SONDERFORSCHUNGSBEREICH 504

Rationalitätskonzepte,
Entscheidungsverhalten und
ökonomische Modellierung

No. 04-13

Evaluating Lotteries, Risks, and Risk-mitigation Programs Ño A Comparison of China and the United States

Mei Wang*
and Paul Fischbeck**

April 2004

Financial support from the Deutsche Forschungsgemeinschaft, SFB 504, at the University of Mannheim, is gratefully acknowledged.

*Sonderforschungsbereich 504, email: meiwang@sfb504.uni-mannheim.de

**Carnegie Mellon University, Social and Decision Science Department, email: pf12@andrew.cmu.edu

Universität Mannheim
L 13,15
68131 Mannheim

Evaluating Lotteries, Risks, and Risk-mitigation Programs

— A Comparison of China and the United States

Mei Wang

University of Mannheim, Germany

Address: University of Mannheim, SFB504, L13, 15-17, 68161 Mannheim, GERMANY

Email: meiwang@sfb504.uni-mannheim.de

Paul S. Fischbeck

Social & Decision Science Department, Engineering & Public Policy Department,

Carnegie Mellon University

ABSTRACT

Two experiments were designed to explore the existence of systematic differences in risk perceptions and risk attitudes between Chinese and U.S. participants. The first experiment involved ranking monetary lotteries using measures of perceived riskiness and WTP. Several simple heuristics were evaluated to predict perceived riskiness and WTP. Using WTP responses, cumulative prospect theory functions were determined for participants from both countries. Compared to their U.S. counterparts, Chinese participants are found to be less risk averse and to have higher within group agreement for each task. The second experiment involved ranking real-world risks and associated risk-mitigation programs using measures of concern and preference, respectively. Conjoint analysis reveals additional cultural differences in the perception and evaluation of multi-attribute risks and risk-mitigation programs. The cross-cultural versus cross-task variation are discussed.

Keywords

risk perception; conjoint analysis; cumulative prospect theory; risk attributes; risk mitigation

JEL : C91, D81

Biographical sketch about each author:

Mei Wang

Ph.D. (Decision Science) May 2003: Social and Decision Science department, Carnegie Mellon University. Currently she is a postdoc in University of Mannheim, Germany. Email: meiwang@sfb504.uni-mannheim.de

Paul S. Fischbeck

Professor of Social &Decision Sciences, and Engineering & Public Policy in Carnegie Mellon University. Ph.D.: Stanford University. Email: pf12@andrew.cmu.edu

INTRODUCTION

Because of economic globalization and an awareness that ecological problems span the world, countries have to negotiate and coordinate on risk-mitigation planning. For example, international cooperation is called for fighting against natural disasters (e.g., Bruce, 1999; Gürer, 1998), pollution (e.g., Wilkening, 2001; Lai, 2001), and terrorism (e.g., Dibb, 2002). Understanding how people with different cultural backgrounds perceive risks is a critical research with direct policy implications. To date, most studies on risk perception and risk preference have included only North American and European participants (e.g., Englander et al., 1986; Holtgrave & Weber, 1993; Johnson & Tversky, 1984; Krewski, et al., 1995; Slovic, Fischhoff, & Lichtenstein, 1980; Slovic, et al., 1996). Studies using Asian participants are relatively scarce (Rorhmann, 1999). The extent to which results from the western studies can be generalized to Asian cultures is open to question.

This paper reports two experiments designed to explore cultural differences in risk attitudes and risk perception. Two streams of cross-cultural risk studies are relevant to the current study. The first is about monetary risks. Typically multi-outcome lotteries are used to test the prediction power of various models. For example, Weber and Hsee et al. conducted several studies on cross-cultural differences in risk judgment and risk preferences (Weber & Hsee, 1998; Bontempo, Bottom, & Weber, 1997; Hsee & Weber, 1999). They found that Chinese respondents were less risk-averse based on the risk-attitude definition found in traditional expected utility theory. The second stream of studies follows the psychometric framework established by Fischhoff, Slovic, Lichtenstein, Read, and Combs (1978), who suggested more dimensions may be relevant to the concept of risk in people's mind. Factor analyses are commonly used to discern the underlying cognitive structures of perceived risk.

For example, Zhang (1994), Xie (1995), and Xie, Wang & Xu (2003) investigated the structure of risk concepts across specific environmental, safety, and societal hazards. However, it is difficult to compare their results directly with Anglo-European studies, because only Chinese participants were recruited, modified response scales were used, and few detailed analyses were reported.

Our approach differs from the above studies in that conjoint designs are used for all tasks: this enables us to check the importance of each dimension in the evaluation of lotteries, hypothetical risks, as well as hypothetical risk-mitigation programs. Conjoint analysis is a method frequently used in marketing science, which helps to reveal the relative importance of different attributes when choosing multi-attribute products. Although hypothetical stimuli have been criticized for the lack of external validity, the conjoint design in this study encourage explicit trade-offs that are essential to many decision (Payne, Bettman, & Sckade, 1999).

The first experiment involves ranking and pricing multi-outcome lotteries. The second experiment extends the study to more general multi-attribute risks and risk-mitigation programs. We have two purposes in this study:

(1) The use of multiple tasks and subject populations with different cultural backgrounds make it possible to examine both cross-cultural variation and cross-task variation. Although culture could play a role in people's risk preference, it is also argued that individuals actually "construct" their preferences, which means preferences are largely depend on the characteristics of the objects that are evaluated (Fischhoff, 1991). The present study seeks evidences to support this latter view.

(2) The WTP data in the first experiment also allowed us to fit cumulative prospect theory (CPT) models at individual level. Though CPT is the best-accepted alternative theory to expected utility (EU) theory, the shape of value (or utility) function is still on debate. For example, although the well-known S-shaped value function has received empirical evidence, the reverse S-shaped utility function suggested by Markowitz (1952) is also supported by some investigations (Levy & Levy, 2002). Moreover, the value or utility function in loss domain is more controversial than in gains (Fennema & Assen, 1999). Therefore, when fitting CPT function in this paper, we includes more relaxed forms of value function that are not restricted to the standard S-shape, but allow concavity or convexity in either gains or losses. In addition, we design *mixed-outcome* lotteries as stimuli for the first experiment because the typical use of pure positive or negative in previous studies has been criticized as not realistic enough and subject to the bias of "certainty effects" (Levy & Levy, 2002).

