Exploring the Impacts of Risk Communication Policies on Welfare: Theoretical Aspects

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EXPLORING THE IMPACTS OF RISK COMMUNICATION POLICIES ON WELFARE: THEORETICAL ASPECTS•

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Abstract

The aim of this paper is to explore possible measures to assess welfare changes resulting from alternative risk communication policies drawing on previous work on welfare losses due to incorrect risk perceptions. A review of the literature analysing models of risk information processing point out the role of Bayesian updating processes in modelling changing risk perceptions. On the other hand welfare analysis of the consequences of action undertaken under ignorance suggest possible measures of the benefits of improved risk communication. An illustrative example of welfare losses due to poor information is provided using the classical data set on milk contamination in Ohau (Hawaii). Welfare measures are obtained comparing the real observed behaviour with an hypothetical risk perception pattern induced by a more effective risk communication policy.

1. Introduction

The way in which consumers judge food safety and make food choices can change dramatically in situations of crisis such as those occurring in case of a food scare (e.g. BSE) or a food poisoning outbreak (e.g. e-coli). The release of information about a food crisis is likely to cause a fall in demand for that food. Depending on the way governments and food industries react to market failures of this sort through risk communication and depending on consumer trust in the sources of risk information, demand will take a certain amount of time to re-adjust after the downturn following the crisis. One of the main issues associated with the time necessary for demand to re-adjust is the speed of adjustment, with subsequent problems of misallocation of resources and welfare losses for both producers and consumers. In the case of a food scare or poisoning outbreak, both consumer trust in risk information sources and effective communication are likely to play a significant role in bringing back perceived risk to the 'normal' level existing before the crisis occurred. Perceived risk, in turn, influences the way in which demand re-adjusts after the drop occurred as a consequence of the crisis.

The aim of this paper is to explore possible measures to assess welfare changes resulting from alternative risk communication policies drawing on previous work on welfare losses due to incorrect risk perceptions. The paper takes the following structure. We start with reviewing some of the literature analysing models of risk information processing, then move , in section 3, to the impact of changing risk perceptions on demand and analysis of the welfare implications of imperfect risk information. In section 4 we provide an example of how welfare losses due to risk misperceptions can be calculated from the same data used to estimate demand curves. Finally, concluding remarks can be find in section 5.

2. Models of risk information processing

One of the main causes of shift in demand shift due to the occurrence of a food scare is the change in the perception of risk across consumers. Most papers that deal with demand shifts following a food safety crisis analyse risk information processing within a Bayesian learning framework either as

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a stand alone process or as a consequence of information flows mainly triggered by the media. In Bocker and Hanf's (2000) paper for example, consumers are Bayesian agents that update their prior beliefs about supplier reliability following news of product failure. Liu *et al.* (1998) and Smith & Johnson (1988) rely upon the prospective reference theory firstly proposed by Viscusi (1979) by which ex post perceived risk is a weighted average of ex ante perceived risk and stated (or sample) risk estimates based on new information.

When information about a food crisis is first released, perceived risk suddenly rises and remains high even after the hazard has been removed or dealt with. Studies examining the impact of risk information on food purchase show that negative information released by the media has an immediate negative effect on sales, whereas positive media coverage does not seem to have any effect on sales (see for example Smith *et al.*, 1988). Liu *et al.* (1998), on the other hand, argue that it is not necessarily true that positive media coverage does not generate any effect on risk perceptions, but rather that the effect of positive information is likely to be delayed over time. The authors analyse the effects of positive and negative information separately and find that such effects are asymmetrical. Information effects' asymmetry is due to the fact that while consumers tend to react instantly to negative information about food risks, immediately modifying their consumption decisions, they take time to assess the reliability of positive information. As a consequence, positive information has a delayed effect over time on consumption decisions, with consumer trust in the positive information provided (e.g. by governments) playing a key role and, presumably, being able to influence the speed with which demand will re-adjust. Positive and trusted information "can help adjust the subjective risk down to the normal (objective) level" (Liu *et al.* 1998). Conversely, distrust slows down the process by which risk perceptions return back to "normal" levels.

