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Does Haze Drive Pro-Environmental and Energy Conservation Behaviors? Evidence from the Beijing-Tianjin-Hebei Area in China

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Abstract: Humans conduct themselves in relation to energy use; energy use has degraded air quality, as reflected by haze occurrence in countries such as China. Improving the population's involvement in environmental and energy conservation necessitates understanding their motivation to behave under haze. Considering the social problems caused by haze conditions in China, this study used people's risk perception as a basis to determine their motivations to perform pro-environmental and energy-saving behaviors. We analyzed motivation from privately and publicly oriented perspectives as well as adaptive and mitigative behavioral viewpoints. Motivation-related data were collected through face-to-face discussion and a survey of 506 respondents in the Beijing-Tianjin-Hebei area, which is one of the most heavily polluted regions in China. We conducted multiple regression analysis to determine the extent to which socio-demographic characteristics and risk perception concerning haze predict motivation and actual behavior. Results showed that these factors explain 36.8% and 30.5% of privately and publicly oriented motivations, respectively, but more strongly explain more adaptive (i.e., privately oriented; 55.0%) than mitigating (i.e., publicly oriented; 8.8%) behaviors. Although the residents are motivated to behave equally for private and public purposes in initial conservation efforts, they tend to exhibit adaptive behavior more frequently than mitigating behaviors. These results serve as a reference in encouraging China's residents to act pro-environmentally and use energy conservatively, thereby contributing to environmental and energy saving education for the society.

Keywords: risk perception; motivation; behaviors; haze conditions; pro-environment; energy-saving

1. Introduction

Air pollution has become the world's most massive environmental health risk, with the problem being responsible for millions of mortalities each year [1,2]. One of the most hazardous air pollutants is particulate matter, given its impact on long-term mortality from cardiovascular and respiratory diseases [3–5]. Particulate matter is generated in various ways, such as factory operation, heating, and driving. Air pollution indiscriminately victimizes people as they enjoy conveniences and economic developments in daily life—a situation that China has been severely grappling with since 2012. The country's confrontation with air pollution began in the Beijing-Tianjin-Hebei (BTH) area, along with unprecedented increases in energy consumption. Areas that suffer from air pollution have since expanded to other parts of the country. A study on the health effects of atmospheric $PM_{2.5}$ in urban China has calculated that, in 2013, 257,000 people across the country's 31 provincial capital cities died prematurely because of $PM_{2.5}$ pollution [6]. The central government issued various regulations

and laws to control air pollution and has invested 63.3 billion CNY (Chinese yuan) in these initiatives since 2013 [7]. The most stringent law enacted that year was the Action Plan, which mandates a reduction of $PM_{2.5}$ concentration by 25%, 20%, 15%, and 10% in the BTH area, YRD (Yangtze River Delta), PRD (Pearl River Delta), and all other Chinese cities, respectively, between 2013 and 2017 [8]. Along with the Action Plan, another round of highly rigorous government regulation was implemented by the Beijing Municipal Commission of Housing and Urban-Rural Development in 2017 to advance the goal of the Action Plan. This regulation prohibits all construction-related works, including house demolitions, cement mixer pouring, roadworks, and water conservancy projects, during the autumn and winter seasons [9]. This law has been applied every year following 2017, after which clearer days could be experienced during the aforementioned seasons.

With consideration for long-term effects and efficiency, laws, regulations, and actions should be formulated on the basis of both scientific explanations regarding the causes of air pollution [10–12], and the public's risk perception to encourage cooperation [13,14]. The problem is that previous studies have been unable to advance a thorough understanding of air pollution causes among most of the Chinese residents [15]. Under this situation, establishing cooperation with residents in the fight against haze is difficult. One of the few attempts to promote understanding is a program called Under the Dome, which featured a journalistic investigation of air pollution in China. Experts and the authorities denied the true causes of air pollution, and the government was worried about protests [16], thereby promoting censorship of this program. The authorities were surprised by the popularity of the program and avoided risk by controlling individuals' behaviors [17]. Public participation and response are vital and fundamental to the espousal of sustainable development goals in developed countries [18]. However, China's development is still in its infancy, and little evidence has been collected on how Chinese urban citizens react individually to life under haze conditions and whether the haze has driven individuals to engage in environmental and energy conservation behaviors. In particular, residents' risk perception toward haze can determine their pro-environmental and energy saving motivation and action [7]. A necessary task, therefore, is to investigate the relationships between the risk perception and motivation of residents and between risk perception and behavior to grasp how residents are influenced to change he manner by which they conduct themselves.

Researchers have extensively studied the residential willingness to pay for green environments and green energy to illuminate the perceptions of residents regarding environmental and energy issues [19,20]. A wide range of empirical studies have also focused on the behaviors of residential energy consumers or explored ways by which they ca be motivated to adopt pro-environmental and energy-saving lifestyles [21–27]. Studies of this category commonly probe into consumer perceptions of the environmental, economic, and comfort-related objectives associated with behavior [28,29]. Oftentimes, however, such perceptions are not measured specifically in relation to pro-environmental and energy saving motivation and behavior. This deficiency may lead to unclear results on drivers of residents' behaviors and may therefore render incentive schemes ineffective. Other studies on environmental and energy policymaking examined the relationship between residential energy-saving behaviors and perceptual characteristics that affect these behaviors. Nevertheless, these endeavors are lacking in terms of a comprehensive and comparative exploration of the risk that residents perceive with respect to the environment and energy that shape their pro-environment and energy saving motivations and behaviors. For instance, if the risks perceived by residents cannot predict motivation and behavior equally, other factors that influence behavioral change among residents can be evaluated. There are also additional opportunities for policymaking that encourages pro-environmental and energy-saving behaviors. Amid this backdrop, understanding how perceived risk in the residential context predicts motivation and behavior and comparing predictions can serve as a foundation for inquiries into potential ways of identifying the drivers of behavioral change and stimulating it. An understanding of the distinction between pro-environment and energy saving motivation and behavior translates to increased target strategies for implementation.