EXPERIMENT 1: EVALUATING MULTI-OUTCOME LOTTERIES

The objective of the first experiment is to model risk perceptions and attitudes towards multi-outcome lotteries. Specifically, the predictive power of several simple decision heuristics are tested, the relative importance of *mean*, *variance*, and *probability of loss* are examined, and parameter values of value function and probability weighting functions are fit for each individual.

Methods

Participants

In both U.S. and China, university students were recruited from psychology and economic classes, using an electronic bulletin board announcement. Participants in the study were 35 U.S. students, (20 women and 15 men, aged 18 to 40), and 37 Chinese students (17 women and 20 men, aged 21 to 32).

Design and Tasks

Participants were given two groups of three-outcome lotteries sequentially. The tasks involved ranking the riskiness of lotteries within each lottery group and giving a WTP for each lottery. WTP was allowed to be negative if the participant judged the lottery as unattractive, at which case the negative WTP is equivalent to Willingness To Accept (WTA). By design, we manipulated three attributes of the lotteries: (1) four levels of expected value (EV — −$10, −1, $1, $10); (2) two levels of standard deviation (SD — 15, 40), and (3) two levels of probability of negative outcomes (P(−) — 0.30, 0.70), resulting a $4 \times 2 \times 2$ design and 16 lotteries. See Table 1 for the design of all lotteries. These lotteries were divided into two groups based on their expected value, with each group containing eight lotteries. The EV of one task was positive ($1 and $10), while the EV of the other task was negative (−$1 and −$10). Each lottery was displayed on a card to facilitate ranking. The orders of two tasks were alternated to avoid order effects.

Insert Table 1 about here

Back-translation methods (Brislin, 1986) were used to create the Chinese version of the materials. The questionnaire, originally written in English, was translated into Chinese by one of the authors. Then, a different bilingual translated the instruments back into English. The two English versions were compared and discrepant passages rewritten. Monetary lottery outcomes were calibrated based on estimates of monthly living expenses of college students in the U.S. and China[1].

Every participant received a large envelope that included a cover letter and four smaller envelopes labeled 1-4. The first two tasks were the lottery tasks in the first experiment. The last two tasks were ranking tasks for risks and risk-mitigation programs in the second experiment, which are described later. In each small envelope, there were eight cards, a description of the specific task, and a set of questions. The participants were asked to open the big envelope, read the cover letter, and complete the four tasks in sequence. The four tasks took a total of 20-45 minutes to complete.

Simple Heuristics

When faced with uncertain choices, individuals can use simple heuristics rather than considering the entire probability distribution of outcomes (Boussard & Patit, 1967; Alderfer & Bierman, 1970). For example, when choosing between monetary lotteries, some individuals can focus on (a) the probability of loss, denoted as P(−) (Bontempo et al., 1997; Alderfer & Bierman, 1970); (b) the minimum outcome, denoted as MIN (Lopes,1987; Weber & Hsee 1998; Alderfer & Bierman, 1970); (c) the maximum outcome, denoted as MAX (Lopes, 1987; Bontempo et. al., 1997); or (d) the spread calculated as maximum outcome minus minimum

[1] One Dollar ($) in English version of questionnaire is converted to one Yuan (Chinese currency) in Chinese version because it is estimated that the monthly expense is about $500~$800 for a student in the U.S., and about 500~800 Yuan for a student in China.

outcome, denoted as MAX−MIN (Ranyard, 1998). Other heuristics are also possible.[2] Using the data collected from our first experiment and the published results from Bontempo et al. (1997) and Weber & Hsee (1998), we evaluated how well these four simple heuristics and one algorithm (EV) performed in predicting how individuals ranked multi-outcome lotteries in terms of perceived riskiness and WTP at the aggregate level.

Fitting CPT

A CPT model (Tversky & Kahneman, 1992) was fit for each participant. We assume that (1) individuals had consistent value functions that could be modeled using their reported WTPs; (2) they could have different value functions for losses and gains (Kahneman and Tversky, 1979); and (3) the value functions had the following functional form:

$$v(x) = \begin{cases} x^{\alpha} & if \quad x \geq 0 \\ -\lambda(-x)^{\beta} & if \quad x < 0 \end{cases} \qquad (1)$$

where α and β are risk-aversion coefficients for gains and losses respectively; and λ is the loss-aversion coefficient.[3] For each lottery, the three outcomes were ranked from worst to best, $x_{-m} < \ldots < 0 < \ldots < x_n$. The weighting function for gains is:

$$\pi^{+}(p_i) = w^{+}(p_i + \ldots + p_n) - w^{+}(p_{i+1} + \ldots + p_n) \qquad (2)$$

[2] We also evaluated three other heuristics: (1) the sum of gains, SUM(+); (2) the sum of losses, SUM(−); (3) the probability of gains, *P(+)*. In our tasks, SUM(+) and SUM(−) were highly correlated with MAX and MIN, respectively, and *P(+)* was equivalent to P(−). We do not discuss these heuristics further.

[3] Because the loss aversion coefficient λ was found to be insensitive insensitive to the results in our data, and did not improve the model fitting (i.e., adding λ into the model did not reduce the RMSD), we hold this value to 1. Similar practices with λ can also be found in Lopes & Oden (1999) and Bernstein, et al. (1997).

where $$w^{+}(p)=\frac{p^{\gamma}}{(p^{\gamma}+(1-p)^{\gamma})^{1/\gamma}}.$$

The weighting function for losses is:

$$\pi^{-}(p_i)=w^{-}(p_{-m}+\ldots+p_i)-w^{-}(p_{-m}+\ldots+p_{i-1}) \qquad (3)$$

where $$w^{-}(p)=\frac{p^{\delta}}{(p^{\delta}+(1-p)^{\delta})^{1/\delta}}.$$

The value of the lottery is represented as $V=\sum_{i=1}^{n}\pi(p_i)v(x_i)$. Using the Solver tool in Excel, the 4-parameter CPT model was fit by minimizing the RMSD (rooted-mean-squared-deviation) between predicted WTP and actual WTP for each individual participant.

Results and Discussion

Differences on pricing of lotteries

Main effects of both nationalities (F(1,1134)=12.5, p<0.001) and lotteries (F(15,1120)=4.93, p<0.001) were found, but no interaction effect between nationalities and lotteries existed. The mean price offered by Chinese was −$5, which was higher that the mean price of −$18 offered by the U.S. participants. Since the average WTP from both cultures are lower than the average expected value of lotteries listed in Table 1, the average participants from both cultures could classified as risk-averse based on the traditional expected-utility definition of risk-attitudes. Consistent with other previous studies (e.g., Weber & Hsee, 1998), Chinese participants seemed to be less risk-averse than the U.S. participants.

