconomic status and attitudes toward food safety on subjects' perceptions of pesticide residues in apples. Results suggest first, that consumers do not expect an increase in the number of apples containing only one pesticide residue, but, rather, in the number of those apples with traces of multiple residues. Second, we find that valid subjective risk measures do not significantly diverge from invalid ones, indicative of little effect of internal validity on the actual magnitude of subjective risks. Finally, we show that subjective risks depend on age, education, a subject's ties to the apple industry, and consumer association membership.

Introduction

Despite progress that international and national authorities have made toward ensuring food safety (e.g., food-labeling, packaging, inspections), food-related risks still get the attention of a substantial proportion of consumers. For example, approximately 30% of all Europeans remain concerned about health consequences of pesticide residues in food (European Commission, 2010).

As both short- and long-term health outcomes induced by food safety are often uncertain, people's own risk estimates become crucial for understanding their choice-behavior towards food products or policies (Kivi and Shogren, 2010).[1] In fact, several empirical investigations have shown that subjective risks often dictate consumers' choices far more than science-based risk predictions would, especially when subjective estimates differ from science-based ones (e.g., Jakus et al., 2009). There might be two general reasons why such a discrepancy exists. First, while science-based risk estimates are simple averages based on frequency values for homogenous populations, individual subjective risks are heterogeneous, and causes for this heterogeneity can be observed or unobserved. For many individuals, their subjective risks might be accurate, and not truly equal to the average population risk. Second, some individuals may make mistakes in processing risk-related information, and formulate estimates that are higher or lower than the science-based predictions. Much of what economists know about subjective risks has been borrowed from initial work by psychologists (e.g., Slovic, 1987).

Although an extensive literature has shown that subjective risks related to financial outcomes affect people's choices in several branches of applied economics (see Manski, 2004 for a review), a relatively small number of studies have investigated the influence that subjective risks related to health outcomes have on people's behavior related to their everyday choices. A few studies have primarily coped with estimates of health risks related to smoking behavior (e.g., Viscusi, 1990; Gerking and Khaddaria, 2011) as well as drinking contaminated water (e.g., Jakus et al., 2009; Shaw et al., 2012). Unfortunately, little has been done to investigate whether subjective health risks related to food safety affect people's economic choices in their everyday life. A relatively small number of studies have shown that consumers' numerical estimates of health risks (i.e., mortality rate) due to the presence of pesticide residues in fresh fruit and vegetables drive their preferences for pesticide-free fresh fruit and vegetables in hypothetical markets (e.g., Hammitt, 1990; van Ravenswaay and Hoehn, 1991; Buzby et al., 1998).

In contrast to other studies, here we mainly examine the risk of having contaminated apples. In particular, we investigate consumers' subjective probabilities that given proportions of apples produced in the Province of Trento (Italy) will contain pesticide residues in the future. Given that pesticide residues have consequences on health, consumers' expectations about the future

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[1] Here, risk is intended to mean the probability that a given outcome occurs.

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http://dx.doi.org/10.1016/j.foodpol.2013.04.012

presence of pesticide residues in apples likely affect their support for an agricultural policy that the Province of Trento is planning to incentivize the production of pesticide-free apples. The investigation of consumers' preferences for this policy becomes particularly important because the saleable gross production of apple is approximately 23% of the entire agricultural saleable gross production in the Province of Trento (P.A.T., 2010).

The bulk of the literature which has investigated subjective risks related to food safety has barely taken into account the fact that elicited risks might not be valid.[2] An exception is the artefactual field experiment conducted by Cerroni et al. (2012) in which the validity of subjective risks elicited via the Exchangeability Method (EM) (Baillon, 2008; Abdellaoui et al., 2011), an innovative elicitation technique based on the notion of exchangeable events (de Finetti, 1937), has been tested. In this study, the validation procedure is based on the de Finetti's notion of coherence under which risk estimates are coherent if and only if they obey to all axioms and theorems of Probability Theory (de Finetti, 1937; de Finetti, 1974a; de Finetti, 1974b).

Investigating the validity of subjective risks contributes to better understand people's choices under risk and uncertainty. In fact, the inclusion of invalid observations in subjective expected utility or other non-expected utility models used to predict decision-making processes might generate biased results, especially if invalid observations systematically differ from valid ones in terms of magnitude. For example, if invalid subjective risks are systematically lower (or greater) then valid ones, consumers' willingness to support agricultural policies might be underestimated (or overestimated).

Given that, in this current paper, by drawing on Cerroni et al. (2012) results on the validity of subjective risks elicited via the EM, we more carefully analyze the actual discrepancy between valid and invalid risk estimates. In other words, we measure the differences in terms of magnitude, which goes beyond the previous study. Furthermore, we also econometrically identify attitudinal and socio-economic factors that shape subject's perceptions, comparing our results with previous findings.