Accordingly, the current research was conducted primarily to acquire and conduct reliable data and analysis for the purpose of addressing the above-mentioned needs. Specifically, the study contributes to the literature in the following ways: It explored (1) perceived risk during haze conditions in a residential context, (2) the publicly and privately oriented motivations of residents under risk perception in regard to haze, (3) the current haze-influenced adaptive and mitigation behaviors of residents, and (4) differences in perceived risk factors that predict residents' motivations and behaviors. This study is the first to provide empirical evidence of a substantial difference between how the risk perceived by residents influence their motivations and behaviors during haze conditions. This novel evidence can pose important implications for future environmental energy policy design that is intended to modify residents' behaviors.

The rest of the paper is organized as follows. Section 2 discusses theoretical models of risk perception, motivation, and behavior. Section 3 describes theoretical propositions taken from the innovation diffusion and adoption literature as well as the design, data, and ordinary least squares regression model used in the current empirical investigation. Section 4 presents the main results and analysis of the survey data, and Section 5 probes into the results in more detail. Section 6 concludes the paper.

2. The Literature on Risk Perception, Motivation, and Behavior

Risk perception is a measure falling under risk communication, which is strictly linked to risk assessment and management, on the basis of public health prevention strategies [30,31]. The term "risk perception" generally refers to natural hazards and threats to the environment or health [32], and it can be formed by both belief and self-appraisal [33,34]. Risk perception influences individual behavioral intentions and typically fosters two kinds of motivations in practice, namely, negative motivation, which pertains to risk avoidance (i.e., motivation related to the private domain) and positive motivation, which refers to the desire to change an environment (i.e., motivation related to the public sphere). In previous studies, motivation was classified into intrinsic and extrinsic motivation [35], but these were difficult to identify in the resident interviews held in the current work. Instead, we discovered that with regard to environmental issues, residents are motivated by the desire to protect themselves and their responsibilities toward society. Therefore, we categorized motivation as that which is privately or publicly oriented.

Few studies have looked into the relationship between risk perception and motivation, yet these factors induce behavioral responses. Risk perception is a crucial component of changes in behavioral facilitation and plays a crucial role in the public's responses to different risks [36–38]. Studies have examined the association between risk perception and individual behaviors as responses to environmental threats. Generally, risk perception can predict two kinds of behaviors: adaptive and mitigation behaviors. It is considered a positive predictor of adaptive behavior in relation to various issues, such as climate change, flooding, and seismic hazards, and is viewed particularly as a positive predictor of self-protection [39]. For example, risk perception as regards an earthquake is positively related to insurance purchase as a measure of seismic adjustment [40]. Of note is the positive relationship of risk perception with people's adaptive behaviors in air pollution studies [16,41–43]. By contrast, findings on the relationship between risk perception and mitigation behavior are mixed. In air pollution studies, residents' mitigation behaviors, such as reducing polluting from cars, are positively associated with their risk perceptions [13], but other research uncovered a minimal connection between risk perceptions regarding air pollution and people's mitigative conduct [44]. In the present study, adaptive behaviors are those exhibited by individuals (self-protection), and mitigation behaviors refer to conduct intended for society's sustainable development and future (social behavior, such as using green transportation, consuming clean energy, and conserving energy). Strict top-down measures (policy, law, regulation) may constrain the motivation of bottom-up engagements because individuals tend to depend on top–down efforts and feel less responsibilities. Therefore, adaptive behavior is more significant than mitigation behavior or motivation influenced by risk perceptions.

For an in-depth understanding of risk perception, motivation, and behavior, we summarized theories related to perceptions and behavioral responses in Table 1. There are theories that describe the relationship among perception, intention, and behavior, such as the theory of reasoned action and the theory of planned behavior, wherein intention is a predictive factor for behavior/action. Meanwhile, motivation has been defined as self-efficacy or perceived enjoyment, that is, the willingness to engage in a given behavior, prompted by a concrete reason ("why are we doing this?") [45]. On this basis, then, motivation is more predictable than behavior. Despite these insights, however, the relationship among risk perception, motivation, and behavior has received little scholarly attention. It is necessary to understand how people make the decision to behave in a certain way on the basis of psychosocial drivers such as knowledge, beliefs, and attitudes [46], which can be described as causal attributes. Such understanding is necessary because attributing cause to an individual can increase his/her motivation to mitigate behaviors [47], whereas attribution to uncontrollable factors may dampen his/her motivation to take action [38]. This phenomenon stems mainly from the influence of causal attribution on self-efficacy [48–51] and the impact of self-efficacy on pro-environmental behavior [52–54].

Table 1. Theories related to risk perception, motivation, and behavior.