The model applied by Liu *et al.* (1998) analyses the impact of both positive and negative food risk information on consumption decisions in two steps. First, the way in which risk perceptions vary as new information becomes available to consumers is modelled as an "updating process of risk perceptions to media coverage" analogous to a Bayesian decision process in which a temporal adjustment component is included. Subsequently, a demand adjustment equation is estimated based on risk perception changes. The starting point is the prospective reference model developed by Viscusi (1989), in which current perceived risk is expressed as the weighted average of the risk perceived prior to a shock (*ex ante)* and perceived risk after receiving new information (*ex post*). Thus for an individual i current perceived risk can be expressed as:

$$R_{it}^{p} = \omega_t R_{it}^{r} + \theta_t R_{it}^{s} \qquad (1)$$

If positive and negative information effects are included assuming asymmetry of such effects, thus incorporating a temporal adjustment process, equation (1) can be written as:

$$R_{it}^{p} = \omega_t R_{it-1}^{p} + \theta_t f_i\left(NEG_{t-k}, POS_{t-j}, T\right) \qquad k,j = 0,1,2,\ldots \qquad (2)$$

Time can play a further role in the process of moving back to a state of normality, with the impact of information fading as time elapses (Kask and Maani, 1992).

Böcker and Hanf (2000) incorporate consumer trust in suppliers' reliability as a new variable in the Bayesian model describing the temporal updating of risk perceptions and then estimate the impact of risk perception changes on demand.

Smith and Johnson (1988) use a modified form of a Bayesian learning model to describe the way in which individuals use risk information to change their risk perceptions. Such model shows that newly introduced information about the risks of radon concentration in homes and their water supply is "about a third as important as their [the individuals'] prior beliefs in forming a posterior risk assessment".

Smallwood and Blaylock (1991) also point out the need for a framework able to look at the dynamic nature of risk perceptions and their influence on demand over time, albeit taking a slightly different viewpoint. The authors argue that demand models generally assume that costs and benefits of any action occur instantaneously and are fully known, whereas this is not always the case with food safety issues. For example, the benefits of a balanced nutrition are likely to occur after a long-time and may be difficult to measure. At the same time, a delay in the onset of consequences from consumption of hazardous goods is found to be one of the factors influencing risk perceptions together with the severity, reversibility and incidence of consequences (Slovic., 1987).

Ippolito (1981) develops a model to analyse the way in which changes in information about the safety of a good affect its consumption over time. The model's basic assumption is that in the absence of risk, consumption will be stable at a certain level throughout the consumer's life. The release of information about the risks involved in consuming a certain product has three possible effects on demand depending on the nature of the hazard and the effect of the hazard on individuals' survival. The first case is that of hazards for which the probability of survival is inversely related to the cumulative level of consumption (e.g. alcohol consumption). The second case is that of instantaneous effect of the hazard, in which the probability of survival is entirely determined by the current level of consumption (e.g. botulism, e-coli). The third case is that of 'delayed effect' in which current consumption does not affect current survival, but survival after a number of years (e.g. cancer linked to intake of pesticide residues present in foods). In all three cases consumption drops to either a very low level or to zero to pick up again after a certain period of time as determined by two opposing effects: the *age effect* and the *discount effect.* In the first case, the older a consumer, the higher the consumption of a hazardous good will be, as lost utility from future consumption reduces with age. In the second case, increased consumption is expected to reduce survivability and, hence, to diminish utility from future consumption. The question of welfare implications within such framework remains, however, open, as it does the issue of trust in information sources.

Up to this point we have mainly concentrated on the analysis of economics literature. Psychologists have also extensively studied changes in individuals' risk perceptions and the impact of media coverage on the formation of such perceptions. Parallelisms exist between models developed by economists and those proposed by psychologists (see for example Liu *et al.*, 1998, p.692). In the next section the welfare implication of changing risk perception and misperceptions will be illustrated.

3. Welfare analysis

In the context of food safety, welfare losses result not only from deterioration of objective food safety but also from misallocation of resources induced by biased perceptions about the level of safety (Foster and Just, 1989; Swartz and Strand, 1981). In the next sub section a welfare analysis framework for this type of market failure will be illustrated drawing on the existing literature. Subsequently some extensions will be explored with reference to the dynamic nature of the welfare change and the possible presence of interrelated markets.