Simple heuristics

To test the prediction power of simple heuristics, correlation analyses were performed at the aggregate levels for the current study, and for the published data of the studies by Bontempo et al. (1997) and Weber & Hsee (1998). Table 2 presents the results of correlation and significance tests for all studies. For each nationality, the lotteries from the two studies were ranked using the average stated riskiness ratings, denoted as Rank*(*riskiness*)*. The lottery with the lowest average stated riskiness rate was ranked first. These ranks were then compared to the ranks generated by sorting the lotteries based on each heuristic, denoted as Rank(heuristics).The lowest value was ranked first. We also compared the average value of WTP and the value based on each heuristic. The prediction power of each heuristic is summarized below.

Insert Table 2 about here

EV (*mean value*) — The fourth column in Table 2 shows that except for Weber & Hsee (1998)'s results of perceived riskiness, ranks of EV were negatively correlated with ranks of riskiness, and EV was positively correlated with WTP. These results were in the same direction as one would expect, higher EV implying lower risk and higher value. The reason for the unexpected patterns in Weber & Hsee (1998)'s results is probably because in their lottery designs: EV was positively correlated with the variance of lottery, which was associated with perceived riskiness.

MAX orMIN (*best or worst payoff*) — As shown in Table 2, MAX was not a consistent predictor for perceived riskiness, but was significantly correlated with WTP as expected, indicating the best outcome is important when pricing the lotteries, whereas it plays a less important role when judging riskiness. In almost all studies, ranks of MIN were correlated with ranks of perceived riskiness, implying worst outcome is a better predictor for riskiness judgments. MIN was also highly correlated with WTP in current study. The unexpected positive correlation of MIN and WTP in Weber & Hsee (1998)'s study may still be explained by their lottery designs — EV was negatively related to MIN in their lotteries, resulting in a negative correlation between MIN and WTP.

MAX–MIN (*range of payoffs*) — In all studies, ranks of (MAX−MIN) were correlated with Rank(riskiness) as expected, i.e., larger range of outcomes implying higher risk. The correlation between Rank(MAX−MIN) and Rank(riskiness) in Weber & Hsee (1998) is somewhat higher for Chinese participants (p=0.10), but this difference is not replicated in other studies. Regarding the pricing of lotteries, WTP is negatively correlated with MAX-MIN in the current study, indicating risk-averse attitudes. The positive correlation of MAX−MIN and WTP in studies by Weber & Hsee (1998) is perhaps again caused by the correlation of EV and variance in their lottery designs.

P(–) (*probability of loss*) — P(−) seemed to be an unstable predictor for perceived riskiness and pricing of lotteries. In the current study, it conflicted with what one can expect — higher probabilities of loss were actually associated with lower perceived riskiness and higher prices. A further look at lottery designs in the present study indicated a negative correlation between P(−) and MIN, which may explain the unexpected pattern of correlation. In the current study, it seemed that the information of probability was largely neglected by participants or dominated by the magnitude of potential loss. In previous studies by Bentempo et al. (1997) and Hsee & Weber (1998), ranks of P(−) were positively related to ranks of riskiness as expected. This correlation was significantly higher for the U.S. participants in the study by Hsee & Weber (1998) ($p<0.05$), which was in the line with the previous findings that Chinese subjects were less accurate in probability calibrations (Wright et al., 1983). Similar difference emerged in Bentempo et al. (1997).

Although across-person tests can cause aggregate errors (Nickerson and McClelland, 1989), the above correlation analyses serves as a starting point to link the three studies. It provides evidence of relatively robust prediction powers for some heuristics, and rather inconsistent performance of other heuristics. The different impacts of heuristics in risk judgment and pricing tasks support previous studies on preference reversal, which suggest that individuals tend to offer higher price for $ bet (low-probability, high payoffs), but choose P-bet (high probability, low payoffs), because the attention shifts as the response modes change (Tversky, Slovic & Kahneman, 1990). Because lotteries can be conceived as multidimensional stimuli, it is found that pricing is more highly correlated with payoffs of the lotteries, whereas rating or choice are more highly correlated with the probability involved (Slovic and Lichtenstein, 1968). An asymmetric preference reversal between riskiness rating and choice was found in a study on hazard risk decisions (Kuhn and Budescu, 1996), with many subjects choosing an option of in a pair that they rated as more risky. It is found that subjects' preference of options was consistent with expected value, even though this information was not provided in the stimuli; on the other hand, the ratings of riskiness were quite consistent with expected loss. Our results suggest the magnitude of loss (MIN) and the range of outcomes (MAX-MIN) are more important in risk judgments, whereas the magnitudes of gain/loss (MAX or MIN) are more important in pricing lotteries. Comparing our results to the studies by Weber and Hsee (1998), it appears that more attention shifts to the downside of payoffs when negative outcomes are involved in the lotteries, and when negative WTP or Willingness To Accept (WTA) are allowed.

The only significant cultural difference in the heuristics analysis was the correlation between ranks of P(−) and ranks of riskiness in the results by Hsee & Weber (1998). But generally speaking, the cross-task differences seemed to be stronger than cross-cultural within-task differences for most heuristics.

Conjoint Analysis on EV, SD, and P(−)

Because we used a 4×2×2 experimental design for EV, SD, and P(−) , we were able to analyze the relative importance of each dimension, using a conjoint analysis approach (Hair, Anderson, Tatham, & Black, 1992). For example, to evaluate the importance of P(−) for each participant, we calculated the differences in the sum of ranks of lotteries with high level of P(−) with the sum of ranks with low level of P(−). Then, we compared the average difference scores for all U.S. participants and Chinese participants for all of the attributes (i.e., EV, SD, and P(−)).

Table 3 presents the results of the conjoint analysis for all lottery tasks. EV was significant in both riskiness ranking and WTP assessments tasks for both nationalities, but was more important to Chinese participants in the riskiness ranking tasks ($p < 0.05$). The SD of the lotteries was important to both nationalities when ranking riskiness. P(−) was significant but opposite to expected direction for most tasks. As discussed before in our heuristic analysis, P(−) was not a straightforward predictor for risk judgment and pricing. It is not clear whether this is because people overestimate the small probability of relatively large loss or gains (Tversky & Kahenamann, 1992) or because they totally ignored the probability dimension. No cultural differences were found for SD and P(−).