The remainder of the paper is laid out as follows. In the next section, we review previous studies dealing with perceptions of pesticide residues and its consequences on human health. Next, we define the aims of the current study and provide detailed information about the experimental design. Finally, we offer a discussion of our results.

Subjective risks and pesticide residues

Many stated-preference (SP) studies have investigated the role of consumers' perceptions of health outcomes due to pesticide residues in determining food-purchasing behavior. In general, these studies have shown a negative correlation between people's perceptions of health outcomes due to pesticide residues and willingness to purchase products which contain those chemical substances. Many food products have been considered, ranging from general unlabeled ones (e.g., Misra et al., 1991; Eom, 1994; Rimal et al., 2008) to specific types of fresh fruit and vegetables (e.g., Fu et al., 1999; Boccaletti and Nardella, 2000).

Most previous studies have not focused on subjective risk estimates expressed in a numerical fashion, but on people's concern about the severity of health consequences due to food safety. For example, individuals have been asked to indicate the presence of health risks using simple descriptive labels (e.g., high, medium, or low), likert or other numerical scales.

Eom (1994) has elicited subjects' concern about the presence of pesticides in general commercially grown food products by using a likert scale between 0 (no risk) and 10 (very serious risk). This study has found that the average concern across consumers was quite high, around 6.6. The same approach was taken by Fu et al. (1999), but for fresh fruit and vegetables. In this case, the average level of concern was extremely high, exceeding 6, on a scale between 0 and 7. In their experimental auction for residue-free foods, Roosen et al. (1998) have used a simple scale of concern (1–5) to investigate the influence of subjective perceptions on consumers' bidding behavior. The approach recently used by Rimal et al. (2008) to elicit people's perceptions of pesticide residues in food was even simpler. In fact, individuals were simply asked to state whether the problem of pesticides in food was serious, moderate, or inexistent, and the finding was that more than half the subjects chose the serious option.

Boccaletti and Nardella (2000) have improved the approach used by Misra et al. (1991) implementing a Likert Attitude Scaling Procedure, where individuals are asked several questions and, then, an individual-specific score is calculated to measure the concern about pesticide residues on fresh fruit and vegetables. The mean score across consumers was 78 on the maximum of 100, where the latter value is not a probability per se, but simply indicates very high concern.

Several scholars have questioned whether perceptions measured on some scale, as done in some of the studies above, are good indicators of risk (e.g., Viscusi and Hakes, 2003). At the very least, one would have to make strong assumptions to re-map from a 0 to 10 discrete response scale to a 0–1 unit interval. This could be done for example, to get a relevant risk measure, which is of course a continuous variable on the unit interval. Simple recoding would of course make it impossible to obtain other risk estimates than in 10% jumps (10%, 20%, 30%, etc.).

While these simple efforts are appealing, they are lacking in that they do not provide the information that would be ideal in actual modeling risky behaviors. In fact, measures of concern, or other responses which are not numerical measures, cannot be directly used in either an expected utility or subjective expected utility framework, (Manski, 2004). Hence, many other studies have paid closer attention to the elicitation of actual numerical risk measures. In most of these studies the elicitation scheme is simple, and people are just asked to state risk estimates. The specific magnitude of the outcome that will happen is typically first presented, and individuals are then asked about the probability of this occurring to others (e.g., Viscusi, 1990, asked people to guess how many smokers out of 100 will get, or die from, lung cancer), or to themselves, but many variations in presentation are possible. The techniques which directly elicit subjective risks are called direct methods (Spetzler and Stael Von Holstein, 1975).

Extensive research, much of which is in the psychology literature, has shown that people do not easily understand numerical risks (especially small ones), and, given that, has suggested different approaches (i.e., frequencies) for making people willing and able to state their best estimates (e.g., Gigerenzer and Hoffrage, 1995; Hammitt and Graham, 1999; Corso et al., 2001).

Several studies have shown that mortality risks be couched as deaths per 100,000 or some other number in the population, avoiding small decimal place numbers that are confusing. Buzby et al. (1998) have asked subjects their own subjective probability of dying from consuming fresh products containing pesticides in a similar manner, specifically, as the annual number of deaths per 1 million individuals. Since this probability-estimation task may be difficult for laypeople, subjects in both of these studies were provided with risk ladders showing probability of dying from

[2] In contrast, one might use observed purchases or transactions as a way of revealing individuals' sense of risk, but identification issues may easily arise in the effort to uncover the risks and sort these out from other influences on purchases.