3.1 Imperfect information about food safety and welfare analysis

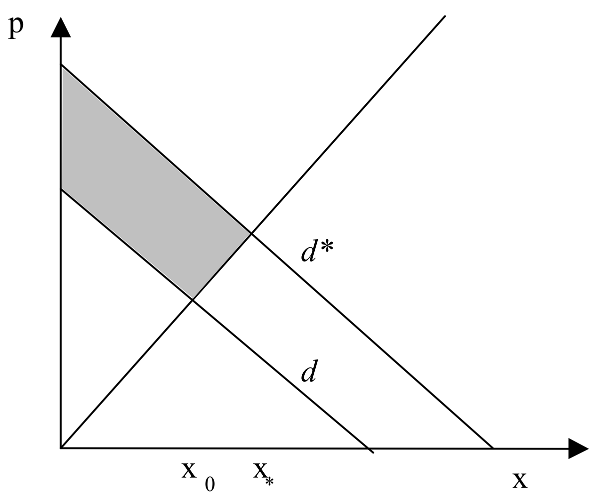

Fig. 1 Welfare losses associated with demand shifts according to Swartz and Strand

A first classification of welfare losses due to a deterioration of food safety is provided by Swartz and Strand (1981) that classify losses in "unavoidable" and "needless". The former occurs when consumers are perfectly informed and their welfare is reduced by an objective lowering of some food safety index. The latter are due to imperfect information about the actual level of food safety so that resources are misallocated as consumed quantities are higher or lower than they would be if the consumer had perfect information (e.g. consumers avoid consuming food that is safe believing that it is risky). This type of losses deserves particularly attention, especially when risk communication policies need to be developed or assessed.

A first measure of needless losses is provided by Swartz and Strand with reference to a case of seafood contamination in the USA. In the case investigated by the authors, consumers living in an area far away from the place where contamination occurred incorrectly believe that the safety of seafood is jeopardized and reduce the level of consumption thus incurring in welfare losses. The welfare loss deriving from such erroneous beliefs is given by the difference between the total surplus area (given by the sum of consumer and producer surplus) under perfect information and the total surplus area under imperfect information as it is illustrated in figure 1. The higher curve (d*) refers to the demand of safe food under perfect information, whereas the lower curve refers to demand in a situation of imperfect information.

However, the Swartz and Strand's measure seems to be affected by the so called paradox of bliss ignorance. To illustrate the problem we take into consideration the case in which a reduction in the level of food safety is underestimated by consumers.

In this case, the paradox goes that, the welfare level in condition of ignorance could be higher than the measure obtained in the informed state (thus ignorance is bliss) as the demand curve would shift downwards when correct information were released. Foster and Just (1989) point out that a welfare measurement related to choices made under ignorance should be always referred to a perfect information state. Indeed, the paradox disappears as soon as welfare is measured in condition of perfect information revealing that choices made under ignorance were not optimal given the actual state of the world.

This point is illustrated in figure 2 where θ_* represents the objective level of a safety parameter whereas θ is the subjectively perceived level of the same parameter. In the case of an improvement with underestimation of the safety level the observed demand curve d (function of price (p), perceived safety (θ) and income (m)) lies under the curve d* that would be observed in condition of perfect information. Thus, the correct measure of needless welfare losses due to ignorance is given by the area between the informed demand and supply curve on the right of the (lower) quantity actually exchanged.

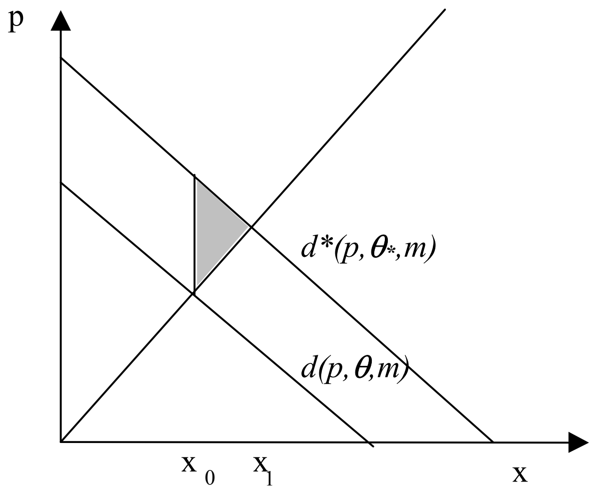

Fig. 2 Welfare losses associated with demand shifts according to Foster and Just

Although consumer surplus is a widely used measure of welfare change, it is well known that such a measure is only an approximation of the true change in consumer welfare (Willig, 1976). Rather, equivalent or compensating surplus or variation should be used as correct welfare measures.

