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Risk perception in Northeast Asia

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Abstract Multi-country surveys of the public's perception of risk using the same questionnaire were sequentially implemented from April to December 2006 in Japan, China, and South Korea. Statistical analyses, such as traditional mean tests, rank order tests, two-step cluster analysis, and principal component analysis were used to analyze the survey data. The results revealed that Chinese tend to be more tolerant of risk than Japanese and South Koreans. In all three countries, the threats of global warming, cancer, traffic accidents, and fire were perceived as higher-order risks, while infectious diseases and threats from high technology were perceived as lower-order risks. Looking across the entire multi-country sample, we found that Chinese participants perceived greater risk in typhoons, SARS, and drugs; Japanese saw greater risk from gas explosions and potential threats coming over the Internet; while people in all three countries identified earthquakes as a primary risk. These differences in risk perception reflect the natural and socioeconomic conditions in the three countries. Although the study did not emphasize differences in risk perception within countries based on demographic factors such as education, age, and gender, we found that differences based on education and age tended to be greater in China and South Korea than in Japan. We also found that men perceived greater risks than women in China and South Korea, while in Japan it was the opposite with women perceiving greater risks. A comparison of these results with previous studies reveals a bias in past studies toward student samples and indicates the need for more representative samples in multi-country surveys.

Keywords Risk perception · Multi-country survey · Principal component analysis · Northeast Asia

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Introduction

Research on risk perception has evolved from focusing on single cultures to cross-cultural or cross-country perspectives (Renn and Rohrmann 2000, pp. 213). As Rohrmann (1999) observed, quite a number of cross-country studies have been carried out by social psychologists, but these mainly focused on Western or industrialized countries. One or two Northeast Asian countries are sometimes included in comparative studies, but they are usually compared with Western countries. A typical sampling of past studies shows that they focused on Japan and the U.S. (Kleinhesselink and Rosa 1991; Hinman et al. 1993; Hirose et al. 1994), China and the U.S. (Keown 1989; Weber and Hsee 1998, 1999; Weber et al 2005), China and Australia (Rohrmann and Chen 1999; Bian and Keller 1999), China and Austria (Schmidt and Wei 2006), and Korea, Japan, and the U.S. (Cha 2000b). Most of these previous studies used students as subjects, who are not sufficiently representative of their populations.

There have been very few Northeast Asian comparative studies on risk perception except for the one done by Jacobs and Worthley (1999), although there are a number of papers on risk perception in individual Northeast Asian countries: Japan (e.g., Tanaka et al. 1989), China (e.g, Zhang 1994; Xie et al. 2003) and South Korea (Cha 2000a). In their study, Jacobs and Worthley (1999) examined perceived risk data from the U.S., China, Japan, and South Korea. They then compared their data with similar results collected from previous studies in Burkino Faso (a West African Country), France, Norway, and Hungary. The data reveal that certain risks such as nuclear weapons, war, and AIDS have high perceived risks in all countries. The results also show that many of the events have dissimilar perceived risks in different countries and that some countries have higher overall levels of perceived risk (South Korea), while others such as the U.S. display generally lower values. Note, however, that the authors acknowledged that their sample was biased: limited to college students, and predominantly male (100% in Japan, 82% in South Korea, and 78% in China). At the same time, that sample was rather small, with only 50 subjects from Japan and 50 from China. Thus, one of our chief concerns in the study reported in the present paper was to see whether a larger and more representative sample would yield different results from those obtained by Jacobs and Worthley.

Some new types of risks have emerged to worry people the world over. New infectious diseases like severe acute respiratory syndrome (SARS), bovine spongiform encephalopathy (BSE), and bird flu have not resulted in many deaths but have generated great consternation all across East Asia. Science and technology have made progress in developing genetically modified organisms (GMOs) that may improve the global food supply, but GMOs could have as yet unknown adverse effects on ecology and human health. The diffusion of information technology is accelerating the transfer of data and opening up all sorts of new opportunities, but it is also accompanied by the growing threat of leakage or theft of our private information. Therefore, our second objective in writing this paper is to clarify how people perceive such risks and to discover what differences exist between different Northeast Asian countries.

When interpreting differences in risk perception between China and Western countries, the framework of Chinese collectivism versus Western individualism (Renn and Rohrmann 2000, p. 137) or the *cushion hypothesis* (Weber and Hsee 1999) is often applied. For centuries past, Northeast Asia has been deeply influenced by Confucian thought and a stronger emphasis on collectivism rather than individualism. Furthermore, although China, Japan, and South Korea are located in Northeast Asia, they have very different geographical, political, social, and economic characteristics (Table 1). So a third objective of this study is to explore different responses to risk in different countries that have different demographic characteristics even though they may share the same broad collectivistic social orientation.

Since implementing reforms and a new policy of openness in 1978, China has emerged as an increasingly important player in today's world

Table 1 Main indicator of China, Japan and Korea

	China	Japan	Korea
Area (100,000 km^2)	960	37.79	9.93
Population (million)	1,316	127.8	48.3
Nominal GDP (billion $)	2,278	4,554	788
Nominal GDP Per Capita ($)	1,732	35,650	16,471
Real GDP growth rate (%)	10.2	3.1	4.0

economy and in international affairs and business. Japan is the world's second largest economy after the U.S., and South Korea is the eleventh largest economy. Government-level interactions among these three Northeast Asian countries have been increasing greatly in recent years, so knowledge of different perceptions of risk among these nations could have enormous potential value, from both the theoretical and practical viewpoints.

Methodology

The understanding of the concept "risk" differs widely across sciences and scientists, and there is no commonly accepted definition for the term risk. Here, risk is defined by the probability of an unwanted event occurring and by the magnitude of its consequences, and risk perception refers to the views or attitudes that people have of risks.

Risk perception is usually studied, as reviewed in detail by Renn and Rohrmann (2000), from the psychometric paradigm and sociological and cultural approaches. Rohrmann and Renn suggest that "the former approach is based on four intentions: (1) to establish risk as a subjective concept, not an objective entity, (2) to include technical/physical and social/psychological aspects in risk criteria, (3) to accept options of "the public" (i.e., lay people, not experts) as the matter of interest, and (4) to analyze the cognitive structure of risk judgments, usually using multivariate statistical procedures. They add that "according to the *cultural approach*, risk is a social and cultural construction, not an *objective* entity to be measured independently of the context in which hazards occur". In the present paper, we try to integrate the above two approaches to discuss risk perception determined by cross-country surveys in Northeast Asia: Japan, China, and South Korea.

Data collection

Same survey questionnaire

Three surveys were conducted using the same questionnaire in Japan, South Korea, and China to maintain comparability. The survey covered 29 risks grouped into 6 categories that were evaluated on an 11-point scale ranging from "not worried at all" (0) to "extremely worried" (10). The risk categories were (1) natural disasters, which included earthquakes, tsunamis and high waves, typhoons, storms, river flooding, landslides, and lightning strikes; (2) environmental perils, which included environmental pollution, global warming, and threats to endangered species; (3) vulnerability to diseases, which included cerebral apoplexy, cardiac arrest, AIDS, SARS, BSE, bird flu, and cancer; (4) traditional daily risks, such as gas explosions, fires, and traffic accidents, labor accidents, robberies, murders, and drugs; and (5) high-technology risks, such as nuclear accidents, Internet security, and adverse effects of GMO foods on ecology and human health.