Insert Table 3 about here

Fitting CPT

The cumulative distributions of the two estimated parameters in value function are shown in Figure 1. In the gain domain, the median value of risk coefficient α was 0.79 for the U.S. sample and 0.80 for Chinese sample. The median value of risk coefficient β was 0.99 for the Chinese sample and 1.64 for U.S. sample. As Figure 1 demonstrates, the distributions of estimated parameters were not significantly different in the gain domain for the two national samples, but in losses, the U.S. sample was more risk-averse ($p<0.01$).

Figure 2 shows the cumulative distributions of the weighting function parameter for both countries in gains and losses. The median value of the gain parameter (γ) was 0.39 for the U.S. sample and 0.54 for the Chinese sample, whereas the median value of the parameter in loss (δ) was 0.45 for the U.S. sample and 0.46 for the Chinese sample. The left panel in Figure 2 indicates that the U.S. sample tended to have smaller values in the weighting function in gain, while the right panel shows little difference between the two countries. In other words, the weighting function for U.S. sample seemed to be more curved in gains, but the two nationalities were similar in weighting probabilities of losses.

Insert Figure 1 about here

Insert Figure 2 about here

Figure 3 plots α and β for each subject — the closer the value is to 1, the more risk neutral the individual. Figure 3 shows that the majority of participants demonstrated risk preferences that were either (1) risk-averse in gains and risk-averse in losses; or (2) risk-averse in gains and risk-seeking in losses. The first pattern is actually implied by the traditional universal concave utility function. The second pattern is consistent with the S-shape value function in prospect theory (Tversky & Kahneman 1992). The consistent risk-averse attitudes in gains and more diverse risk-attitude in losses are also supported by previous research in framing effects (Schneider, 1992).

Insert Figure 3 about here

In summary, the first experiment reveals some cross-cultural differences in heuristics and risk-attitudes for mixed-outcome lotteries. In the next section we will focus on the cultural-differences in evaluation of multi-attribute risks and risk-mitigation programs.

EXPERIMENT 2: EVALUATING MULTI-ATTRIBUTE RISKS AND RISK-MITIGAITON PROGRAMS

The first experiment focused only on monetary risks as presented in lotteries. In everyday life, however, people face a variety of risks that have more attributes than single-attribute monetary lotteries. In the original work by Fischhoff et al. (1978), nine qualitative psychometric risk variables were listed. In extended studies (Slovic, Fischhoff, & Lichtenstein, 1980; Slovic, Fischhoff, & Lichtenstein, 1985), they found that perceived and acceptable risks were predictable by risk variables and underlying factors. Since 1978, numerous risk-perception studies have demonstrated that people consider a variety of risk attributes. For example, based on an extensive reanalysis, of Fischhoff et al. (1978), Jenni (1997) suggested that appropriate attributes should include *voluntariness, immediacy, controllability, severity, personal or societal exposure*, *equity*, and *impacts on future generations*, as well as outcome uncertainty measures, such as *newness, knowledge, or catastrophic potential*.

Furthermore, policymakers are interested in people's opinions about risks. Because risks are complex, the lay public can benefit from information materials that represent risks in a relatively straightforward and consistent manner (Morgan, et al. 1996). Risk rankings by lay people can help governments make risk-management decisions (Florig, et al. 2001; Morgan, et al. 2001; Fischbeck et al. 2000); however, it is not enough because risk rankings are not always consistent with the demand of risk mitigation, and for each risk, many strategies can be used for risk mitigation. Policy makers have to allocate limited resources and choose the optimal risk-mitigation programs. Therefore, public attitudes towards risk-mitigation priorities are important inputs for policy-making processes (Morgan et al., 1996). As an extension of previous studies, we designed the second experiment to explore the cross-cultural differences in multi-attribute risk judgment and evaluation of risk-mitigation programs.

Methods

Participants

The participants were the same as in the first experiment.

Design and Tasks

Starting with a conjoint design, a multi-attribute procedure was used to explore the relative importance of different dimensions in people's perceptions of health, safety, and other everyday risks. Participants were given eight hypothetical risks described by seven attributes, and were asked to rank eight hypothetical risks according to their concerns. Each risk was represented on a separate card. Based on previous risk-attribute studies, seven attributes known to be important in lay risk-rankings were selected: (1) *number of expected deaths per year*; (*2) number of illnesses/injuries per year*; (3) *uncertainty of the estimated numbers*; (4) *quality of scientific understanding*; (5) *ability to control exposure*; (6) *the greatest number of deaths in a single episode*; and (7) *time between exposure and effect*.

We also designed a task to assess people's attitudes towards risk-mitigation programs. Respondents were asked to rank eight hypothetical risk-mitigation programs according to how valuable they thought these programs were. As in the previous task, the programs were represented on eight separate cards. Each program has seven attributes: (1) *number of expected lives saved per year*; (2) *uncertainty of the estimated number*; (3) *quality of life improved*; (4) *probability that the program will not help*; (5) *scope of benefits*; (6) *fairness*;

and (7) *when the benefits are realized*. Table 4 presents the design of the hypothetical multi-attribute risks and risk-mitigation programs. Appendix 1 presents the definition of above attributes in risks and risk-mitigation programs.

Insert Table 4 about here

Back-translation methods (Brislin, 1986) were used to create the Chinese version of the materials the same way as in the first experiment. This experiment was conducted after the first experiment. See Experiment 1 for the procedure.

Results and Discussion

Hypothetical Multi-attribute Risks

In order to check the existence of other potential predictors, we ran a linear regression including gender, age, major and nation as independent variables for the relative importance of each attribute. No significant demographic predictors were found except a gender difference for the attribute of *uncertainty of the estimated number of deaths, illness or injuries.* Female participants were less concerned with high uncertainty risks ($p<0.05$).

Insert Table 5 about here

As shown in Table 5, Chinese participants were concerned about all dimensions in risk except for *the time between exposure and impact*, whereas U.S. participants were concerned about all dimensions except for *uncertainty of the estimated number of deaths, illnesses or injuries* and *scientific understanding*. When ranking concerns for hypothetical risks, Chinese and U.S. participants were significantly different on three dimensions: (1) *uncertainty of the estimated number of deaths, illnesses or injuries* ($p < 0.01$); (2) *time between exposure and effects* ($p<0.05$); and (3) *the greatest number of deaths in a single episode* ($p<0.01$). In other words, the U.S participants were somewhat more concerned about risks with higher uncertainty, more immediate effects after exposure, whereas Chinese participants were more concerned about risks that are more catastrophic.