Below we will utilise the definition of compensating and equivalent variation adopted by Foster and Just (1989) which use reversed signs with respect to the usual ones. Whereas Foster and Just (1989) analyse a case of reduced safety following food contamination, in this paper reference is made to some action that restores safety levels at the pre-contamination state. In this context, compensating variation measures the amount of money (in this case negative) that should be added to income in order to keep consumers as well off after the change as they were in the original state provided that they are free to adapt their consumption choices to the new situation (that is, in case of improved safety, they can expand their consumption of the safer food). In the same context, Foster and Just (1989) define compensating surplus as the amount consumers will be willing to pay when they cannot change their consumption pattern following the change but are forced to consume the same bundle of goods they chose in the original state.

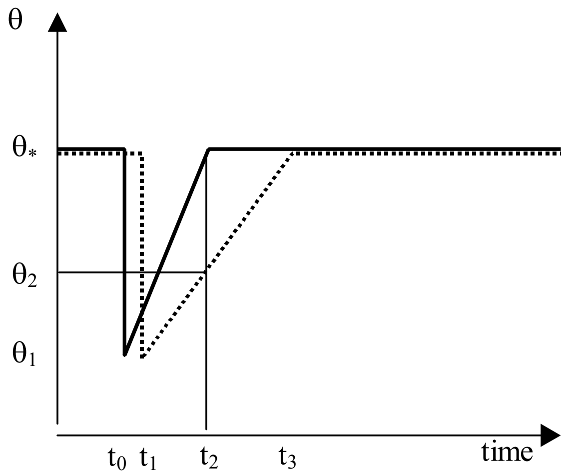

Fig. 3 Subjective perceptions and objective level of food safety in a food scare

The corresponding equivalent measures consider as the baseline utility the utility consumers experience after the recovery of the pre-contamination safety level. Thus, equivalent variation measures the minimum amount of money consumers will be willing to accept in order to forego the change towards the pre-contamination state when they can adapt their consumption bundle to the new, improved, situation. Again according to Foster and Just (1984), equivalent surplus would measure the change in welfare when the consumption bundle is constrained to the level of consumption that would have been chosen in the new, safer, situation. As the authors underline, this level of consumption would not be observed either before or after the safety change if information is incorrect. Thus a possible alternative measure should take again as a reference the initial level of consumption while maintaining as baseline utility the post-change level.

Drawing on Foster and Just (1989), these measures can be applied to the study of need less welfare losses as well. Suppose that the objective level of food safety changes following the time pattern illustrated by the solid line in fig 3. At time t_1 an outbreak causes a drop in the level of safety from $\theta_*$to θ_1. As the government intervenes to solve the problem, the objective level of safety returns back to normality at time t_2. Now, let the subjectively perceived level of safety be represented by the dotted line in the same figure. As communication about the objective level of risk is not completely trusted, the perceived safety recovers to the initial level more slowly and lags behind the objective level for some time. For example, at time t_2 the perceived safety level is θ_2 , still lower than the objective level θ_*.

Taking as reference the utility (U_*) at time t_3 with safety level equal to θ_*, the compensating variation for a change in safety from θ_2 to θ_* is given by:

$$CV = e(p,\boldsymbol{\theta}_*,U_2) - e(p,\boldsymbol{\theta}_2,U_2) \tag{3}$$

where $e(p,\theta,U_*)$ is the minimum expenditure needed to attain utility U_2 at price p and safety level θ. If at safety level θ_2 the optimal consumption of food is x_2, then the compensating surplus for a change from θ_2 to θ_* is:

$$CS = \tilde{e}(p,\boldsymbol{\theta}_*,U_2 | x = x_2) - e(p,\boldsymbol{\theta}_2,U_2) \tag{4}$$

where $\tilde{e}(p,\boldsymbol{\theta},U_2 | x = x_2)$ is the constrained expenditure function indicating the minimum expenditure needed to attain utility U_2, given safety level θ, price p and consumption of quantity $x = x_2$. As the value of a constrained minimization problem is never lower than the value of the unconstrained problem, $\tilde{e}(p,\boldsymbol{\theta},U_2 | x = x_2)$ is greater than or equal to $e(p,\theta,U_2)$ and , consequently $CV \leq CS$. Intuitively, the welfare improvement related to a change of safety level from θ_2 to $\theta_*>\theta_2$ is lower whenever consumers are "forced" to consume the same quantity of food they consumed in the lower safety state. Thus they will pay a smaller amount of money to obtain the change with respect to the case when they are free to adapt their consumption (that is a smaller negative amount of money needs to be added to income in order to keep utility at the original level). Indeed, an improvement in food safety is likely to increase consumption of the safer food and the impossibility to exploit this opportunity lowers consumers' welfare gain.