The initial questionnaire was written in Japanese and administered first in Japan. After the success of the Japanese survey was confirmed, the questionnaire was translated into Chinese by Chinese survey cooperators who are fluent in Japanese and into Korean by Korean native translators in Japan. After the survey was translated, the Chinese version was checked and confirmed by one of the authors (a native Chinese) and the Korean version was checked by Korean survey cooperators who are fluent in Japanese.

The three surveys were administered in the same year, 2006, to avoid any timing bias effects (Table 2). The surveys were modeled after the Total Survey Design (TSD) method, which attempts to achieve an optimum balance across all areas of effort. TSD was developed and improved by Dillman (1978), Mangione (1995), and others and has proved successful in securing high response rates from general and specialized samples. The procedure for the survey used here has also been tested and proven to be effective in Japan (Zhai et al. 2006; Zhai and Ikeda 2006).

Survey in Japan

The first survey was conducted in coastal zones of Yokohama city from April 14 to May 14, 2006

Table 2 Survey process in Japan, China and Korea

	Japan	China	Korea
Survey time	April 14 to May 14, 2006	Mid-November to mid-December, 2006	1st November 2006 to 11 December, 2006
Focused participants	Coastal residents	Coastal residents	Coastal residents
Sampling method	Random sampling from telephone directory	Random sampling from school list	On-site delivery
Distributed samples	1,000	1,000	1,090
Validly distributed samples	835	1,000	1,090
Collected samples	450	963	865
Survey process	1. Delivering survey booklets to sampled participants along with reply postcards	1. Delivering survey booklets to sampled schools	1. Delivering the survey booklets to surveyors.
	2. Sending reminder postcards to not returning the reply postcards	2. Sampled schools distributed booklets to students	2. Surveyors distributed booklets to participants.
	3. Collecting the booklets	3. Students took booklets back and their parents answered them.	3. Collecting the booklets
		4. Collecting the booklets	

as follows. More time and effort were expended on this initial survey to ensure the success of the later two surveys in China and South Korea. First, several people were asked to formally pre-test the questionnaire and provide feedback on how much time they spent, the difficulties they had with the questions, and so on. The questionnaire was revised based on the information obtained. Second, 1000 households were randomly selected from a commercial phone directory database (Kurofune 2004, published by Datascape & Communications Inc.) as the subjects. Third, the questionnaire was sent to the selected households by mail with a cover letter giving details of the institute and instructions for completing the survey. Also enclosed was a self-addressed stamped envelope for the subjects to return their surveys and a postcard on which the subjects were instructed to give their responses. The respondents were asked to send their questionnaires and postcards separately to ensure that their replies to the surveys were anonymous. Fourth and finally, we followed up with a reminder postcard 2 weeks after the initial mailing to encourage those who had not responded to do so. Out of a total of 835 surveys successfully distributed, we received responses from 450 households, for a response rate of 53.9%.

Surveys in China and South Korea

After the first survey in Japan demonstrated that the questionnaire was practical, the other two surveys were administered in China and South Korea at the same time. In China, the survey was conducted in the coastal area of Tianjin Municipality from mid-November 2006 to mid-December 2006. Exactly 1000 questionnaires were distributed to the parents of primary, junior-high, and high school students after gaining consent for the survey through the schools. Responses came back for 963 questionnaires, for a response rate of 96.3%.

In South Korea, the survey was also conducted in a coastal area from November 1 to December 11, 2006. The questionnaire was given to 1,090 people working or studying in local enterprises or schools/colleges. Of these, 865 questionnaires were returned for a response rate of 79.35%.

General characteristics of respondents' data

The different survey methods resulted in different respondent characteristics (Table 3). In Japan and South Korea, there were more male respondents, while in China there were slightly fewer. The respondents in China and South Korea were

Table 3 Respondents' characteristics

	Japan	China	Korea	Total
Percent of female	21%	57%	30%	40%
Age (10s = 1,..., more than 70 = 7)	5.7	2.9	2.8	3.4
No. of household (person)	3.0	3.9	3.8	3.7
Percent of movers from outside	84%	24%	91%	62%
Residing period (years)	33.7	33.7	9.2	24.2
Sample	450	965	865	2280
(Response rate %)	(53.9%)	(96.5%)	(79.35%)	(77.9%)

somewhat younger than those in Japan, but covered a wide range of ages in all three countries: respondents in Japan ranged in age from their 20s to 70s, while respondents in South Korea and China ranged from teens to 70s. The Chinese and Japanese respondents had lived in their communities longer than those in South Korea, and the Chinese sample revealed a smaller percentage of people who had moved into the district from other areas. This characteristic reflects the socioeconomic setting of the respondents. In this case, coastal zones have greater development potential and tend to develop along with national economic growth, and this tends to draw people in from other areas.

Data analysis methods

Analysis methods

Comparisons for all risks for the three countries were based on traditional mean tests and rank order tests to explore the differences in individual risk. Two-step cluster analysis (TSCA) was also used to see the difference among the three countries. TSCA, which is a kind of cluster analysis, seeks to identify a set of groups that both minimize intra-group variation and maximize inter-group variation. TSCA creates pre-clusters and then clusters the pre-clusters. It can handle very large datasets, is the method chosen when data are categorical, and has the largest array of output options, including variable importance plots. However, general patterns of risk perception can be difficult to identify when the data involve so many variables (29 risks, three countries, age, gender, education, and so on)—especially since the luxury of graphical representation was not available—so we used principal component analysis (PCA) (Appendix 1), a powerful tool for analyzing data to find the general differences between countries and demographic characteristics. SPSS (Statistical Package for the Social Sciences) 10.0J for Windows (SPSS Inc. 1999) was used for the statistical analyses during the study.

Data for analysis

Data for mean tests should be carefully handled because the age bias of samples can result in different conclusions. Here, we used a sub-sample of respondents in their 40s for the comparative analysis of individual risk perception. The reasons for doing this were that there was a large number of respondents in their 40s in all three countries and also that the PCA scores for people in their 40s exhibited similar patterns within the total sample. The numbers of respondents in their 40s were 55 for Japan, 169 for China, and 198 for South Korea. Note, however, that the total sample was used in PCA to explore the general differences in demographic characteristics such as age, education, and gender.