Hypothetical Multi-attribute Risk-Mitigation Programs

Table 5 also shows that when ranking the risk-mitigation programs based on how valuable they are, Chinese and U.S. participants were only significantly different in the *scope-of-benefits* dimension ($p< 0.01$) — although both nationalities preferred broader benefits, it was much more important for Chinese. When evaluating programs, both nationalities were concerned about all dimensions except for the *uncertainty* dimension.

Within-Culture Agreement vs. Between-Culture Agreements (For both experiments)

The within- and between-culture agreements within each task were estimated by the average rank order correlation between all pairs of participants for all tasks in both experiments. In Table 6, two patterns are observed: (1) For all tasks, Chinese participants exhibited higher agreements within each task. (2) For both nationalities, the lowest agreements existed in the tasks of ranking or pricing negative-EV lotteries, whereas the highest agreements existed in the task of ranking risk-mitigation programs. See more discussion about this in the next section.

Insert Table 6 about here

GENERAL CONCLUSION

This study examined three issues related to individual risky decision making: (1) What attributes are important when assessing lotteries, hypothetical risks, and hypothetical risk-mitigation programs; (2) What value and probability weighting functions in CPT are best fit for the data; (3) What heuristics are better in predicting perceived risk and subjective value for monetary lotteries. In this section, we discuss possible culture interpretations of our results and the methodology concerns.

Culture is considered to have relatively stable and constant influences on people. Two cultural factors provided by Hofstede (1980) may be relevant here. One is Uncertainty Avoidance (UA), an index that measures the tendency to prefer stability. In Hofstede' study, the United States had a score of 36, which is much lower than Asian countries (e.g., Hong Kong's score is 61, and Taiwan's score is 73). The higher Uncertainty Avoidance scores for Asian countries (Hofstede, 1980) imply that variance or uncertainty are expected to have greater influences for Chinese participants in risk judgment and lottery valuation. The higher weights on catastrophic potential (i.e., the greatest number of deaths in a single episode) by

Chinese participants in the second experiment might reflect this tendency. However, in the second experiment, the U.S. participants were more concerned about the risks with higher *uncertainty*, and in the first experiment, no significant cultural differences were found for MAX-MIN from the heuristics analysis or for relative weights on SD from the conjoint analysis. Similar to *probability-of-loss* attribute, the attention on uncertainty of risky options seemed to vary across contexts. No conclusive cultural differences were observed concerning *uncertainty* attribute.

Another index, individualism-collectivism distinction, is widely used to explain behavior variations in culture. In general, U.S. participants come from a more individualistic culture in which independence and freedom are encouraged. By contrast, confrontations are not encouraged in the Asian educational tradition, and people are expected to show respect to authorities and be harmonious with others. As a consequence, the collective vs. individualistic culture differences might explain the higher agreements among Chinese participants for all tasks. The student samples used in the current study were supposed to be more homogenous than a more representative national sample, so we expect the differences of agreement rates to be greater for larger population. In addition, the higher concern of *scope of benefits* by Chinese participants in the risk-mitigation task may also reflect their collective culture tradition.

Although cross-national differences did emerge from the two experiments that we conducted, a more remarkable phenomenon in this study, as well as in many previous studies, is that individuals' preferences are more situational-dependent. For example, the current study was motivated by a comparison of several simple heuristics. The correlation patterns of these heuristics in previous studies and in our own studies were very different at the first sight. We considered that some of the differences and anomalies could be explained by the different designs of stimuli and task. A more careful look at the results of the heuristic analysis provides some convergent evidence across all cultures and all studies. For instance, the magnitudes of gain/loss (MAX or MIN) were important in the tasks of pricing lotteries, but less important in riskiness-ranking tasks.

Regarding the CPT function assessment, we should also consider the potential impacts of different elicitation methods used by researchers to assess utility functions. We adopted the certainty equivalence method to assess utility function to make current studies comparable to the study by Weber and Hsee (1998), although many other assessment methods exists, such as probability equivalence methods and preference comparison methods (Farquhar, 1984). Every elicitation method has its advantages and potential sources of biases (Hershey, Kunreuther, & Schoemaker, 1982). Different response modes may lead respondents to attend to different dimensions of the lotteries, which result in systematically different risk attitudes such as findings documented in preference reversal studies (e.g., Tversky et al., 1990; Tversky and Thaler, 1990).

The difficulty of tasks is another factor that can influence preferences. Many researchers have found that it is more difficult for individuals to evaluate the desirability of values on some attributes than others (Hsee, Lowenstein, Blount, & Bazerman, 1999). Our study supports the claim that people have clearer preferences on the attributes that are more familiar, more salient, and less complex (Fischhoff, Welch, & Frederick, 1999). For these attributes, people will have stronger and more stable attitudes, which are called "basic values" (Fischhoff, 1991). In this study, these attributes proved to be *annual deaths*, *annual injuries/illnesses*, and *annual lives saved*. Their relative importance weights were consistently higher in the expected directions. By contrast, an attribute like *P(–)* was not a straightforward predictor in the first experiment, but *probability of failure* in risk-mitigation programs proved to be important to both nationalities in the second experiment. It appears that the use of probability information might vary when the salience or response modes vary. The uncertainty or variance attribute seems to be another example of such unstable attributes.

The views about less stable preferences in negative domains are further supported by two findings:(1) Both nationalities have lowest agreements for negative-EV-lottery tasks and highest agreements for risk-mitigation tasks; (2) The fitting of CPT functions suggests that the risk-averse value function are more stable in gains, but that the shape of value functions are far more variable in the loss domain, a result that is consistent with previous research on the shape of utility functions (Fennema & Assen, 1999) and framing effects (Schneider, 1992).