The needless welfare loss in the case depicted above can be measured by the cost of ignorance (COI), a measure first developed by Foster and Just (1984, 1989), given by the difference between CS and CV:

$$COI = \tilde{e}\left(p, \boldsymbol{\theta}_*, U_* \middle| x = x_2\right) - e\left(p, \boldsymbol{\theta}_*, U_*\right) \quad (5)$$

COI measures the welfare losses that consumers bear since at time t_2 they don't choose the optimal consumption level of food given the objective safety level θ^* . Rather, believing that safety level is θ_2 instead of θ_* they are likely to consume a lower quantity of the food (x_2) giving raise to a needless welfare loss. Noticeably, as in the case of the total surplus loss illustrated in fig. 2, measurement of welfare gains and losses takes place in condition of perfect information. That is, consumer welfare is measured under condition of improved information by comparing the consequence of informed actions with those of misinformed ones (i.e. consumption of quantity x_2). In this situation, COI is an ex post measure of the value of better information stemming from the partial removal of self-protection activities such as avoiding consumption of unhealthy food and self-insurance activities aimed to reduce the prospective severity of the health consequences.

COI measures have been applied to a number of cases. Teisl et al. (2001) use the framework to evaluate the welfare impact of nutrition information using scanner data from a field experiment in the USA. Mazzocchi and Stefani (2002) provide a COI measure for withheld information referring to the BSE scare in Italy. Another recent application of the COI measure is an experimental work by Rousu et al. (2002) about the value of verifiable information in the market for GM foods. Interestingly, measures of COI can also be obtained within the decision theory framework and the random utility models used to analyse discrete choices. While decision theory provides well established measures of the ex post value of information messages (Hirshleifer and Riley, 1992) , the investigation of COI in the literature on random utility and choice experiments is a relatively recent and promising development (Leggett, 2002).

3.2 Possible extensions of the framework

The framework illustrated in the previous subsection, can be enriched considering a number of interrelated markets rather than the single market of the affected food and evaluating the effects of different degrees of inflexibility on both the supply and the demand side of the markets. A further area of investigation leading to an extension of the framework illustrated in the previous section is the analysis of the dynamic nature of the adjustment process. As ineffective risk communication is one of the causes of the slow adjustment back to objective perceptions of safety, the longer consumers overreact to a food safety crisis (that is the longer it is the interval between t_1 and t_3 in figure 3) the longer the market misallocates resources by continuing to produce and exchange lower than the optimal quantity of food.

There is a paucity of literature investigating these points in a welfare analysis framework. A noticeable exception is the work of Rausser and Walraven (1990) that analyses the dynamic effects of linkages among exchange rate, interest rate and commodity future markets. The temporal pattern followed by prices after a shock originated in one of the markets is evaluated by means of a dynamic welfare analysis whereby welfare losses occurred in each period are discounted and summed up to give the present value of welfare changes.

In this model the producer side of the market is taken into account as well within a partial equilibrium analysis of market behaviour and related welfare changes. As for the case of biased risk perception, external shocks cause unexpected demand shifts away from the long run equilibrium level that in turn misplace production decisions causing welfare

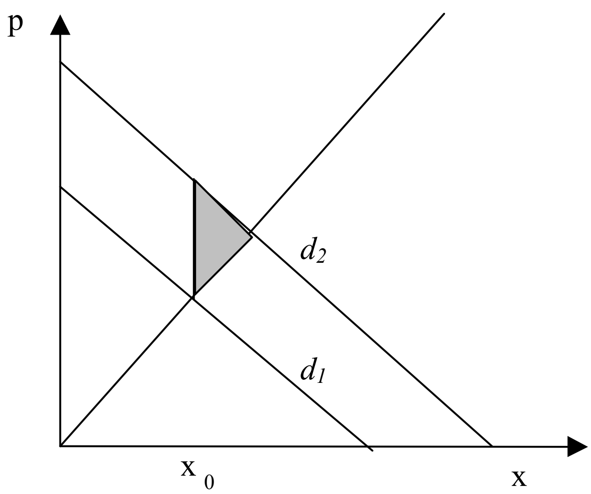

Fig. 4 Welfare losses due to inaccuracy of forward prices

losses. This is the same misallocation problem investigated in speculative markets where optimal resource allocation depends on the accuracy of forward price at the time production decisions are taken (Stein, 1981). The welfare losses are similar to those illustrated in the safety change context. Again, it is the shift of the demand curve relative to the forecasts that causes the losses but now rationing is determined by the lower quantity supplied (fig. 4). For example, farmers allocate farm area to a crop in order to produce quantity x_0 as they expect demand d1 to occur (following the observation of future prices at the time decision is taken). Subsequently, an external shock shifts demand to d_2 but production decision can no longer be changed, thus underproduction and higher prices result leading to the welfare loss given by the shaded triangle.