Main results

Ranking of perceived risks by country

Descriptive statistics of each risk for each country are shown in Table 4. For people in their 40s in Japan, risks of earthquakes, global warming, cancer, traffic accidents, endangered species, and fires were perceived as the most serious. Among the total of 29 risks, 23 had mean risk perception

Table 4 Descriptive statistics of each risk for each country (40s sample)

		Mean ± SD			
		Total	Japan	China	Korea
Natural disaster risks	Earthquakes	5.21 ± 3.45	8.18 ± 1.75	6.13 ± 3.71	3.69 ± 2.73
	Tsunamis and high waves	4.34 ± 3.58	3.43 ± 2.93	2.59 ± 3.58	5.93 ± 2.98
	Typhoons	5.77 ± 3.64	6.47 ± 2.48	2.70 ± 3.22	7.93 ± 2.31
	Storms	6.57 ± 2.95	6.24 ± 2.51	5.09 ± 3.04	7.80 ± 2.41
	River flooding	4.98 ± 3.20	4.61 ± 2.94	3.35 ± 3.41	6.32 ± 2.40
	Landslides	4.52 ± 3.33	4.16 ± 2.97	2.49 ± 3.24	6.12 ± 2.57
	Lighting strikes	5.19 ± 3.57	5.41 ± 2.52	3.26 ± 3.31	6.63 ± 3.30
Environmental risks	Environmental pollution	5.77 ± 3.26	6.45 ± 2.56	4.89 ± 3.84	6.26 ± 2.76
	Global warming	7.11 ± 2.90	8.12 ± 1.70	6.23 ± 3.07	7.52 ± 2.84
	Endangered species	6.49 ± 3.03	7.25 ± 2.08	5.90 ± 3.58	6.74 ± 2.69
Disease risks	Cerebral apoplexy	5.81 ± 3.52	6.45 ± 2.64	4.30 ± 3.80	6.79 ± 3.10
	Cardiac insufficiency	5.81 ± 3.44	6.35 ± 2.61	4.65 ± 3.88	6.56 ± 3.02
	AIDS	4.12 ± 3.30	4.06 ± 2.69	3.41 ± 3.81	4.68 ± 2.92
	SARS	4.88 ± 3.30	5.94 ± 2.65	4.68 ± 4.02	4.77 ± 2.73
	BSE	4.27 ± 3.17	4.98 ± 2.72	3.05 ± 3.62	5.02 ± 2.59
	Bird influenza	4.93 ± 3.11	5.98 ± 2.83	3.93 ± 3.64	5.43 ± 2.48
	Cancer	6.69 ± 3.42	7.67 ± 2.22	5.21 ± 3.87	7.57 ± 2.89
Traditional daily risks	Gas explosions	5.72 ± 3.48	5.51 ± 2.40	4.06 ± 3.74	7.07 ± 2.90
	Fires	6.51 ± 3.26	7.06 ± 2.19	4.98 ± 3.77	7.57 ± 2.52
	Traffic accidents	7.20 ± 3.10	7.60 ± 1.95	6.08 ± 3.71	7.98 ± 2.49
	Drug	3.60 ± 3.17	3.51 ± 2.62	4.16 ± 3.94	3.19 ± 2.52
	Labor accidents	5.35 ± 2.93	5.90 ± 2.49	4.43 ± 3.41	5.91 ± 2.42
	Robbery	5.27 ± 2.86	6.53 ± 2.10	4.53 ± 3.52	5.52 ± 2.25
	Murder and terror	4.72 ± 3.16	6.12 ± 2.62	3.97 ± 3.70	4.94 ± 2.63
High-tech risks	Aircraft accidents	3.82 ± 3.33	5.31 ± 2.42	3.68 ± 3.95	3.54 ± 2.90
	Atomic power accident	4.42 ± 3.24	5.51 ± 2.71	3.61 ± 3.88	4.75 ± 2.66
	Internet damage	5.15 ± 3.30	6.96 ± 2.58	3.48 ± 3.50	5.93 ± 2.72
	Effects of GMO to ecology	5.15 ± 3.21	6.08 ± 2.23	3.68 ± 3.55	6.04 ± 2.70
	Effects of GMO to human health	5.31 ± 3.20	5.94 ± 2.53	3.95 ± 3.60	6.17 ± 2.64
	Average	5.33 ± 3.26	5.99 ± 2.47	4.22 ± 3.62	6.01 ± 2.69

values of more than 5.0. In China, the highest ratings were for global warming, earthquakes, traffic accidents, cancer, endangered species, storms, and fires. But out of the 29 risks, only six had mean risk perception values of more than 5.0. In South Korea, the most seriously perceived risks were traffic accidents, typhoons, storms, cancer, fires, and global warming. Among the total 29 risks, 22 had a mean risk perception values of more than 5.0. Therefore, global warming, cancer, traffic accidents, and fires were the common higher-order concerns that were worrisome to people in their 40s in all three countries. Common lower-order risks to people in their 40s in all three countries included nuclear power plant accidents, tsunamis, and high waves, BSE, AIDS, and aircraft crashes, all of which were ranked 20th and below in the list of perceived risks.

Perception differences for individual risks between countries

If we consider large differences in risk perception mean scores (more than three points), we find that between Japan and China, they were for typhoons and Internet viruses. Between South Korea and China, they were all for risks in the natural disaster category: typhoons, landslides, lightning strikes, and tsunamis and high waves (Fig. 1). Between Japan and South Korea, however, only one risk had a perception difference of more than three points: the risk of earthquakes.

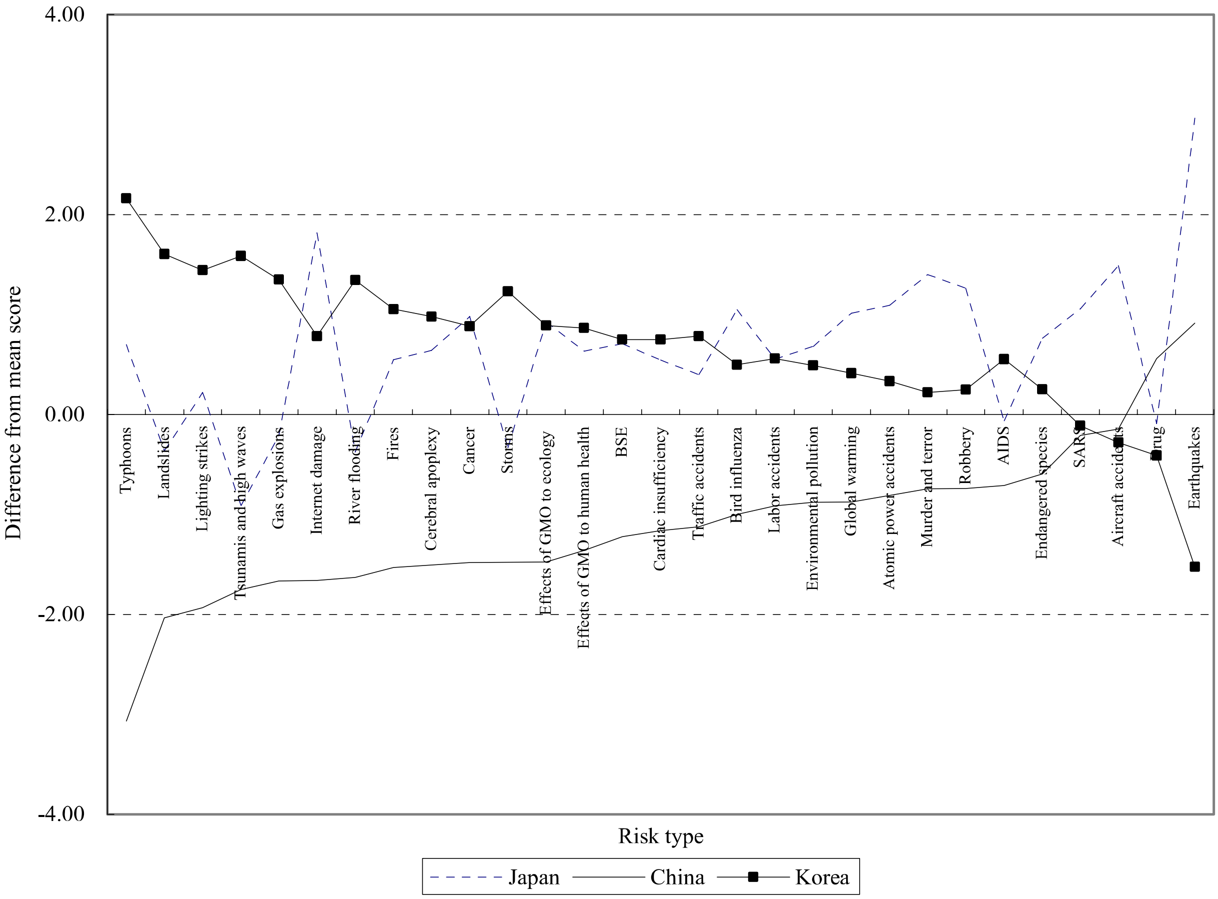


Fig. 1 Cross-country comparisons in mean score (40s' sample)