Theory	Content
Theory of reasoned action (TRA) [55,56]	Attitude and subjective norm can predict behavior. Behavioral intentions are the immediate antecedents to of behavior.
Theory of planned behavior (TPB) [57]	Compared with TRA, perceived behavioral control is included as an exogenous variable that affects both has both effects on behavior and behavioral intention.
Social cognitive theory (SCT) [58]	The theory describes a social context as characterized by dynamic and reciprocal interaction among a person, environmental, and behavior.
Health belief model (HBM) [59]	Perceived susceptibility, perceived severity, perceived benefit, perceived barriers, and health motivation are predictors of action.
Theory of subjective culture [60]	Subjective culture is the intangible part of the culture, including ideas, attitudes, assumptions, and beliefs, which influence behavior.
Transtheoretical model (TTM) [61]	The model that assesses an individual's readiness to act. It is composed of stages of change, change processes, change levels, self-efficacy, and decisional balance.
Integrated behavioral model [62]	It is similar to TRA/TPB, but more factors are included, such as knowledge and habit. Intention is also the most important determinant.
Protection motivation theory [63]	People protect themselves on the basis of four factors: the perceived severity of a threatening event, the perceived probability of the occurrence, or vulnerability, the efficacy of the recommended preventive behavior, and the perceived self-efficacy.

Few studies have compared individual and social motivations for environmental and energy conservation in accordance with endeavors to deal with haze situations under a strict top-down policy. Japanese experiences of addressing air pollution might provide a perspective from which to help China. Japan overcame environmental pollution problems through the cooperative efforts of national and local governments, the private sector, and citizens. To some extent, local governments, the private sector, and citizens are more active and motivated than national governments in solving pollution problems [64]. Unfortunately, limited studies have shed light on the motivations that drive social

behaviors. The present research filled this void by investigating risk perception regarding haze and the drivers of corresponding adaptive (self-protection) and mitigation (social behavior) behaviors. It also delved into differences in privately oriented (adaptive) and publicly oriented (mitigative) motivations.

Using the above-mentioned research on behavioral and perception theories as basis, we designed a questionnaire to measure risk perception, motivation, and behavioral change in connection to air pollution. We used an ordinary least-squares regression to determine the extent to which socio-demographic characteristics and risk perception concerning haze predict motivation and actual behavior and identified policy implications for mitigating risk perception.

Figure 1 depicts the analytical framework of this research. Drawing from the literature on risk perception, motivation, and behavior, the present study examined the role that risk perception plays in predicting the motivations and behavioral responses of China's residents to air pollution.

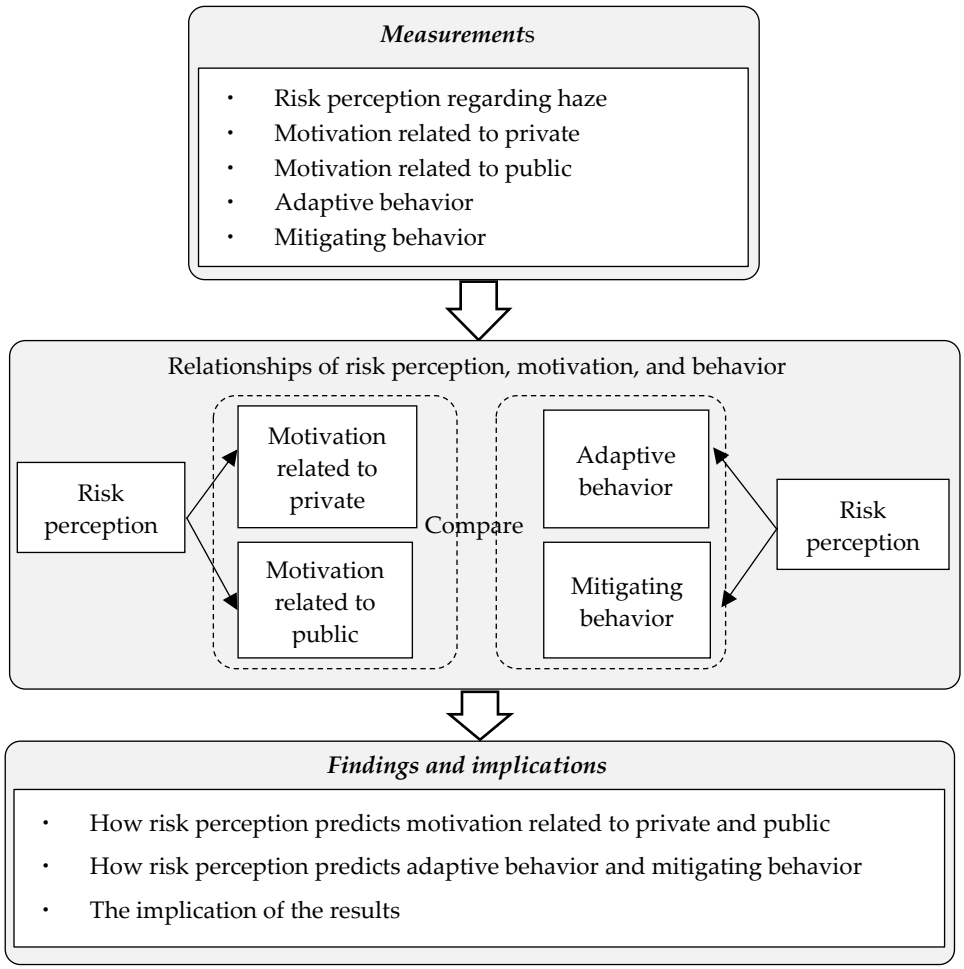

Figure 1. Analytical framework of this research.