If markets are linked, shocks in one market lead to different degrees of disequilibrium in other markets depending on the relative flexibility of supply across a number of periods until equilibria are re-established. To some extent this model could be applied to food scares as well, especially when supply elasticities vary across substitute goods . Indeed, so far, COI measures has been investigated only from the consumer point of view and within a static framework.

As risk communication policies shape the pattern according to which risk perception and food consumption return to normality, the welfare impact of these policies need to take into account the temporal dimension of the adjustment and its impact on welfare. This may be approximated by the accumulated sum of welfare losses resulting in each period from misallocation of resources due to biased perceptions. To some extent this is only an approximate measure as it does not consider what has been termed by Keen (1990) the intertemporal compensating variation that is the maximum amount individuals would be willing to pay in order to reallocate expenditure (and utility) across periods. A correct measure of intertemporal welfare change should be given by the compensating or equivalent variation in the initial wealth. However, such measures are not available from market data unless welfare change is captured by the value of some marketable asset (Freeeman III, p.203-207). This is not usually the case of food safety changes. In such context the present or future value of single period changes seems to be the only feasible alternative that can be relied upon to assess risk communication policies.

In the following section an example of how needless losses can be measured with reference to a hypothetical communication action will be provided. Unlike previous applications of COI, the dynamic nature of the adjustment process will be explicitly taken into account.

4. Needless losses: an illustration of the COI calculation for an hypothetical case

In order to illustrate how needless losses can be measured in the context of the assessment of alternative risk communication strategies, we have reproduced some of the findings of Foster and Just (1984, 1989) work using a slightly different dataset provided by S. Liu . The purpose of such exercise is to show how a measure of the dynamic welfare effects of a risk communication policy can be calculated. Of course, the implementation of the policy is hypothetical, the only aim of the exercise being methodological. The database contains price, income and consumption data about a case of milk contamination with heptachlor, a highly toxic and carginogen pesticide, that occurred in the island of Ohau (Hawaii) in 1982. Inhabitants of the island became aware of the contamination by mid March 1982. As soon as the news of contamination spread, milk consumption dropped dramatically (Fig. 5). Although, starting from May, media news became encouraging and reported that milk safety was back to

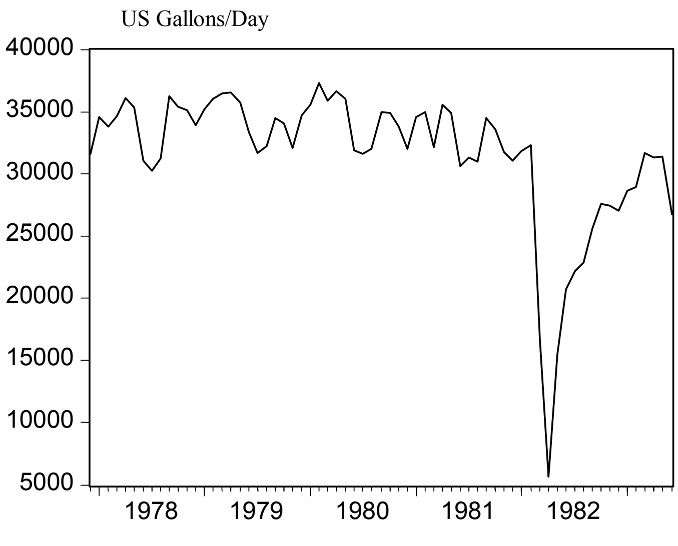

Fig. 5 Monthly consumption of fresh milk in Oahu-Hawaii (Foster and Just, 1989)

normality, consumers remained wary for a longer time and pre-contamination levels of milk consumption were recovered only one year later. In that occasion public authorities were criticised for delaying the disclosure of information to consumers thus providing the case for the measurement of the cost of ignorance. Besides Foster and Just, the Oahu case was studied by other authors (Smith et al., 1988; Liu et al., 1998) that mainly focussed on modelling the impact of media news on risk perception and , consequently , on demand shifts. Our focus is rather on assessing the needless losses due to the slow recovery of milk consumption to normal levels after the scare. Drawing on the paper by Foster and Just we estimated the Hawaii milk demand curve and recovered the indirect utility and cost functions to obtain CS and CV measure for different levels of perceived food safety (alternatively, demand systems can be derived from known expenditure functions (See for example Mazzocchi and Stefani (2002) and Teisl et al. (2001)). Following Foster and Just (1989r), a semilog specification of the milk demand was adopted. Demand is thus represented by the function:

$$x_t = f(\theta_t) e^{\gamma m_t - \alpha p_t} \quad (6)$$

where x_t represents monthly per capita milk consumption (in half gallon units), m_t real per capita income (in 1967 US dollars) and p_t is milk price (dollars per half gallon). The single valued index $f(\theta_t)$ summarises the impact of the perceived safety level (θ) on milk demand. The semilog functional form and the associated direct and indirect utilities have two desirable properties:

$\partial U / \partial f > 0$, $\partial V / \partial f > 0$ and $\partial f / \partial \theta > 0$

f and x satisfy weak complementarity (if x=0 then $\partial U / \partial f = 0$)

The first property assures that perception of increasing safety levels positively affects utility and demand for milk . The second implies that when consumption is zero no further losses in utility occur following a deterioration of the safety level. The expenditure function that Foster and Just (1989) retrieved from this demand specification (let aside multiplicative constants) adopting the Hausman (1981) procedure is of the form:

$$e(p_t, U_t, \theta_t) = \frac{1}{\gamma} \ln\left[\frac{1}{\alpha} f(\theta_t) e^{-\alpha p} + K + U\right] \quad (7)$$

for some constant K.

Moreover, Foster and Just (1984, 1989) provided a dummy variable specification for the index $f(\theta)$ compatible with the semilog form of the demand function and capable to account for the varying time pattern of milk consumption during the crisis (that is sudden fall and slow recovery):

$$f(\theta_t) = A e^{\beta p_1} \exp\{\delta d_t + a_M D_{March} + a_A D_{April} + b(1+t)^{-c} D_t^*\} \quad (8)$$

where A is a constant; p_1 is the price of fruit nectar considered as a milk substitute; d_t is a dummies for months when school is in session; D_{march} and D_{april} are dummies for the months where the safety level changes while D* =1 for any month following disclosure of information (May 1982 and subsequent months) and 0 otherwise; t indexes months starting from May '82 with t=0, June '82 with t=1 and so on; A, β, δ, a_M, a_A, b and c are unknown parameters. Provided that c >0, the term $b(1+t)^{-c}$ tends to zero as time elapses thus capturing the slow recovery of demand after the dramatic drop in the aftermath of contamination news. Noticeably, greater values of c account for faster pace of recovery of consumption to normal levels.

Monthly data from December 1977 to June 1983 were used to estimate the demand equation with non linear least squares. -The estimated coefficients are as follows (t statistics in parentheses):

$\ln x_t$=	.990	+.000970 m_t	-0.766 p_t	+0.007 $p1_t$	+0.095 d_t
	(1.37)	(0.58)	(-1.97)	(0.04)	(6.57)
	-0.751D_{March}	-1.831D_{April}	-0.776 D_Star$_t$	*$(1+t)^{-0.578}$	R^2=.97
	(-14.63)	(-35.73)	(-16.20)	(-10.28)	

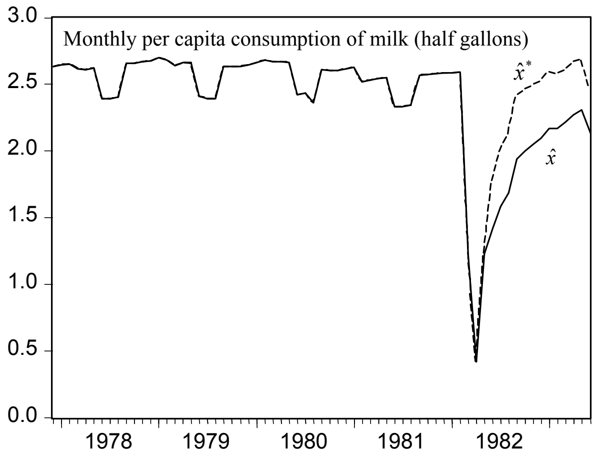

Fig. 6 Hypothetical effects of improved risk communication

The estimated f(θ) captures the effect of the media coverage of the scare on consumers' risk perceptions. In order to provide an example of how alternative risk communication patterns impact on consumer welfare an artificial series of milk consumption was created setting to –1.35 the exponent of the (1+t) term of the index. The value is arbitrarily taken from the range that generates a faster adjustment process. In figure 6 the fitted values of the original demand equation ($\hat{x}$) and those of the artificial one (x^*) are shown. As it was expected the greater the value of c the faster the recovery of consumption to normal levels. This pattern could be considered the (hypothetical) outcome of improved risk communication.