The message from this study suggests that cross-cultural differences might not be as dramatic as we imagine. Cross-national communication and cooperation on risk-mitigation projects may be quite promising and feasible. A repeated theme underlying the above issues is that people's judgment and choice are greatly influenced by the contexts; on the other hand, we tend to believe that people have some stable and basic values across context and culture. Before drawing any conclusions about cultural differences, we must be aware that sometimes the influence from researchers could be greater than cultures. As we discussed throughout this paper, some seemly trivial changes in stimuli, response modes, or other aspects can affect the preference judgment or decision-making in a dramatic way. We feel that multi-stimuli, multi-response-mode, and multi-analytic-method studies like this one should be encouraged in the future to help us reach more reliable results and gain more insights about people's value structures and decision rules (Weber and Hsee, 1999).

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Table 1. Design of Lotteries in Experiment 1

Lotteries used in Task 1 (EV>0)									
Lottery No.	Outcome1 ($)	Probability1	Outcome2 ($)	Probability2	Outcome3 ($)	Probability3	EV ($)	SD ($)	P(-)
A1	10.50	0.70	-18.50	0.25	-35.00	0.05	1	15	0.30
B1	33.00	0.70	-30.00	0.25	-118.00	0.05	10	40	0.30
C1	45.00	0.05	18.00	0.25	-8.00	0.70	1	15	0.70
D1	153.00	0.05	41.50	0.25	-11.50	0.70	10	40	0.70
E1	27.00	0.70	-63.00	0.25	-43.00	0.05	1	40	0.30
F1	17.50	0.70	-0.10	0.25	-46.50	0.05	10	15	0.30
G1	45.00	0.05	65.00	0.25	-25.00	0.70	1	40	0.70
H1	30.00	0.05	34.00	0.25	-0.10	0.70	10	15	0.70
Lotteries used in Task 2 (EV<0)									
Lottery No.	Outcome1 ($)	Probability1	Outcome2 ($)	Probability2	Outcome3 ($)	Probability3	EV ($)	SD ($)	P(-)
A2	8.00	0.70	-17.50	0.25	-45.50	0.05	-1	15	0.30
B2	11.50	0.70	-41.50	0.25	-153.00	0.05	-10	40	0.30
C2	45.00	0.05	15.00	0.25	-10.00	0.70	-1	15	0.70
D2	147.50	0.05	11.00	0.25	-29.00	0.70	-10	40	0.70
E2	25.00	0.70	-64.00	0.25	-50.00	0.05	-1	40	0.30
F2	0.10	0.70	-34.00	0.25	-31.00	0.05	-10	15	0.30
G2	50.00	0.05	62.00	0.25	-27.00	0.70	-1	40	0.70
H2	28.00	0.05	9.00	0.25	-19.50	0.70	-10	15	0.70

Table 2. Correlation of simple heuristics with Rank(riskiness) and WTP

			Algorithms	Heuristics			
			EV	MAX	MIN	MAX−MIN	P(−)
Correlation between Rank(Riskiness) and Rank (heuristics)	Bentempo et al., 1997	China	-0.70*	-0.21	-0.46*	0.27	0.26
		US	-0.68*	-0.04	-0.46*	0.36*	0.35*
	Weber & Hsee, 1998	China	0.70*	0.78*	-0.39	0.76*	0.15[a]
		US	0.47	0.86*	0.12	0.51*	0.62*[b]
	Current Study EV>0	China	-0.66*	-0.19	-0.69*	0.36	-0.44
		US	-0.29	0.10	-0.71*	0.78*	-0.33
	Current Study EV<0	China	-0.60*	-0.19	-0.40	0.18	-0.22
		US	-0.48	0.38	-0.19	0.59*	0.22
Correlation between WTP and heuristics	Weber & Hsee, 1998	China	0.92*	0.89*	-0.28	0.86*	0.22
		US	0.91*	0.91*	-0.28	0.88*	0.29
	Current Study	China	0.46*	0.60*	0.83*	-0.14	0.70*
		US	0.20	0.45*	0.92*	-0.35	0.79*

* Significant different from zero at 0.05 level.

[a] Values identified by different superscripts are significantly different from each other at the .05 level.

Note:

1. The Chinese group in Bentempo et al., 1997 is the combination of all subjects from Hong Kong and Taiwan in Bentempo et al. 1997.
2. Lower rank of riskiness corresponding to lower riskiness; lower rank of other values corresponding to lower values.

Table 3. Conjoint analysis for Experiment 1

	Attributes of Riskiness Ranking			*Attributes of WTP Ranking*		
Lottery EV> 0	EV	SD	P(−)	EV	SD	P(−)
China	-4.9*[a]	5.1*	-4.4*	4.9*	-2.8*	7.7*
U.S.	-2.2*[b]	6.4*	-3.0	2.6*	-5.3*	4.4*
Lottery EV<0	EV	SD	P(−)	EV	SD	P(−)
China	-6.3*[a]	2.3*	-1.7	4.8*	1.1	3.7*
U.S.	-3.8*[b]	3.1*	1.2	3.0*	-1.8*	3.3
Hypothesized direction	–	+	+	+	–	–

* Significant different from zero at 0.05 level

[a] Values identified by different superscripts are significantly different from each other at the .05 level.

Note:

1.For each attribute, the difference between sum of ranks of high level and of low level was calculated. One sample *t test* was used to test whether the difference is significant.

2.Two-sample *t* test was used to test whether the cross-nation within task differences was significant.

3. Lower rank of riskiness corresponding to lower riskiness; lower rank of other vaues corresponding to lower values.

Table 4. Conjoint design for Experiment 2

Hypothetical Risks	A	B	C	D	E	F	G	H
Number of expected deaths per year –: 0.5 +: 5	–	+	–	+	+	–	+	–
Illness/injury per year –: 20 +: 2000	+	+	–	–	–	–	+	+
Uncertainty of the estimated number of deaths, illnesses or injuries –: low uncertainty: low estimate (best estimate) high estimate (deaths) 0.4 (0.5) 0.6 4 (5) 6 (illness/injury) 18 (20) 22 1800 (2000) 2200 +: high uncertainty: low estimate (best estimate) high estimate (deaths) 0.01 (0.5) 2 0.1 (5) 20 (illness/injury) 5 (20) 100 500 (2000) 10000	–	–	–	–	+	+	+	+
Quality of scientific understanding –: low +: high	+	+	–	–	+	+	–	–
Ability to control exposure –: no control +: voluntary	+	–	–	+	+	–	–	+
The greatest number of deaths in a single episode –: 5 +: 500	+	–	+	–	+	–	+	–
Time between exposure and the effects (deaths, injuries or illnesses) –: immediately +: many years	+	–	–	+	–	+	+	–