China had the lowest ratings not only on average (4.22 ± 3.62), but also for most of the risks except earthquakes and drugs (Table 4). Japan and South Korea had approximately the same average ratings (5.99 ± 2.47 and 6.01 ± 2.69, respectively), but differed greatly in their perceptions of individual risks (Fig. 1).

Cross-country comparisons for all risks (Table 5) also revealed that nine out of 29 risks had statistically significant differences in comparisons at the 0.05 level, which mainly related to natural disasters (typhoons, storms, river flooding, and lightning strikes) and risks encountered in daily life (robbery, murder and terror, and gas explosions). Comparing the mean rating scores of 11 risks for the three countries, we found that South Korea had a higher score than China, but a lower score than Japan. Three risks (robbery, murder and terror, and Internet viruses) had statistically significant differences at the 0.05 level both between South Korea and China and between South Korea and Japan. Similarly, among the 14 risks that exhibited the relationship South Korea > Japan > China in mean rating scores, six risks (typhoons, storms, river flooding, landslides, lightning strikes, and gas explosions) had statistically significant differences in both comparisons. Out of the total of 29 risks, China had the lowest rating scores for 25 of them, of which 22 had statistically significant differences from Japan or South Korea. The only three exceptions were for tsunamis and high waves, AIDS, and SARS.

Among the three countries, we found high negative correlation coefficients in score differences from the mean between South Korea and Japan (−0.676) and between South Korea and China

Table 5 Cross-country comparisons of risk perception (40s sample)

Mean comparisons	Number of risks	Risks
JP > KR > CN	11 (3[a])	Environmental risks: environmental pollution, global warming, endangered species, Disease risks: cancer, SARS, bird influenza, Traditional daily risks: robbery[a], murder and terror[a], High-tech risks: atomic power accidents, Internet damage[a], effects of GMO to ecology
KR > JP > CN	15(6[a])	Natural disaster risks: tsunamis and high waves, typhoons[a], storms[a], river flooding[a], landslides[a], lighting strikes[a], Disease risks: cerebral apoplexy, cardiac insufficiency, AIDS, BSE, Traditional daily risks: gas explosions[a], fires, traffic accidents, labor accidents, High-tech risks: effects of GMO to human health
JP > CN > KR	2	Earthquakes, aircraft accidents
CN > JP > KR	1	Drug
Total no.	29	

[a]Refers to the number of risks with statistically significant differences in both comparisons at 0.05 level

(−0.967), but positive correlation coefficients in mean scores between Japan and China (0.769) (Table 6).

Rank order analysis (Table 7) revealed that traffic accidents, global warming, cancer, storms, fires, and endangered species had higher score ratings in all three countries. We found great differences in risk perceptions for gas explosions and Internet viruses (Japan vs. China and South Korea), for typhoons, bird flu, and drug abuse (China vs. Japan and South Korea), and for earthquakes (South Korea vs. China and Japan). China and Japan exhibited a high correlation in both rank order (correlation coefficient 0.734) and difference (correlation coefficient 0.506), but China and South Korea had a negative correlation coefficient (−0.603). If the risks that were perceived so differently are excluded from the correlation analysis, the three correlation coefficients of rank order between countries and that of the difference in rank order between China and South Korea increase to more than the absolute value of 0.5 (Fig. 2 and Table 8).

Table 6 Correlation coefficients for rating scores between three countries

	Japan	China	Korea
Japan	1	0.467	−0.676
China	0.769	1	−0.967
Korea	0.430	0.220	1

Above for the correlation coefficients of score difference from mean between each country

Below for the correlation coefficients of mean scores between each country

Two-step cluster analysis was applied to group the three countries based on the data of the total sample. The mean differences between the clusters on the continuous variables used for clustering (here, risk-perception-related variables were used to classify county-groupings) are shown in Table 9. The results show that Cluster 2 had a higher risk perception than Cluster 1 for all risks. As shown in Table 10, Chinese tended to be in Cluster 1 (63.7%) and Japanese and South Koreans in Cluster 2 (79.6% and 65.1%, respectively).

Integrated evaluation of risk perception and differences in demographic characteristics with PCA

The total sample for all three countries was first normalized and then was used in PCA. The first and second principal components (PC1 and PC2) accounted for 54.39% of the total variance and could be used to explain the overall risk perception. The first PC had positive signs for all risk categories and could be labeled *general evaluation of risks*, while the second PC was negatively and highly correlated with natural disaster risks and was labeled *natural disasters* (Fig. 3). Exposures to everyday risks such as gas explosions, fires, robbery, and so on had higher loadings on the

Table 7 Descriptive statistics of rank order for each country (40s sample)

Risk type	Mean score_rank	Japan_rank	China_rank	Korea_rank	Japan_RD	China_RD	Korea_RD
Traffic accidents	1	4	3	1	3	2	0
Global warming	2	2	1	6	0	−1	4
Cancer	3	3	5	4	0	2	1
Storms	4	13	6	3	9	2	−1
Fires	5	6	7	5	1	2	0
Endangered species	6	5	4	9	−1	−2	3
Cerebral apoplexy	7	10	13	8	3	6	1
Cardiac insufficiency	8	12	10	11	4	2	3
Typhoons	9	9	28	2	0	**19**	−7
Environmental pollution	10	11	8	13	1	−2	3
Gas explosions	11	21	16	7	**10**	5	−4
Labor accidents	12	20	12	20	8	0	8
Effects of GMO to human health	14	18	18	14	4	4	0
Robbery	15	8	11	21	−7	−4	6
Earthquakes	16	1	2	28	**− 15**	**−14**	**12**
Lighting strikes	17	23	26	10	6	9	−7
Effects of GMO to ecology	18	15	20	16	−3	2	−2
Internet damage	19	7	23	18	**−12**	4	−1
River flooding	20	26	25	12	6	5	−8
Bird influenza	21	17	19	22	−4	−2	1
SARS	22	19	9	25	−3	**−13**	3
Murder and terror	23	14	17	24	−9	−6	1
Landslides	24	27	30	15	3	6	−9
Atomic power accidents	25	22	22	26	−3	−3	1
Tsunamis and high waves	26	30	29	19	4	3	−7
BSE	27	25	27	23	−2	0	−4
AIDS	28	28	24	27	0	−4	−1
Aircraft accidents	29	24	21	29	−5	−8	0
Drug	30	29	15	30	−1	**−15**	0

Bold values refer to larger than 10

RD difference from mean score rank = country rank minus mean score rank

first component than other risks did. Newer types of risks—SARS, BSE, GMO, and bird flu—had median loadings on PC1 and PC2, but more than natural disaster risks on PC1.

