AVALUATION: Estimating the Economic Value of the Avalanche Bulletin

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ABSTRACT: When planning their excursions, backcountry and out-of-bounds skiers rely on avalanche bulletins that provide information about the danger level, the snow conditions and other safety-relevant aspects. The users of avalanche bulletins and accompanying information maps are charged only a nominal price that covers the transmission costs (e.g. costs for internet use) but does not bear a relationship to the costs of providing this information. Under these conditions, it is not possible to use market information to place a monetary value on avalanche bulletins. Here, we present a contingent valuation study to estimate the economic value of avalanche bulletins to the users. For this purpose, we draw on data of an internet-based survey, which asked users of the Swiss avalanche bulletin about their valuation of improved avalanche information. Based on the stated answers, we are able to (i) estimate the willingness-to-pay for improvements in the avalanche bulletins and—by making assumptions about the reduction in avalanche fatalities due to the improved bulletin service—to (ii) value the avalanche bulletin in monetary units.

KEYWORDS: Avalanche Bulletin; Contingent Valuation, Willingness-to-pay; Value of Statistical Life.

1 INTRODUCTION

Over the last two decades, backcountry travelling and out-of-bounds skiing have become increasingly popular winter sport activities in Europe (Holler, 2007; Zweifel et al., 2006) and North America (Grimsdottir and McClung, 2006; Stethem et al., 2003). For example, the share of the Swiss population who state that they do backcountry skiing has more than doubled within the last eight years (Lamprecht et al., 2008). Most of these backcountry activities take place in avalanche terrain and thus it is not surprising that snow avalanches are the most important risk associated with these recreational activities.

In the last 20 years, almost 90% of the avalanche victims in Switzerland were backcountry or out-of-bounds skiers (SLF, 2009). This corresponds to approximately 23 recreationists dying each year in avalanches, or an average mortality risk of about 10^{-4} per year (Waeger and Zweifel, 2008). Despite the rising number of people who are travelling in the backcountry and ski out of maintained resorts, the avalanche risk has been slightly decreasing. In a recent paper, Etter and colleagues (2008) analyzed this trend and concluded that the main reasons for this decrease are improved avalanche warnings, better education among recreationists and new developments in emergency rescue devices.

This improvement does not come as a free lunch. Indeed, the Swiss avalanche warning Service issues its avalanche bulletin at an average annual cost of CHF 6 million (US$ 5.6 million). It is, however, unclear by how much the bulletin reduces the statistical risk to die in an avalanche. Even if the risk reduction could be roughly estimated, it is difficult to monetize these benefits. Yet, economists would recommend that, when evaluating the avalanche bulletin service, at least some consideration be given to its benefits. One way of determining the economic value of the bulletin is by assessing the willingness-to-pay (WTP) for the bulletin service. In contrast to North America, there is no market for avalanche related information in Europe. Hence, estimation of the WTP for avalanche related information has to be based on non-market valuation methods (Bateman et al., 2002; Freeman, 2003).

This paper presents the first attempt to value the Swiss avalanche bulletin in monetary units. We present a contingent valuation (CV) survey conducted during the winter season 2008/09 to elicit the WTP for improvements in the avalanche bulletin. Our results can be used to estimate the value of reductions in the risk of dying in an avalanche. To our knowledge, this is the first valuation study focusing on avalanche warning information although there have been CV studies on avalanche risk mitigation measures (Leiter and Pruckner, 2008). The rest of the paper is structured as follows. In section 2, we describe the survey and the respondents; section 3 introduces the CV method; section 4 presents major results of the empirical analysis and section 5 concludes by drawing some implications of our findings.

2 SURVEY & RESPONDENTS

In February-April 2009, we posted an invitation to participate in an opinion survey on the web site of the WSL Institute for Snow and Ava-

lanche Research (www.slf.ch). By clicking a link, visitors to the web site were re-routed to the survey, which was available in German, French, English or Italian. Fortunately, we had a very good response. A total of 1,197 persons participated in the survey. To guarantee a convincing sample of professional mountain guides, we invited members of the Swiss Mountain Guide Association per email to participate in the study; 73 professional guides did so. Table 1 displays descriptive statistics of sample characteristics.