Hypothetical Risk-mitigation Programs	A	B	C	D	E	F	G	H
Number of expected lives saved per year –: 1 +: 10	–	+	–	+	+	–	+	–
Uncertainty of the estimated number of expected lives saved per year –: low uncertainty: low estimate (best estimate) high estimate 0.9 (1) 1.1 9 (10) 11 +: high uncertainty: low estimate (best estimate) high estimate 0.1 (1) 3 1 (10) 30	+	+	–	–	–	–	+	+
Quality of life improved –: little +: greatly	–	–	–	–	+	+	+	+
Probability that the program will not help –: 1% +: 20%	+	+	–	–	+	+	–	–
Scope of benefit –:narrow benefit +:broad benefit	+	–	–	+	+	–	–	+
Fairness –: the program does not benefit those people who contribute or sacrifice +: the program benefit those people who contribute or sacrifice	+	–	+	–	+	–	+	–
When the benefits are realized –: this generation +: next generation	+	–	–	+	–	+	+	–

Table 5. Conjoint analyses for experiment 2

Attributes of Hypothetical Risks	Deaths	Illnesses/Injuries	Uncertainty	Scientific understanding	Control	Greatest number of deaths in a single episode	Time between exposure and effect
China	5.8*	2.8*	-2.2*[a]	0.7*	-5.1*	8.0*[a]	-0.8[a]
U.S.	3.8*	4.0*	1.1[b]	0.2	-4.3*	2.1*[b]	-4.2*[b]
Attributes of Risk-Reduction Programs	Lives saved	Uncertainty	Life quality	Probability of failure	Scope of Benefit	Fairness	When benefits are realized
China	5.0*	-0.3	6.8*	-3.5*	6.7*[a]	2.8*	-3.4*
U.S.	7.2*	-0.3	6.6*	-3.7*	1.7*[b]	2.2*	-2.8*

* Significant different from zero at 0.05 level

[a] Values identified by different superscripts are significantly different from each other at the .05 level.

Note:

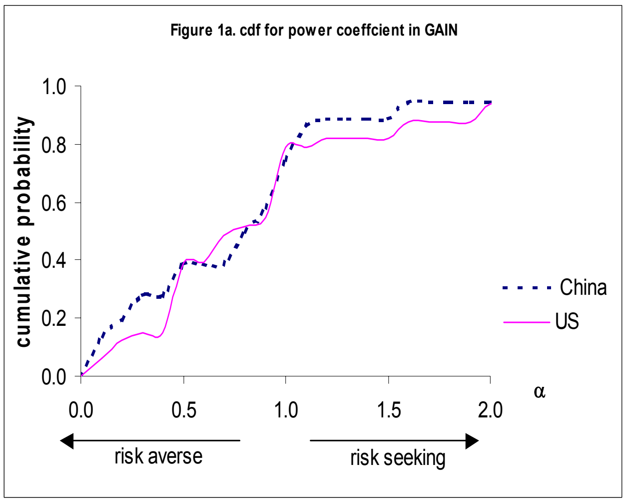
1.For each attribute, the difference between sum of ranks of high level and of low level was calculated. One sample *t test* was used to test whether the difference is significant.

2.Two-sample *t* test was used to test whether the cross-nation within task differences was significant.

Table 6. Within-culture agreement vs. between-culture agreement

		Lottery Rank(riskiness)		Lottery WTPs		Hypothetical Risks	Risk-mitigation Programs
		EV>0	EV<0	EV>0	EV<0		
Average correlation	China	0.26	0.14	0.30	0.12	0.39	0.42
	US	0.19	0.06	0.19	0.05	0.19	0.35
	Between US and China	0.28	0.10	0.24	0.12	0.18	0.34
	All Participants	0.22	0.10	0.24	0.09	0.26	0.37

Figure 1. Risk-aversion coefficient for both nationalities in gains and losses



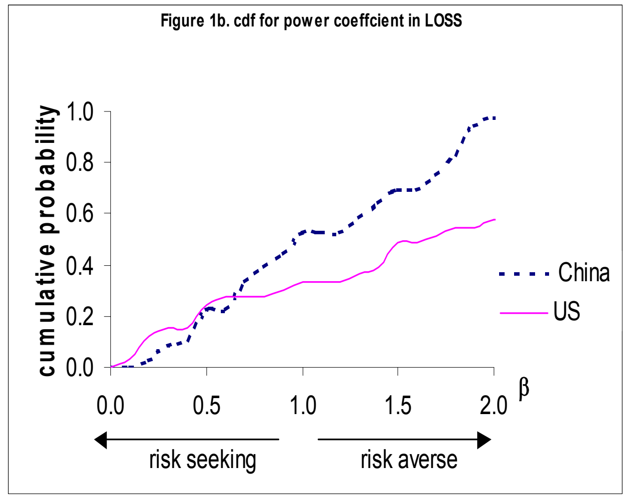
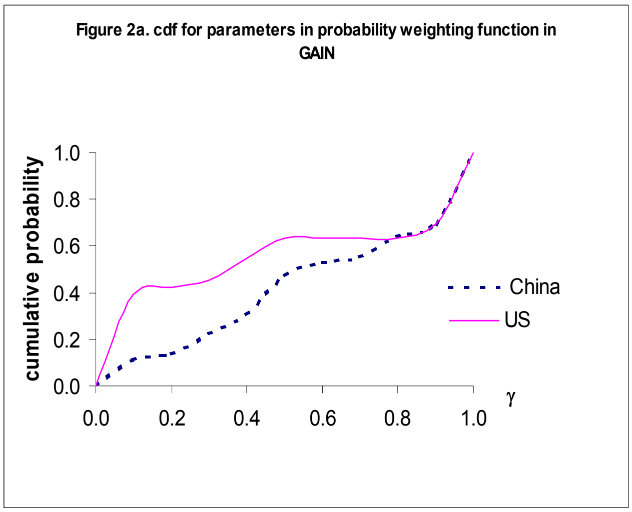