3. Methods

3.1. Survey Instrument

We developed a questionnaire covering a range of topics related to public risk perception and motivation, as well as behavioral responses to haze and information on individuals' demographics, lifestyles, and situations (Supplementary Materials).

3.2. Key Variables

In this work, the motivation to behave in a certain manner encompassed privately and publicly oriented motivations (independent variables). The questionnaire included questions on whether respondents behave for public purposes (such as establishing a good reputation, adhering to public morals) or private purposes (such as ensuring the welfare of family members, building a good environment for children, saving money, and convenience). Behavioral responses to haze include adaption and mitigation. As regards adaptive behaviors, the respondents were asked whether they had taken specific adaptive measures (e.g., using an air purifier, wearing masks) and mitigating measures (e.g., reducing automobile driving) to combat pollution. Risk perception toward haze was measured from three perspectives: (1) risk perception related to health (perceived risk of developing asthmatic bronchitis, cardiovascular diseases, respiratory diseases; perceived risk in connection to children's health, worsening health conditions), (2) risk perception related to psychology (perceived risk of prolonged haze conditions, frustration over health conditions and safety during ventures outdoors), and (3) risk perception associated with lifestyle (impossibility of engaging in outdoor exercise and other activities, unpleasant smells, cautious travel because of low visibility).

3.3. Control Variables

Previous studies suggested that the public's motivations and behaviors are related to demographics, work styles (lifestyles), and situational information, such as place of residence. Therefore, in assessing how risk perception influences motivation and behavior, we treated data on demographics (e.g., gender and age) and situations (e.g., place of residence) as control variables.

3.4. Sampling Strategy

We targeted a sample of 600 participants, evenly distributed across residents' districts in Beijing City, Tianjin City, and Hebei Province. A pilot study involving residents was conducted before the questionnaire administration. After the questionnaire was revised, the survey was administered in December 2018 and January 2019 to resident committees in Beijing City, Tianjin City, and Hebei Province. We received a total of 610 questionnaires, among which 104 were excluded from further analysis because of missing data. This yielded a final sample of 506 respondents or valid questionnaires (83% response rate).

3.5. Regression Model Specification

An ordinary least-squares regression model was incorporated with socio-demographic characteristics and all predictors of risk perceptions. The model is specified as follows:

$$M\&B_i = \beta_0 + \alpha_i'\beta_1 + \delta + \varepsilon_i \quad (1)$$

where $M\&B_{ij}$. denotes the motivation and behavior of resident i, α_i' is a vector of the risk perception factors, β_0 refers to the regression intercept, β_1 is the regression coefficient, δ captures the unobserved fixed effects, and ε_i is the error term.

4. Results

Little's missing completely at random (MCAR) test [65] yields non-significant results ($\chi^2 = 440.841$, $p = 0.959$), indicating that data are missing at random. The missing values were replaced by running the expectation-maximization (EM) algorithm in the Statistical Package for the Social Sciences (v.23.0). This generated a comprehensive dataset for all the measures considered in this study. Tables 2 and 3 report the descriptive statistics of the dependent variables and independent variables, respectively. The mean value of publicly oriented motivations (M = 4.36), such as cultivating a good reputation (establishing a good image in the community to build a sound relationship with

community members), is higher than that of privately oriented motivations (M = 4.21). This difference indicates the importance of human relationship in Chinese society.

Table 2. Summary statistics of the dependent variables (n = 506).

Dependent Variables	Motivation		Behavior	
	Private [3]	Public [4]	Adaptive [5]	Mitigating [6]
1 = strongly disagree, 5 = strongly agree				
Average (median) [1]	4.36	4.21	3.94	3.12
SD [2]	0.65	0.60	0.68	0.34
Min	1.75	2.00	1.60	5.00
Max	5.00	5.00	1.00	5.00

Notes: [1] Median in parentheses; [2] SD = standard deviation; [3] motivation related to private issues includes establishing a good reputation, adhering to public morals; [4] motivation related to public issues includes acting for family members and children's future, saving money, convenience; [5] adaptive behaviors encompass using air purifiers, wearing masks, using haze apps to check on situation, eating food for immunity against haze, and relocating to a clean residential area; [6] mitigating behaviors cover reducing driving and focusing on renewable energy.

Table 3. Summary statistics of the independent variables (n = 506).

Independent Variables	Average (Median) [1]	SD [2]	Min	Max
Risk perception [3] (1 = strongly disagree, 5 = strongly agree)	4.36	0.564	2.15	5.00
Age	41	1.243	10	70
Gender (1 = Male)	0.48	0.500	0	1
Average monthly individual income (CNY) (1 = less than 4500, 2 = 4501–6500, 3 = 6501–8500, 4 = more than 8501)	2.23	0.700	1	4
Education (1 = illiterate, 2 = elementary, 3 = junior high school, 4 = high school, 5 = bachelor's, 6 = master's, 7 = doctorate)	5.10	0.838	1	7
Marital status (1 = Yes)	1.30	0.532	1	2
Child (1 = Yes)	1.35	0.477	1	2
Residential distance to the main road (1 = less than 100 m, 2 = more than 100 m)	1.46	0.499	1	2

Notes: [1] Median in parentheses; [2] SD = standard deviation; [3] The mean value of 12 items of risk perception.

4.1. Residents' Risk Perception, Motivation, and Behavior

The risk perception of the residents as regards haze was expressed through 10 items, to which the participants assigned a rating that signifies their perceived of extent of the risk. Figure 2 illustrates the participants' responses for each risk perception item.