Variable	N	Mean	Std. Dev	Min	Max
Years of education	1172	16.1	2.6	4	21
Monthly income (in CHF)	1111	7675	3348	2500	13000
Gender (male = 1)	1197	0.85	0.36	0	1
Age	1171	40.5	12.0	14	76
Married (yes = 1)	1197	0.65	0.48	0	1
Children (yes = 1)	1197	0.40	0.49	0	1
Mountain guide (yes = 1)	1197	0.06	0.24	0	1
Leading groups (yes = 1)	1197	0.48	0.50	0	1
Backcountry skills (very experienced = 1)	1197	0.29	0.45	0	1
Caught in avalanche (yes = 1)	1197	0.20	0.40	0	1
Avalanche education (yes =1)	1183	0.76	0.43	0	1
Grasp of bulletin (most of the time, often = 1)	1197	0.40	0.49	0	1
Own perceived risk (lower than average = 1)	1197	0.42	0.49	0	1
Risk behavior in traffic (risk taking = 1)	1197	0.21	0.40	0	1

Table 1. Relevant sample characteristics.

The survey was comprised of five parts. It started by asking questions to find out whether the respondent is a professional guide or a recreational user of the mountain environment, and by inquiring about his or her level of proficiency as a backcountry skier, out-of-bounds skier or snowboarder, and downhill skier. We also asked how many times the respondents had already gone on a trip in the winter season 2008/09 and how often they had gone in the previous season 2007/08.

In part 2, we inquired about the use of the bulletin and the general awareness about avalanche risks. Respondents were asked whether they regularly look up the avalanche bulletin before a backcountry excursion, and if so, how they access the bulletin. Further, we asked whether they had ever attended an avalanche prevention, safety and rescue training and what safety and rescue equipment they bring along on a backcountry excursion or an off-piste run. To validate the stated information, we additionally asked respondents how much they had spent on avalanche search and rescue equipment over the last 5 years and how often they practice rescue searching every winter season.

In part 3, respondents reported about their comprehension and ease of use of the avalanche bulletin. We also asked them whether they had ever been caught in an avalanche. Respondents then rated several statements about avalanche accidents and prevention as well as about their familiarity with and use of avalanche risk reduction methods. This part closed with the question at the heart of this study—people's willingness to pay for an improved avalanche bulletin. Respondents were randomly assigned to one of two possible treatments for the WTP question. Those receiving treatment 1 were told about an enhanced avalanche bulletin service that would provide more detailed local information and a longer forecast range, which should aid in excursion planning. Those receiving treatment 2 were given the same information, but were also reminded that every year on average 20 people die in recreational avalanche accidents. The enhanced avalanche bulletin service would reduce the average number of fatalities to either 16 (first subvariant of treatment 2) or 14 (second sub-variant of treatment 2). Again, assignment to the sub-variants within treatment 2 was random.

All respondents were queried about their WTP for the enhanced service using a sequence of two dichotomous choice questions. Specifically, people were asked whether they would be willing to pay a fee for having annual access to the hypothetical service. The height of this fee amount was selected at random from a preselected list of bid amounts (CHF 15, 40, 50, 100, 200). If the respondent agreed to pay the proposed amount, we questioned him again at a higher amount (CHF 40, 50, 100, 200, 300). If he declined to pay, we asked him if he would pay a lower amount (CHF 7, 15, 40, 50, 100). Only those respondents who answered "no" to both payment questions were asked to directly state their maximum WTP. Table 2 reports the sequence of answers to the WTP questions. For all treatments a decrease in the number of positive responses for increasing bids is observed. Although this trend is not monotonic, it indicates that respondents' statements are sensitive to the height of the bids proposed.

When asking people to report their WTP for a specific reduction in the number of avalanche fatalities, it is important to learn whether they believe that their risk of dying in an avalanche is lower, the same as, or higher than that of the average backcountry skier. We asked such a question immediately after the WTP question. In parts 4 and 5 we collected information about sport preferences, risk behavior, health status and personal characteristics of the respondents.

Initial Bid	Treat	YY	YN	NY	NN
	T1	33.81	35.97	14.39	15.83
CHF 15	T2a	29.11	36.71	8.86	25.32
	T2b	41.51	39.62	5.66	13.21
	T1	39.50	17.65	15.97	26.89
CHF 40	T2a	36.07	16.39	19.67	27.87
	T2b	34.43	24.59	18.03	22.95
	T1	11.82	38.18	5.45	44.55
CHF 50	T2a	13.56	37.29	3.39	45.76
	T2b	11.48	42.62	0.00	45.90
	T1	7.83	24.35	19.13	48.70
CHF 100	T2a	7.27	29.09	27.27	36.36
	T2b	0.00	37.10	27.42	35.48
	T1	6.31	17.12	19.82	56.76
CHF 200	T2a	1.96	25.49	19.61	52.94
	T2b	3.77	15.09	20.75	60.38

Table 2. Response sequence (in %) to payment questions per treatment (YY = yes first bid, yes second bid, etc.).