PC1 scores were 0.116 for Japan, 0.07 for South Korea, and −0.132 for China, while PC2 scores were 0.49 for South Korea, −0.181 for Japan, and −0.445 for China, respectively (Fig. 4). For China and South Korea, PC1 of general risk perception increased with education, but this did not seem to be the case for Japan (Fig. 5). PC2 peaked in the case of South Korea, but changed only insignificantly for Japan and China.

The age factor affected risk perception differently in different countries (Fig. 6). In South Korea, people older than 60 had much lower general risk perception (PC1) than those younger than 60, while those in their 40s had a higher risk perception than respondents in their 30s and 50s. In China, people older than 60 seemed to have the highest general risk perception among all age groups, but they showed no statistically significant difference in PC2 natural disaster risk perception. Japan exhibited no statistically significant differences in either PC1 or PC2. For the sub-sample of respondent in their 40s, Japan had the highest PC1 score, while China had the lowest. Mean tests on the scores of the three countries showed statistical significance at the 0.05 level.

Gender-based scores revealed different patterns in different countries (Fig. 7). Males seemed to have higher PC1 general risk perception than females in China and South Korea, but this was reversed in Japan. South Korean males seemed to

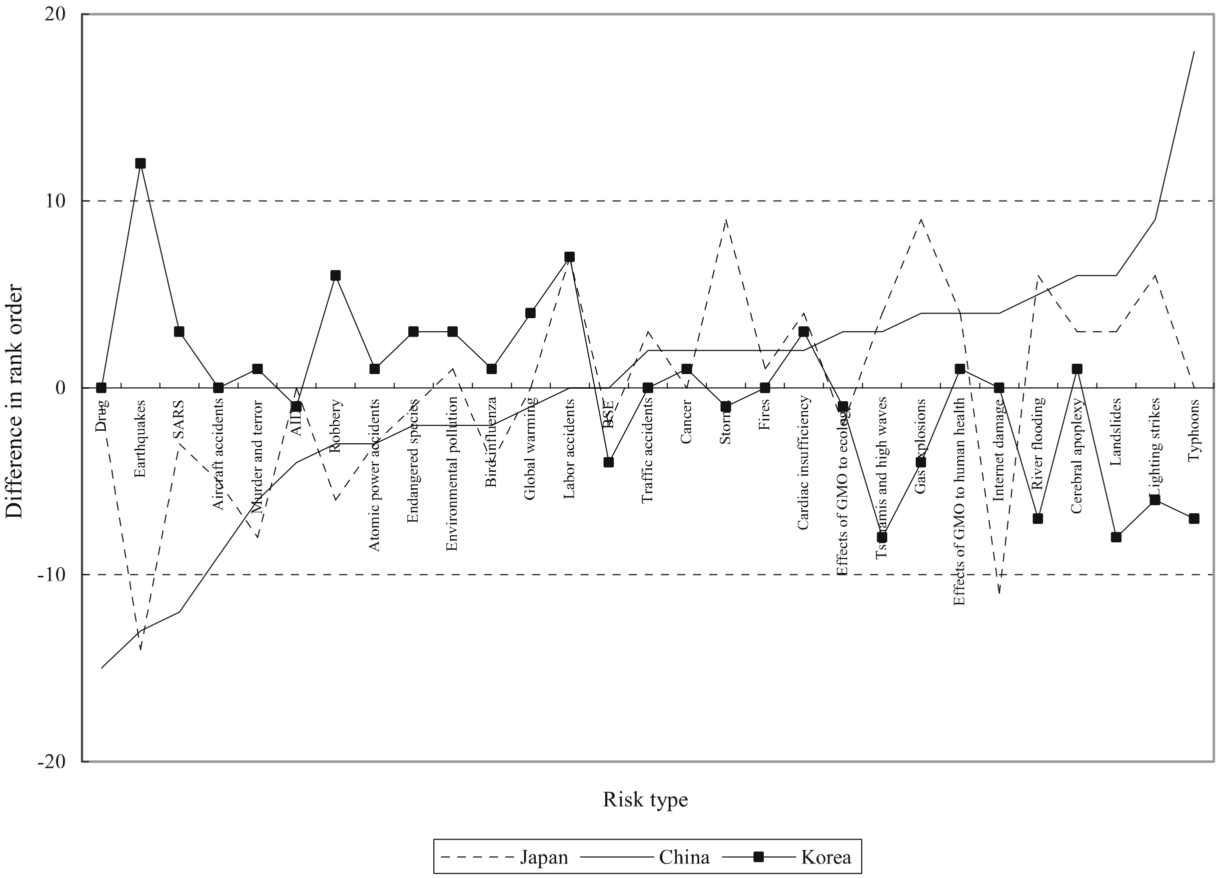


Fig. 2 Cross-country comparisons in rank order (40s' sample)

exhibit higher risk perception of natural disasters than females, but this was apparently not true of Chinese and Japanese males. China exhibited a statistically significant gender difference in PC1 but not in PC2, while the opposite was true for South Korea. Japan revealed no statistically significant gender differences for either PC1 or PC2. Across all three countries, we found that males had fewer differences in PC1 than females.

Table 8 Correlation coefficients for rank order between three countries

	Japan	China	Korea
Japan	1	**0.506** **(0.724)**	−0.468 (−0.255)
China	**0.734** **(0.933)**	1	**−0.603** **(−0.558)**
Korea	0.486 **(0.695)**	0.281 **(0.628)**	1

Upon right matrix is the correlation coefficient of difference in rank order between each country. Left below matrix is the correlation coefficient of rank order between each country. Values in parenthesis are the correlation coefficients after the risks with great difference (larger than 10) are excluded from analysis dataset. Bold values refer to more than **0.5**

Discussion

Chinese tend to be more risk tolerant than Japanese and South Koreans. The results of PCA and TSCA show that South Koreans perceived risks as moderate although their mean risk rating scores were approximately equal to Japanese scores. This might be attributed to a number of complicated reasons. First, Sokolowska and Tyszka (1995) found that poorer countries tend to be less concerned about technological and en-

Table 9 Difference between clusters on each risk perception obtained from Two Step Cluster Analysis