Generally, all the risks in Figure 2 are highly perceived, with the most commonly discerned risk being that related to children's health (67.5%), followed by the impossibility of engaging in outdoor activities (55.7%), unpleasant smells (53.3%), and safety issues during hazy weather due to low visibility (52.4%). These results indicate that residents care for children most. At the same time, they perceived a higher risk of disease development due to haze (prolonged conditions) under the current situation than in the future.

As it shown in Figure 3, the residents are motivated to act in favor of the environment mostly for their children (59.1%) and for other family members (58.3%). Their environment-friendly behaviors are least motivated by the desire to save (26.1%), indicating that urban residents have a relatively

high standard of living. The residents are also motivated by the need to establish a good reputation and adhere to public morals to a high degree (45.9% and 53.6%, respectively), again reflecting the importance of human relationships in Chinese society.

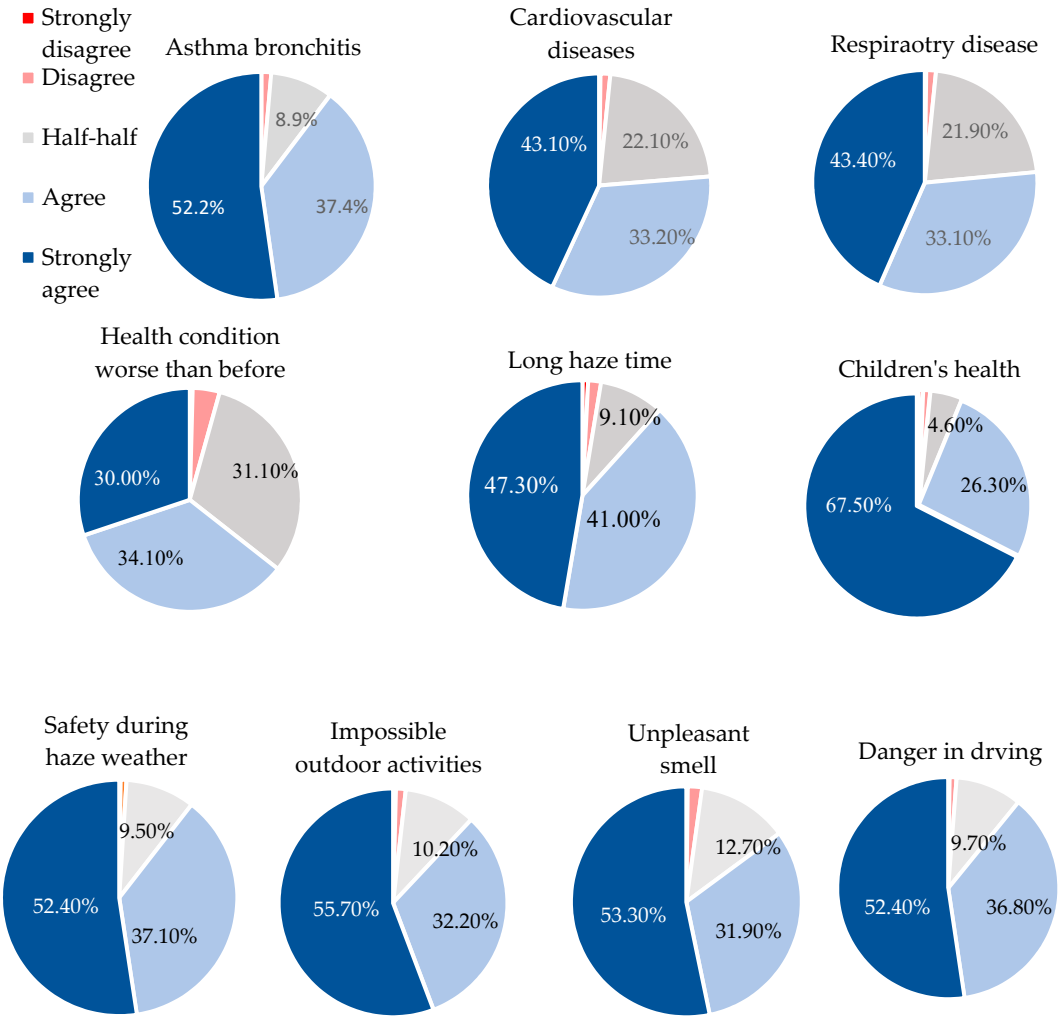

Figure 2. Residents' risk perception towards the haze.

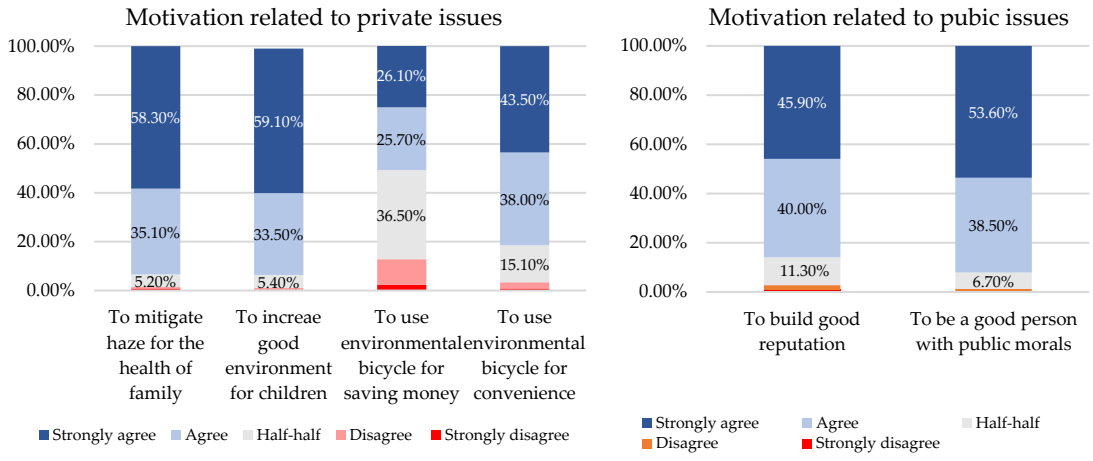

Figure 3. Residents' motivations for behaving environmentally.