3   METHOD

One option to monetarily assess goods for which no market and, hence, no price information exists is by applying the CV method. CV is a questioning technique where information on the value of goods is gathered by directly asking respondents how much they would be willing to pay for the provision of the non-market good. Theory suggests that the value of weather warnings such as the avalanche bulletin should be the value of the losses to life and property that people manage to avoid thanks to the warning itself, net of the costs of issuing these warnings.

Suppose that when the avalanche danger is unknown, backcountry recreationists and out-of-bounds skiers would incur death or serious injuries with probability q_0. Further suppose that the information provided by the bulletin would enable a skier to bring down his risk of dying to q_1 (i.e. $q_1 < q_0$). Hence, the value of the avalanche bulletin corresponds to the skier's WTP for $\Delta q = q_0 - q_1$, or, in words, the maximum amount of money that can be subtracted from the skier's income at risk q_1 for him to experience the same utility as with the initial level of income and q_0:

$$V(y - WTP, q_1, \mathbf{p}; \mathbf{X}) = V(y, q_0, \mathbf{p}; \mathbf{X}), \quad (1)$$

where $V(\cdot)$ is the indirect utility function, y is income, p is the vector of all prices, and X is a vector of individual characteristics of the skier.

To assess the WTP for the avalanche bulletin service, we surveyed 1,197 backcountry recreationists informing them that, at present, their

risk of dying in an avalanche accident is q_0, and that an improvement of the avalanche bulletin could reduce this risk to q_1. Respondents were then asked how much they would be willing to pay for such an enhanced bulletin. In particular, we used the dichotomous choice procedure outlined above. Based on the responses, we could infer the interval into which the respondent's WTP falls. Those who declined to pay at both offered prices were requested to report their maximum WTP for the improved information. Therefore, our sample consists of a mix of interval-data and continuous observations on WTP. Formally, let $f(\cdot, \theta)$ and $F(\cdot, \theta)$ denote the pdf and cdf of WTP, θ is a vector of parameters. The log likelihood function of the sample becomes:

$$\ln L = \sum_{i \in G_1} \ln[F(WTP_i^H; \boldsymbol{\theta}) - F(WTP_i^L; \boldsymbol{\theta})]$$
$$+ \sum_{i \in G_2} \ln f(WTP_i; \boldsymbol{\theta}), \quad (2)$$

where WTP_i^H (WTP_i^L) denotes the upper (lower) bound of the interval around the WTP for respondents with interval-data information (subsample G_1). Respondents of subsample G_2 provided an exact WTP amount.

Several explanatory variables were available to examine the determinants of the respondents' WTP for the improved avalanche bulletin. We started with estimating mean WTP using two major covariates, which represent the experimental treatment the respondent was assigned to. They were included as (i) a dummy variable TREAT1 equaling one if the respondent was assigned to treatment 1, which does not mention the number of lives saved by the improved bulletin; and (ii) an indicator ΔLARGE equaling one if the description of the hypothetical avalanche bulletin mentions that on average 6 lives saved could be saved a year. When a lognormal distribution of WTP is assumed, this implies that:

$$\ln WTP_i^* = \beta_0 + \beta_1 TREAT1_i + \beta_2 \Delta LARGE_i + \varepsilon_i, \quad (3)$$

where WTP* denotes the true WTP, which is latent for respondents in subsample G_1 and observed exactly for respondents in subsample G_2, and ε is an i.i.d. normal error term with mean zero and constant variance σ^2.

To learn about the determinants of WTP, we included further regressors that measure individual characteristics of the respondent (income, gender, age, marital status, children, education) and capture attitudes and beliefs about avalanche risks, ability to avoid or reduce such risks, and effectiveness of the avalanche bulletin in conveying information about risks. Specifically, we entered dummies into the model denoting

that the respondent (i) is a professional guide, (ii) leads groups of skiers, (iii) has advanced backcountry or out-of-bounds skills, (iv) has attended an avalanche safety education, and (v) has been caught in an avalanche before. We further included a proxy for risk tolerance referring to road traffic risks. Finally, dummy variables indicating the respondents' understanding of the avalanche bulletin were included assuming that WTP for improving the bulletin should depend on how satisfied one is with the format and ease of interpretation of the existing bulletin. Section 4 reports the major results of our regression analysis.