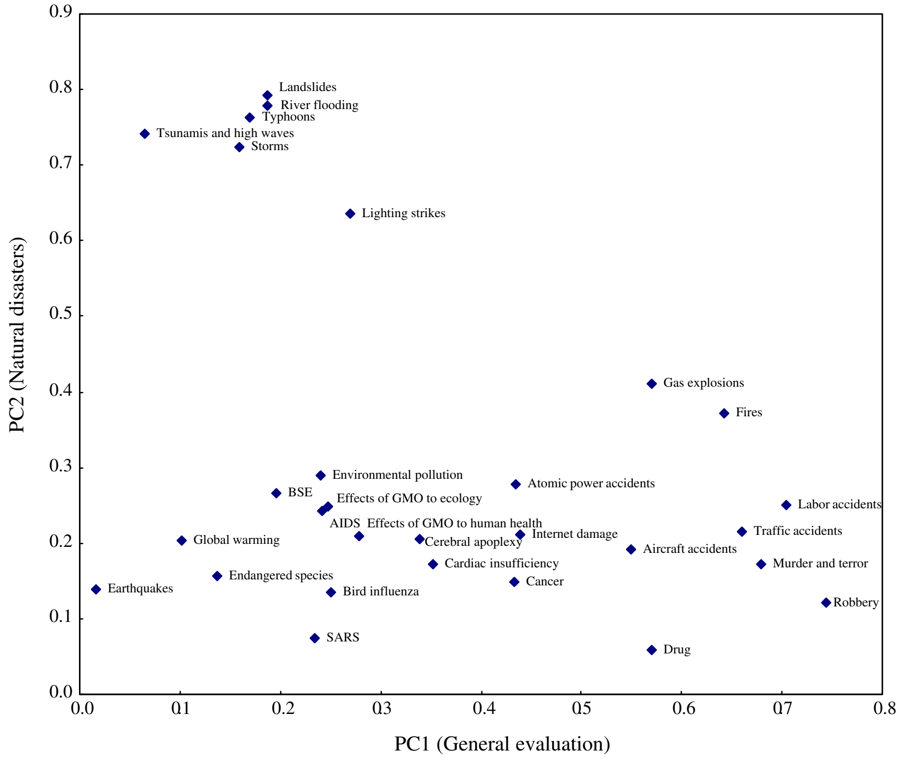
	Mean ± SD		
	Cluster 1	Cluster 2	Combined
Earthquakes	3.59 ± 3.53	5.50 ± 3.32	4.67 ± 3.54
Tsunamis and high waves	1.79 ± 2.68	4.88 ± 3.34	3.54 ± 3.43
Typhoons	3.16 ± 3.27	6.87 ± 2.82	5.26 ± 3.54
Storms	4.46 ± 2.99	6.98 ± 2.44	5.89 ± 2.96
River flooding	2.32 ± 2.80	5.57 ± 2.90	4.16 ± 3.28
Landslides	1.76 ± 2.55	5.22 ± 3.07	3.72 ± 3.33
Lighting strikes	2.25 ± 2.66	5.80 ± 2.87	4.26 ± 3.29
Environmental pollution	3.29 ± 3.22	6.80 ± 2.47	5.27 ± 3.31
Global warming	5.10 ± 3.12	7.82 ± 2.10	6.64 ± 2.92
Endangered species	4.05 ± 3.36	7.31 ± 2.34	5.90 ± 3.26
Cerebral apoplexy	2.70 ± 3.07	6.99 ± 2.55	5.12 ± 3.51
Cardiac insufficiency	2.72 ± 3.12	6.99 ± 2.46	5.14 ± 3.49
AIDS	1.35 ± 2.14	5.20 ± 3.09	3.53 ± 3.32
SARS	2.52 ± 3.07	6.39 ± 2.67	4.71 ± 3.43
BSE	1.41 ± 2.11	5.86 ± 2.68	3.92 ± 3.29
Bird influenza	2.40 ± 2.77	6.55 ± 2.53	4.75 ± 3.34
Cancer	3.60 ± 3.32	8.05 ± 2.11	6.12 ± 3.49
Gas explosions	2.55 ± 2.67	6.90 ± 2.35	5.01 ± 3.29
Fires	3.48 ± 2.89	7.57 ± 2.02	5.79 ± 3.17
Traffic accidents	4.87 ± 3.28	8.25 ± 1.84	6.78 ± 3.06
Aircraft accidents	1.66 ± 2.29	5.45 ± 2.93	3.81 ± 3.27
Labor accidents	3.00 ± 2.86	6.41 ± 2.37	4.93 ± 3.10
Robbery	2.97 ± 2.78	6.74 ± 2.22	5.10 ± 3.10
Murder and terror	2.11 ± 2.49	6.44 ± 2.51	4.56 ± 3.29
Drug	1.73 ± 2.56	5.06 ± 3.17	3.61 ± 3.35
Atomic power accidents	1.41 ± 2.11	5.65 ± 2.86	3.81 ± 3.32
Internet damage	2.88 ± 3.14	6.77 ± 2.70	5.08 ± 3.48
Effects of GMO to ecology	2.49 ± 2.78	6.52 ± 2.47	4.77 ± 3.29
Effects of GMO to human health	2.88 ± 2.97	6.82 ± 2.34	5.11 ± 3.28

vironmental risks, and China, as the largest developing country in the world, does exhibit lower levels of perceived risk than Japan and South Korea, which are developed countries. Certainly, risks are relative, and it may be reasonable to assume that at this stage in their development, Chinese are more preoccupied with what for them are more fundamental risks like food shortages because they have limited resources. A second source of greater risk tolerance may stem from China's growing self-confidence due to recent rapid economic development. Xie et al. (2003) found a higher risk rating among Chinese after the East Asian financial crisis than before, and they concluded that the timing of the later survey and the inclusion of many laid-off workers in their sample may have contributed to the relatively higher risk rating. This implies that good

Table 10 Frequency of country for each cluster obtained from Two Step Cluster Analysis

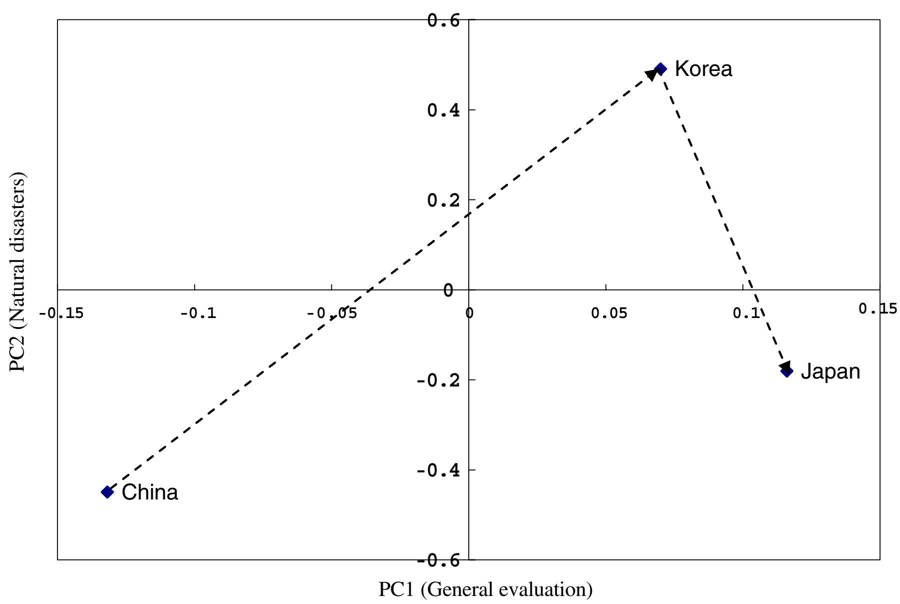
Country		Cluster 1	Cluster 2	Combined
Japan	Frequency	68	266	334
	Percent	20.4%	79.6%	100%
China	Frequency	446	254	700
	Percent	63.7%	36.3%	100%
Korea	Frequency	267	498	765
	Percent	34.9%	65.1%	100%