The residents' adaptive behaviors were measured on the basis of the five actions presented in Figure 4. Almost 50% of the participants choose to wear masks to protect themselves, 42.9% use air purifiers at home, and 37.6% use apps to check the haze situation in their localities before deciding on a day's activities. This result indicates that most of the residents exercise mainly adaptive behavior is haze situations. Their mitigative behaviors are shown in Figure 5. In general, the participants exhibit environmental awareness and would like to adopt pro-environmental and energy conservation behaviors to help change the haze situation in China. For example, 39.5% of the participants expressed the desire to lessen driving, and 45.9% stated that they pay more attention to renewable energy as a means of contributing to air pollutant reduction. The percentage of respondents predisposed toward a middle ground (i.e., half the time, they favor reducing driving, and the rest of the time, they consider renewable energy adoption) is also high, showing that haze occurrence has induced corresponding behaviors from the residents, who have begun mitigating activities that exacerbate haze conditions.

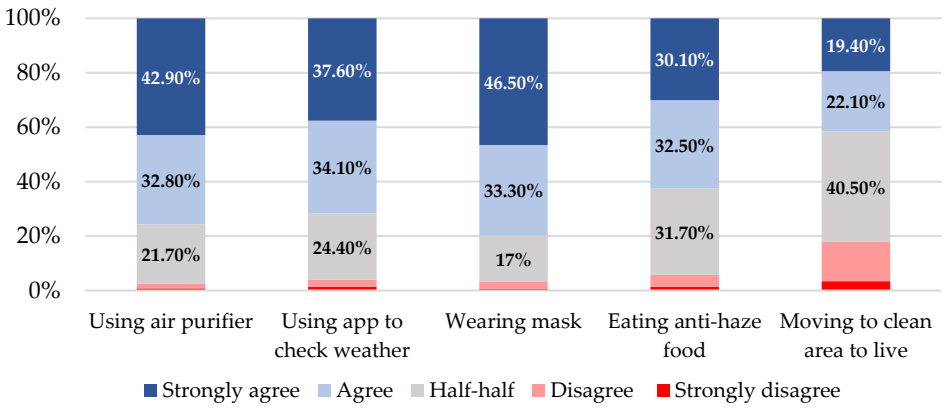

Figure 4. Residents adaptive behavior.

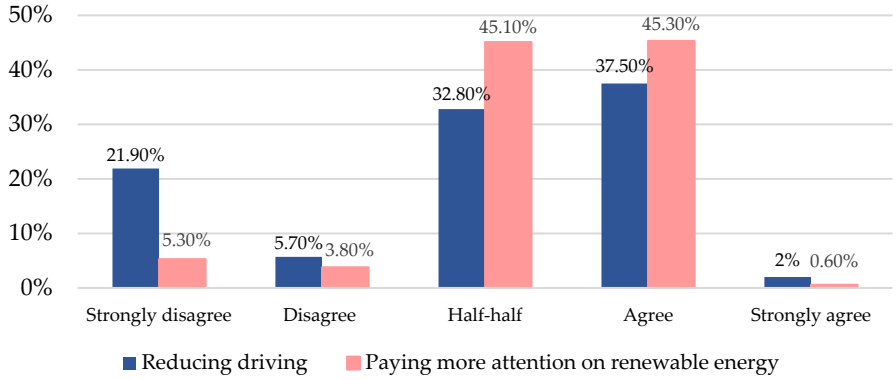

Figure 5. Residents mitigating behavior.

4.2. Analysis of Residents' Risk Perception towards Haze

This section recounts the investigation of the relationships between the influencing factors of motivation and behavior and a composite motivation scale. The investigation was meant to ascertain the effective predictors to be examined in the empirical analysis carried out through correlation analysis and ordinary-least squares regression estimation to rule out uncorrelated variables. The bivariate correlations between the composite motivation measure and all the potential predictors that it covers and bivariate correlations between the composite behavior measure and all the potential predictors that it covers, as well as the results of the complete regression estimation (Equation (1)), are presented in Tables 4 and 5, respectively. Gender has a significantly negative correlation with both privately oriented ($R = -0.181$) and publicly oriented ($R = -0.090$) motivations. All the risk perception factors are positively correlated with motivation. In particular, the perception of risk regarding unpleasant smells and the