Figure 2 Parameter estimates in weighting function in gains and losses



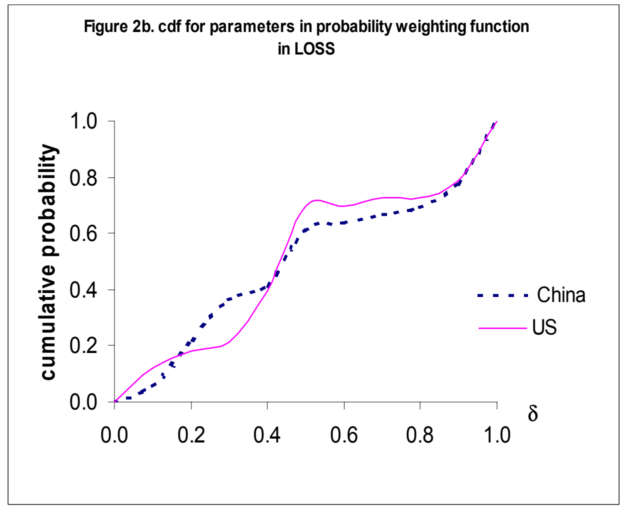
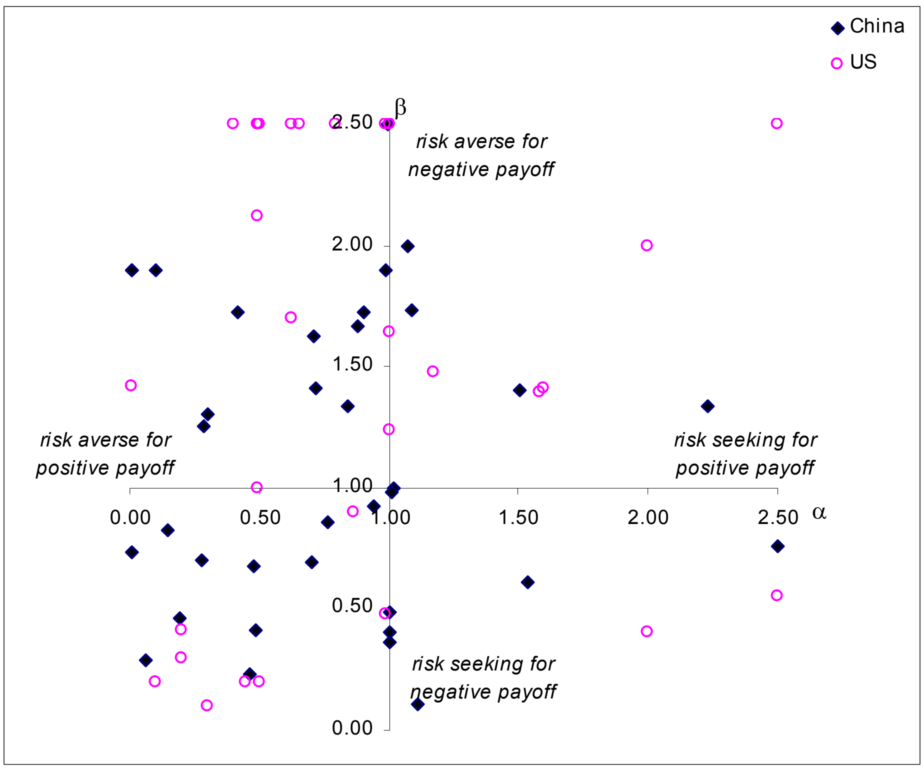


Figure 3. Individual Risk Coefficient in CPT value function for Gains and Losses



Appendix 1. The Definition of Each Attribute in risk-ranking and risk-mitigation programs

Part III. Risk Ranking Imagine that you are living in a small city with a population of 100,000 people. Everyday, you and your community face various health and safety risks, from traffic accidents to air pollution. We want to know which risks concern you the most.

In this envelope, you will find 8 cards --- each describing a risk that you and your community are exposed to. These risks are only labeled by letters (A through H) and are described using six attributes, defined as follows:.

Number of expected deaths per year. This is the average number of deaths per year in the community as a result of exposure to this risk, whether the deaths occur now or years in the future. Due to uncertainty, best estimates, low estimates, and high estimates are given.

Number of illness or injury cases per year. This is the average number of illnesses or injuries that occur per year in your community as a result of exposure to this risk. Due to uncertainty, best estimates, low estimates, and high estimates are given.

Quality of scientific understanding. This measure describes how well scientists know the relationship between a risk and its resulting health impacts. For instance, for many cancers, scientists do not know how exposure leads to a particular disease, but scientists do understand how automobile accidents cause injuries. Two categories are used to rate scientific understanding: “low” and “high.”

Ability to control exposure. For some risks, exposure is beyond your control (for example, air pollution – you have to breathe), but for other risks, exposure maybe voluntary (for example, swimming or motorcycle riding – you choose to participate). Two categories are used to describe the level of control: “no control” and “voluntary.”

Greatest number of deaths in a single episode. Some of the risks in your community can only affect a few people at a time, while other risks can affect a large group of people all at once. For instance, falling down a flight of stairs could only hurt at most one person, but an airplane crash could claim hundreds of lives at once.

Time between exposure and effects (deaths, illness or injury). Some risks, such as accidents, have immediate impacts, while other risks such as chemical pollution may not effect people until many years into the future.

Part IV. Risk-mitigation Program Ranking Imagine that you are living in a small city with a population of 100,000 people. Everyday, you and your community face various health and safety risks, from traffic accidents to air pollution. The government has proposed 8 different programs to reduce or control these risks. Assume that each costs the same to implement.

In this envelope, you will find 8 cards -- each describing a proposed risk-reduction program. These programs are labeled by letters (A through H) and are described using six attributes, defined as follows:.

Number of expected lives saved per year. This is the average number of lives that the program is expected to save each year. Due to uncertainty, best estimates, low estimates, and high estimates are given.

Quality of life improvement. In addition to saving lives, some programs improve the general quality of life for the community (for instance, better recreation or park space, more educational facilities and libraries). Two categories are used to rate improved quality of life: "little" and "greatly."

Probability that the program will not help. Though all programs are expected to reduce risks, some programs may not be successful (for example, finding new highly efficient energy resources), while other programs are almost guaranteed to work at some level (for example, recycling the waste).

Scope of benefits. Some programs help many people in the community while others are focused on a smaller group (for example, only old people). Two categories are used: "broad benefits" and "narrow benefits."

Fairness. For some programs, the people who contribute or sacrifice directly benefit from the program, while for other programs, the people sacrificing are not the ones that benefit (for example, families are forced to moved because of a new highway project).

When the benefits are realized. For some programs, the benefits are not realized until the next generation (for instance, saving natural resources), while for other programs benefits are realized by this generation (for instance, reducing traffic accidents).