4 RESULTS

Our approach described in section 3 aims to answer two questions: How much are backcountry skiers willing to pay on average for advanced avalanche danger information provided in avalanche bulletins? And which factors have positive/negative influence on the respondents' stated WTP? Out of the 1,197 respondents 8 did not answer the WTP question, 218 stated a zero WTP and 971 would be willing to pay a positive amount. Table 3 presents median and mean WTP based on equation (3) assuming a lognormal distribution and using only the sample of the 971 positive WTP answers.

Subsamples	Median WTP	Mean WTP
Treatment 1 (lives saved not mentioned)	53.57	87.49
Treatment 2a (smaller risk reduction)	77.17	126.03
Treatment 2b (larger risk reduction)	81.44	133.01
Observations	971	971

Table 3. Median and mean WTP for enhanced avalanche information based on N = 971 respondents with positive WTP.

Respondents in treatment 1, who were not informed about the number of lives saved (483 individuals), have a median (mean) WTP of CHF 54 (CHF 87). Depending on their sub-variants, respondents in treatment 2 received different information on numbers of lives saved. They were either informed that the enhanced avalanche bulletin service would reduce the average number of avalanche fatalities from 20 to 16 (treatment 2a) or to 14 (treatment 2b). 195 (187) respondents valued the smaller (larger) risk change. The median (mean) WTP of respondents valuing the smaller risk reduction is CHF 77 (CHF 126); those valuing the larger risk change have a median (mean) WTP of CHF 81 (CHF 133). While the WTP estimates under treatment 1 are significantly lower than the ones

under treatment 2, WTP of individuals who assessed the smaller and larger risk change are not significantly different from each other.

To test for significant determinants of WTP we run a regression based on the comprehensive model, which additionally includes individual characteristics and respondents' risk attitudes (the results are available from the authors upon request). The estimates show that attendance of an avalanche safety education course and personal income significantly increases the height of the stated WTP. Other variables included are not statistically significant, meaning that they do not impact the height of the WTP for improved avalanche information.

As mentioned, respondents who stated a zero WTP were excluded from the above regression analysis. Since we are interested in the factors that may explain a zero response (i.e. an unwillingness to pay), we examined the stated answers using a probit model. In this model, the dependent variable is a dummy indicating zero WTP (1 if respondents state a zero WTP, 0 else), which we regress on the explanatory variables listed in section 3. We find that people who have children, professional mountain guides, advanced backcountry skiers, people with higher risk tolerance and those who believe that their risk of dying in an avalanche is lower than the risk of the average backcountry skier are significantly more likely to have a zero WTP.

These findings suggest that the value of additional avalanche information in the bulletin is of less value for experienced backcountry skiers. Indeed, feedback from some of the professional guides let us assume that they consider the offered improvement of little extra worth, as they rely much more on their experience and local knowledge than on the information provided by the avalanche bulletin.

The finding that participants who do have children are more likely to state a zero WTP is surprising. We expected that people with children are more willing to pay for information that could possibly save their life. Respondents with higher risk tolerance and/or those who think that their subjective avalanche risks is below average are also not willing to financially support enhanced avalanche bulletins. This is in line with our basic assumption about the economic value of risk reducing information given in equation (1). If someone has a higher risk tolerance, he or she should be willing to pay less to reduce this risk; similar, if someone's subjective baseline risk is smaller, he or she should be willing to pay less to reduce this risk (Pratt and Zeckhauser, 1996). Thus, we see these results as an indication of behavioral validity of our study.

5 CONCLUSIONS

This paper estimates for the first time the monetary value of avalanche warnings. The valuation is based on a contingent valuation study in which 1,197 users of the Swiss avalanche bulletin were asked about their maximum WTP to access an extended avalanche bulletin service. The median (mean) WTP for this enhanced service ranges from CHF 54 to 81 (CHF 87-133) depending on the information that respondents received about the number of lives saved as a positive consequence of the improved avalanche warnings. From these results, we conclude that the avalanche bulletin is a highly appreciated service for whose improvement a considerable WTP among the users of the Swiss avalanche bulletin exists.

We find that advanced skills in avalanche safety and rescue as well as increasing income leads to significantly higher WTP statements. Hence, we conclude that recreationists who are well educated and therefore more aware of avalanche risks would have most use for enhanced avalanche information.

Focusing on the determinants of zero WTP we argue that professional mountain guides, experienced backcountry skiers, risk tolerant persons and skiers who perceive their subjective avalanche risk as below average are significantly more likely to refuse financial support for extended avalanche bulletins. For these people, the existing avalanche bulletin seems to be a sufficient source of information. While we could identify some of the characteristics of these defaulters, it will be a next step to integrate their zero responses into the estimation of WTP in order to adjust the value of enhanced avalanche information.

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