dangers of driving ($R > 0.5$) is more strongly correlated with motivation induced by individual-specific factors than that triggered by the public sphere ($0.4 < R < 0.5$). To sum up, 10 predictors, including two socio-demographic characteristics, were subjected to ordinary least squares regression to examine their influences on residents' motivations. The overall model is significant, F (24, 481) = 11.684, p = 0.000. Table 3 lists the results on significant predictors. Gender, risk perception of prolonged haze conditions, children's health, the impossibility of engaging in outdoor activities, unpleasant smells, and the dangers of driving substantially predict motivations related to privacy. These factors can also predict 36.8% of individual motivation (R^2 = 0.368). Privately oriented motivation can be accounted for by the linear combination of the six predictors. The variance inflation factor (VIF) is in the range of 1.118 to 2.786, which is below the threshold value of 10 [66], denoting the absence of multicollinearity in this work. In terms of motivation related to public morals, marital status, risk perception as regards worsening health condition, children's health, the impossibility of participating outdoor activities, and unpleasant smells are significant predictors, accounting for 30.5% of motivation related to public morals (R^2 = 0.305). The model markedly predicts motivation related to the public sphere (F (24, 481) = 24.478, p = 0.000). Summarily, risk perception more strongly predicts the residents' privately oriented motivation than their publicly oriented motivation. However, the difference between the two is non-significant.

Table 4. Bivariate correlation and full regression analysis on residents' risk perception predicting motivation: predictor selections (n = 506).

Dependent Variable: Motivation	Motivation Related to Private Issues Model 1				Motivation Related to Public Issues Model 2			
	B	β	Variance inflation factor (VIF)	Pearson's R	B	β	VIF	Pearson's R
Gender	−0.082 (0.046)	−0.073 *	1.118	−0.181 ***	0.010 (0.052)	0.008	1.118	−0.090 **
Marital status	0.010 (0.050)	0.009	1.554	0.028	−0.102 (0.058)	−0.084 *	1.554	−0.108 **
Risk perception regarding asthmatic bronchitis	−0.039 (0.047)	−0.047	2.421	0.397 ***	0.044 (0.054)	0.048	2.421	0.400 ***
Risk perception regarding respiratory disease	0.034 (0.038)	0.047	2.098	0.361 ***	−0.038 (0.043)	−0.050	2.098	0.315 ***
Risk perception as to worsening health conditions	0.033 (0.033)	0.054	1.838	0.368 ***	0.063 (0.037)	0.087 *	1.838	0.354 ***
Risk perception regarding prolonged haze	0.112 (0.040)	0.147 ***	2.045	0.410 ***	0.031 (0.045)	0.037	2.045	0.359 ***
Risk perception toward children's health	0.203 (0.055)	0.211 ***	2.475	0.454 ***	0.183 (0.062)	0.176 ***	2.475	0.449 ***
Risk perception as to the impossibility of outdoor activities	−0.078 (0.046)	−0.100 *	2.581	0.390 ***	0.110 (0.058)	0.120 *	2.783	0.399 ***
Risk perception regarding unpleasant smells	0.167 (0.045)	0.222 ***	2.673	0.512 ***	0.107 (0.051)	0.132 **	2.673	0.449 ***
Risk perception regarding the dangers of driving	0.163 (0.050)	0.196 ***	2.786	0.505 ***		−0.001 (0.057)	0.408 ***	0.408 ***
R^2			0.368				0.305	
Adjusted R^2			0.337				0.271	
F for change in R^2			11.684 ***				8.810 ***	

Note: The values in parentheses are robust standard errors; * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Standardized regression coefficients are enclosed in parentheses. Only significant values are presented in the table.

In the analysis of the residents' behaviors and the factors influencing these, adaptive and mitigating behaviors served as the independent variables. All risk perception factors are significantly correlated with adaptive behaviors (Table 4). This correlation is particularly evident in connection to worsening health conditions, safety issues due to low visibility, the impossibility of engaging in outdoor activities, unpleasant smells, and the dangers of driving ($R > 0.50$); contrastingly, not all the risk perception factors exhibit a significant correlation with mitigating behavior, with risk perception related to unpleasant smells having the strongest correlation with mitigating conduct (R = 0.129). The correlation in this respect is not as strong as that observed in adaptive behaviors ($R < 0.50$); that is, the risk perception factors are more strongly correlated with adaptive behaviors than mitigating behaviors. This result

indicates that under haze conditions, the residents prefer to use adaptive behaviors, such as using masks and air purifiers, eating anti-haze food, and relocating to other places, over mitigating behaviors, such as reducing driving and paying attention to renewable energy.

Table 5. Bivariate correlation and full regression analysis of residents' risk perception predicting behavior: Predictor selections (n = 506).

Dependent Variable: Behavior	Adaptive Behavior Model 3				Mitigating Behavior Model 4			
	B	**β**	**VIF**	**Pearson's R**	**B**	**β**	**VIF**	**Pearson's R**
Gender	0.013 (0.044)	0.010	1.118	−0.124 ***	−0.097 (0.070)	−0.064	1.115	−0.078
Age	0.016 (0.021)	0.029	1.553	0.093 *	0.103 (0.033)	0.168 ***	1.552	0.127 **
Duration of residence in area	0.026 (0.014)	0.061 *	1.167	0.099 *	0.011 (0.022)	0.024	1.166	0.040
Risk perception regarding asthmatic bronchitis	−0.023 (0.046)	−0.024	2.421	0.478 ***	−0.126 (0.073)	−0.118 *	2.415	0.033
Risk perception as to respiratory disease	0.042 (0.036)	0.051	2.098	0.473 ***	0.033 (0.057)	0.036	2.087	0.079
Risk perception as to worsening health condition	0.221 (0.032)	0.290 ***	1.838	0.575 ***	0.103 (0.050)	0.121 **	1.838	0.103 *
Risk perception as to prolonged haze	0.046 (0.038)	0.053	2.045	0.447 ***	0.015 (0.061)	0.015	2.020	0.029
Risk perception toward children's health	0.030 (0.050)	0.030	2.629	0.446 ***	0.109 (0.078)	0.089	2.144	0.098 *
Risk perception toward the impossibility of outdoor activities	0.022 (0.49)	0.023	2.783	0.519 ***	−0.103 (0.078)	−0.096	2.783	0.111 *
Risk perception as regards unpleasant smells	0.332 (0.043)	0.388 ***	2.673	0.657 ***	0.123 (0.068)	0.128 *	2.673	0.129 **
Risk perception regarding the dangers of driving	0.108 (0.048)	0.11 ** (0.048)	2.786	0.567 ***	0.035 (0.023)	0.112	2.786	0.089 *
R^2	0.550				0.088			
Adjust R^2	0.527				0.045			
F for change in R^2	24.478 ***				2.023 ***			