Fig. 3 Risk loadings after rotation



economic development may lower risk perception. The Chinese economy today is now at the take-off stage and has been growing at close to 10% a year since 1990. The per capita GDP has now broken the US$1000 level, which means that peoples' basic needs to survive and live are now being met. Rapid economic development and a sustainable rise in the standard of living may

Fig. 4 Location of countries within the two-component space for pooled data



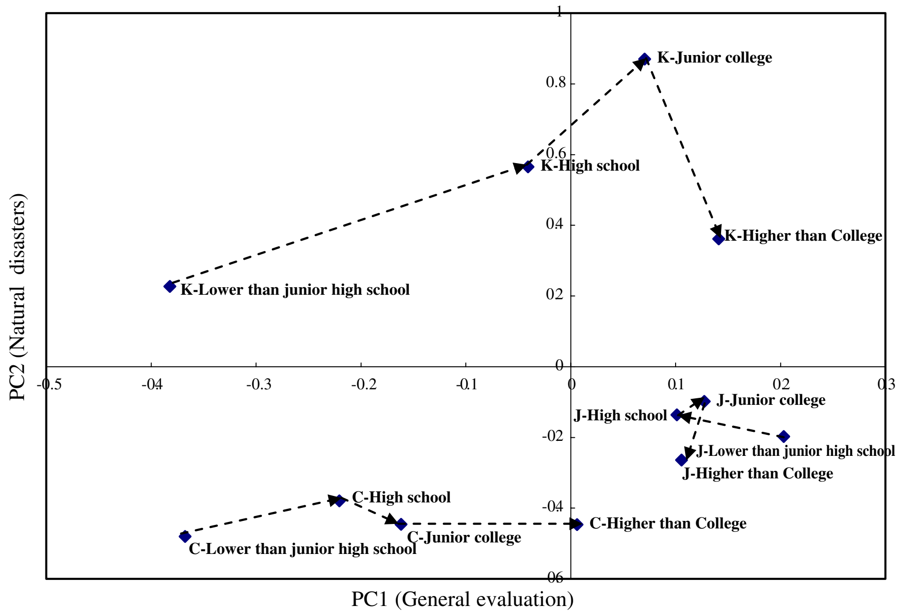


Fig. 5 Location of education levels within the two-component space for pooled data (*C* China, *J* Japan, *K* Korea)

promote general optimism and self-confidence toward the future, which have the effect of lowering peoples' risk perception. A third factor in China's greater risk tolerance may simply be a lack of sufficient information about potential risks. China is a developing country, and the people are making great sacrifices to improve the quality of their lives by promoting economic growth. In this context, the importance and necessity of political and social stability are strongly emphasized through extensive media coverage, while the risks associated with high technologies such nuclear power and genetic engineering are little discussed in public (Xie et al. 2003). One final factor may be the long-standing historical and/or cultural tendency of the Chinese. Proverbs suggest that Chinese tend to be less risk averse in financial and social dealings than Americans (Weber and Hsee 1998).

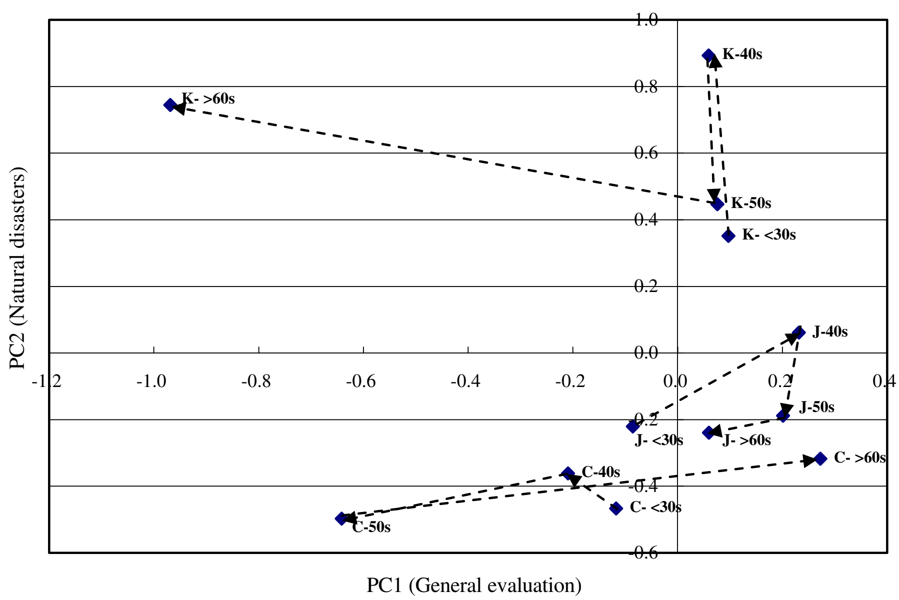


Fig. 6 Location of different ages within the two-component space for pooled data (*C* China, *J* Japan, *K* Korea)

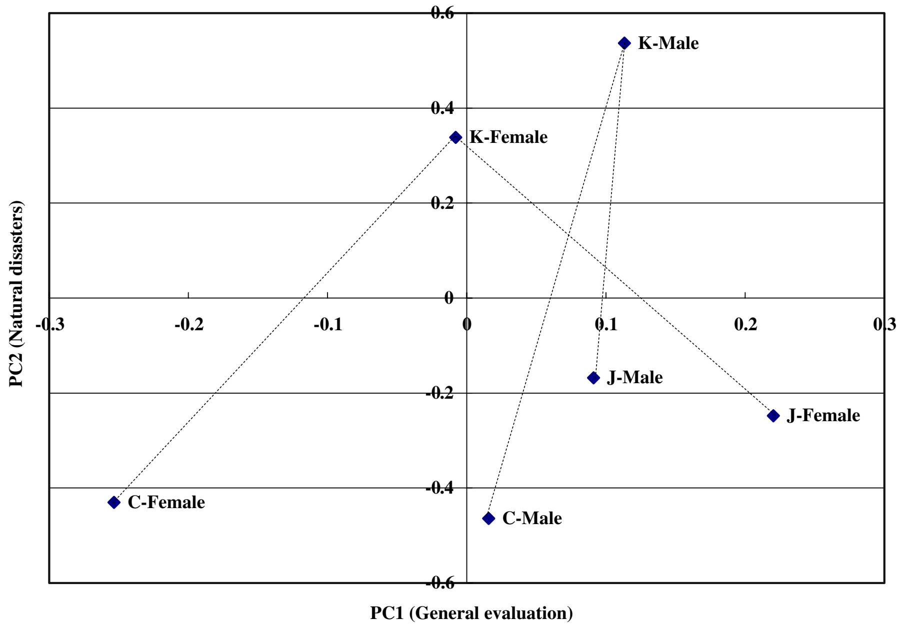


Fig. 7 Location of male and female within the two-component space for pooled data (*C* China, *J* Japan, *K* Korea)

The findings presented here are consistent with those of Jacobs and Worthley (1999), whose sample may be regarded as a sub-sample of the younger-than-40 cohort in our study. Regarding the younger-than-40 subjects, South Koreans exhibited higher PC1 scores than both their Japanese and Chinese counterparts (Fig. 6). This suggests that a sample with a wider range age could dilute the age-specific bias of this sample.