For each month following May 1982 the two different level of milk consumption ($\hat{x}$ and x^*) correspond to subjective perceptions of milk safety $\hat{\theta}$ and θ^* respectively. It is assumed that θ^* is a better approximation of the objective safety levels, given the higher value of *c*. Therefore, consumers behaving under ignorance incur in needless welfare losses given by the Cost of Ignorance illustrated by equation 5. Even if this is only an illustrative simulation, there are reasons to believe that actually consumers overreacted to the food scare and that the return to normality was too slow with respect to the objective conditions of safety (see Liu, (1998)).

The expenditure functional form (7) leads to the following representation of CV and CS for a change from $\hat{\theta}$ to θ^* (Foster and Just, 1989):

$$CV = \frac{1}{\gamma}\ln\left[\frac{\gamma}{\alpha}\left(f(\theta^*)e^{\gamma m^* - \alpha p^*} - f(\hat{\theta})e^{\gamma\hat{m} - \alpha\hat{p}}\right) + 1\right] \quad (9)$$

$$CS = \frac{f(\hat{\theta})e^{\gamma\hat{m} - \alpha\hat{p}}}{\alpha}\left[\ln f(\hat{\theta}) - \ln f(\theta^*)\right] \quad (10)$$

Each measure has been computed for June 1982 trough June 1983 (see Table 1) together with the COI value which is given by the difference between CS and CV. The value of per capita milk consumption in 1967 dollars given in the last column of the table (VMC), assess the relative importance of needless losses. Besides single period welfare losses, the accumulated amount of these values at an interest rate of 5% is shown. Given the ex post nature of the COI (consumers become aware of their losses only once they are fully informed), a future value rather than a present value of the flow of compensating amounts seems more appropriate.

Of course, as the modified consumption pattern is hypothetical, the only aim of the exercise is to show how the COI measure can be implemented in a real-like case to assess the impact of alternative risk communication strategies. To this purpose a sensible simulation of the impact of risk communication on food demand is required.

5. Concluding remarks

In this paper we have explored the welfare effects of suboptimal temporal adjustment of risk perception. Drawing from the literature about welfare impact of misallocation of consumption under ignorance, a measure of the overall welfare change induced by risk communication policies is proposed. As such policies affect the way in which risk perceptions change over a certain time span, it is possible to compute single period welfare losses corresponding to consumption choices made in a situation of poor information relative to an improved information status. The ex post cost of ignorance is given by the difference between compensating surplus (calculated holding constant the consumption

Table 1 Needless welfare losses due to ignorance

	CS	CV	COI	VMC
June '82	-0.40	-0.45	0.05	0.94
July	-0.49	-0.55	0.06	0.99
August	-0.50	-0.57	0.06	1.06
September	-0.55	-0.62	0.06	1.18
October	-0.54	-0.60	0.06	1.27
November	-0.52	-0.58	0.05	1.23
December	-0.51	-0.56	0.05	1.21
January '83	-0.50	-0.55	0.05	1.27
February	-0.48	-0.53	0.04	1.28
March	-0.47	-0.51	0.04	1.36
April	-0.47	-0.51	0.04	1.30
May	-0.46	-0.49	0.04	1.33
June	-0.41	-0.44	0.03	1.08
Posticipated COI (r=0.05)			0.66	

bundle as it is chosen under ignorance) and compensating variation. Single period measures can subsequently be accumulated to provide an overall present or future value measure of the impact of risk communication.

We provide an example of how COI can be calculated for a case where the demand shift induced by changing risk perceptions is estimated ex post by means of a simplified functional form and using observed data from a milk contamination scare. Other works on the same food scare (Liu et al., 1998; Smith et. al. 1988) try to analyse the impact of different types of information (such as positive *vs.* negative media news) on demand. By pursuing this strand of research it is possible to build up models that relate demand shifts to a number of social variables that in turn can be targeted by specific communication actions. Social psychologists have already explored these issues within the framework of social amplification of risk (Renn et al., 1992). As it was stressed in section 2 the parallelism between models developed by psychologists and economists need further investigation in order to provide reliable assessment of the welfare effect of risk communication policies.

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