In all three countries, the threats of global warming, cancer, traffic accidents, and fires were perceived as higher-order risks, while infectious diseases and threats from high technology were perceived as lower-order ones. Previous studies focused on the public perception of different risks, so we cannot directly compare our results with theirs. In the case of China, Xie et al. (2003) reported an obsessive concern with risks threatening national stability and economic development and far less concern with high-technology risks and natural disasters by analyzing 28 risks pertaining to social issues, everyday life activities, natural disasters, and science and technology development. Jacobs and Worthley (1999) found that nuclear weapons, war, and AIDs have universally higher perceived risks in all countries by evaluating 30 risks relating to potentially dangerous activities, technologies, or substances. Integrating our findings with the data published on China in previous studies (Xie et al. 2003; Jacobs and Worthley 1999), we can tentatively prioritize the order of perceived risk from most to least worrisome in China as risks affecting national stability and economic development, ones related to environmental issues and natural disasters, ones related to disease, and risks faced in everyday life activities.

New types of risks were perceived as more threatening than natural disasters in the overall PCA evaluation, despite the fact that they inflict much less real damage. All the new types of risks had lower than mean ratings in China, while SARS, BSE, and bird flu had lower than mean ratings in South Korea, and only BSE had a lower than mean rating in Japan. New risks having marginally mean ratings were GMO in South Korea and SARS, bird flu, and GMO in Japan. This may be explained as the result of much more extensive media overage of these risks compared with natural disasters, in accordance with the social amplification of risk framework (SARF) scheme proposed by Kasperson et al. (1988). Within this framework, the media are regarded as important transmitters of risk information, potential ‘amplification stations’ that increase the volume of risk information about an ‘event,’ and through reinterpretation and elaboration of available symbols and imagery, they serve to increase the salience of certain aspects of a message to its receivers.

We found the greatest differences in risk rank order for typhoons, SARS, and drug abuse for China; for gas explosions and Internet viruses for Japan; and for earthquakes for all three countries. These differences reflect the socioeconomic circumstances of each country. For example, consider earthquakes. During the period from 1980 to 2000, China and Japan experienced many earthquakes (2.1 and 1.14 major quakes a year, respectively), while South Korea registered no major earthquakes at all during this period (UNDP 2004). The direct exposure to earthquakes in China and Japan has heightened awareness and perception of the risk of this form of natural disaster in these two countries. Risk perception results for typhoons, gas explosions, and some of the new types of risks such as SARS may be similarly analyzed. The greater concern over the risk of Internet viruses in Japan may be attributed to the extensive media coverage of private information protection after the enactment of the Private Information Protection Law in 2003 and its implementation on April 1, 2005. The much higher risk for drug abuse perceived by Chinese can be attributed to the draconian and widely publicized laws against illegal drugs in that country up to and including capital punishment.

Although our study did not emphasize differences in risk perception within countries based on demographic factors such as education, age, and gender, we found that differences based on education and age tended to be greater in China and South Korea than in Japan and that each country had its own unique distribution pattern. We also found that men perceived greater risks than women in China and South Korea, while in Japan it was the opposite with women perceiving greater risks. These findings are consistent with the review by Renn and Rohrmann (2000, p. 227), and they indicate the need for further investigation.

We found correlation relationships in the risk perceptions of Japanese, Chinese, and South Koreans. In particular, if we exclude outlier values that strongly reflect national characteristics, the correlation coefficients increase greatly. These findings are consistent with those of Jacobs and Worthley (1999).

Concluding remarks and issues for future research

Multi-country surveys on public risk perception were conducted in the same year using the same questionnaire (translated into the local language) in Japan, China, and South Korea—three countries that share a similar collectivistic orientation in their social structures. The results revealed that Chinese tended to be more risk tolerant than Japanese and South Koreans. In all three countries, the threats of global warming, cancer, traffic accidents, and fires were perceived as higher-order risks, while infectious diseases and threats from high technology were perceived as lower-order risks. New types of risks such as SARS and BSE were perceived as more serious threats than natural disasters. We found that the different risk perceptions reflected the natural and socioeconomic circumstances of each country. Our study did not emphasize differences in risk perception within countries based on demographic factors. It covered a wide range of ages, which explains the disparities between our results and the findings of previous studies, which tended to be biased toward younger subjects (often students). This indicates the importance of more representative samples in multi-country studies.

Five different aspects of risk (involving 27 variables) have been identified: risk level aspects, qualitative features of hazards, beneficial aspects, personal relationship to the hazard, and acceptability aspects (Renn and Rohrmann 2000). Slovic (1987) used 18 variables and asked participants to evaluate 81 risks in a study designed to explore the factorial structure of the risk concept. Our study focused on just a single aspect of overall risk rating, and we may wish to reassess this approach and perhaps incorporate other aspects of risk in future research.

This paper leaves some interesting issues and questions that lie beyond the scope of this research. The first is the sample bias due to different sampling methods. Sample bias has two different aspects: whether the sample is representative of the total population and whether there is good comparability for data obtained from different countries. The former is an age-old question in survey research: how representative is "representative enough". The latter always seems to conflict with the availability of data when collecting data in different countries, particularly in developing countries like China. We once planned to carry out surveys with identical samplings in Japan, China, and South Korea, but failed because of some national regulations or an insufficient telephone database. Although the present study did to some degree modify and improve on the results of previous research, it still left some questions. To what extent do these groups reflect the general attitudes of the total population? To what degree do these risk perceptions reflect national, cultural, or current concerns?

The second issue is the effects of the nature of the risks on risk perception. The 29 risks that we evaluated have quiet different characteristics: some are natural while others are technological risks; some are visible but some are invisible; some can be experienced but some cannot. Although there is a body of literature, it is necessary to discuss in more detail to what degree these natures have similar influences on the general attitudes of different populations.

The third issue is to what degree culture and economic development affect risk perception. Although we have provided some thoughts or interpretations about some of the results presented in this paper, we feel that more profound evidence is needed for the interpretation. Furthermore, along with rapid economic development in China, the way in which Chinese risk perception changes and in what direction it changes should be explored deeply and widely.

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Appendix 1: Principal Component Analysis (PCA)

PCA is one of the multivariate methods of analysis and has been used widely with large multidimensional data sets. It is mathematically defined as an orthogonal linear transformation that transforms the data to a new coordinate system such that the maximum variance by any projection of the data comes to lie on the first coordinate (called the first principal component), the second maximum variance on the second coordinate, and so on (Rao 1964; Cooley and Lohnes 1971; Jolliffe 2002). PCA is theoretically the optimum transform for given data in least square terms. PCA results are usually discussed in terms of component scores and loadings (Shaw 2003).

For a data matrix $\boldsymbol{X^T}$ with zero empirical mean, the PCA transformation is given by

$$Y^T = X^T W = V \sum .$$

Here, $\boldsymbol{V \Sigma W^T}$ is the singular value decomposition of $\boldsymbol{X^T}$. **Y** is a matrix where each vector is the projection of the corresponding data vector from matrix **X** onto the basis vectors contained in the columns of matrix **W**. **X** is a data matrix consisting of the set of all data vectors, one vector per column. **W** is the matrix of basis vectors, one vector per column, where each basis vector is one of the eigenvectors of **C** and where the vectors in **W** are a sub-set of those in **V. V** is the matrix consisting of the set of all eigenvectors of **C**, one eigenvector per column. **Σ** is a matrix containing the singular values.

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