Note: The values in parentheses are robust standard errors; * $p < 0.1$; ** $p < 0.05$; *** $p < 0.01$. Standardized regression coefficients are enclosed in parentheses. Only significant values are included in the table.

In the regression analysis of adaptive behaviors, the model significantly predicts adaptive behaviors with F (24, 481) = 24.478. Concretely, risk perception regarding worsening health conditions, unpleasant smells, and the dangers of driving significantly explains 55.0% of adaptive behavior (R^2 = 0.550). Risk perception toward acquiring asthmatic bronchitis, worsening health conditions, and unpleasant smells significantly predicts mitigating behaviors at a prediction rate of 8.8% (R^2 = 0.088). Risk perception related to worsening health conditions is the highest influencing factor for predicting mitigating behaviors. Furthermore, risk perception with respect to unpleasant smells can predict both adaptive and mitigating behaviors. Consistent with Pearson's correlation results, the residents' risk perception factors affect their adaptive behaviors more strongly than their mitigating behaviors. The results showed that under haze conditions, the residents care for themselves more frequently than engage in acts meant to change their environment.

5. Discussion

Our survey revealed that under haze conditions, the residents suffer from severe health effects (worsening health condition) and are motivated to behave in an environment-friendly manner. To inquire into their energy saving and pro-environmental motivations and behaviors, we classified motivation into privately oriented and publicly oriented motivations and categorized behaviors into adaptive and mitigating behaviors. Varying results were derived on the matter of risk perception as a predictor of both motivation and behavior.

The women are more inclined than the men to be privately motivated, consistent with the previous studies that found females to exhibit a greater tendency to avoid environmental risks and attach importance to personal happiness [67,68]. On the subject of behavior, duration of residence in the area can significantly predict adaptive behaviors, indicating that living for a long time in polluted areas significantly affects people's involvement in behaviors that protect themselves. Age can

positively predict mitigating behaviors, but other demographic factors, such as education, marital status, do not significantly predict either motivational and behavioral factors for environmental protection and energy-saving.

Risk perception positively predicts both motivation (private and public) and behavior (adaptive and mitigating). The results echo earlier findings on the relationship between risk perception and motivations and behaviors in response to haze, adding new evidence in support of the argument that looking into risk perception alone is insufficient to predict the motivation of residents to conserve energy and protect the environment (Figure 6). Risk perception correlates with both motivation and behavior, but such perception differs minimally with respect to privately and publicly oriented motivation (R^2 = 0.368 and R^2 = 0.305, respectively).

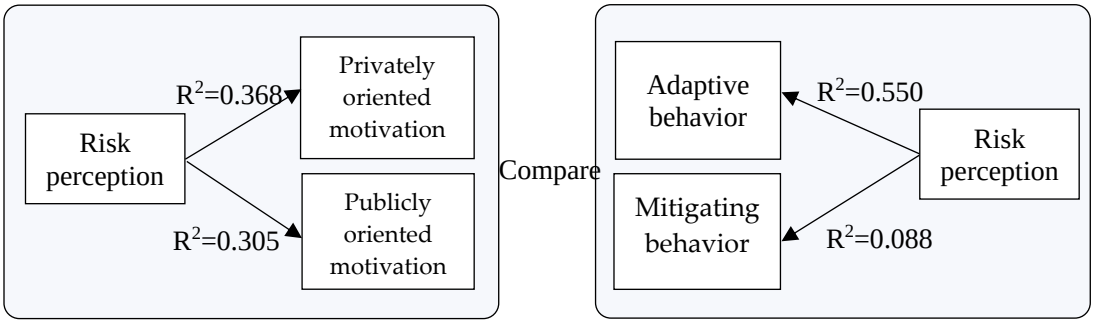

Figure 6. Comparison between motivation and behavior predicted by risk perception.

This result indicates that personal issues motivate the residents more strongly than public issues; nevertheless, they are also encouraged to conserve energy and protect the environment for public purposes. Interestingly, a considerable difference was found between adaptive (R^2 = 0.550) and mitigating (R^2 = 0.086) behaviors, leading us to conclude that although the residents exhibit a desire to act equally in pursuit of private and public purposes, they tend to engage more frequently in adaptive behaviors than mitigating behaviors when they initiate energy conservation and environmental protection efforts. On this basis, the residents' motivation cannot fully predict their behaviors with respect to environmental issues. There is no previous studies on how motivation would predict behaviors. This finding expands the literature on motivation and behavior field and proved that motivation is not the only factor that could predict behavior.

This study's potential implications revolve around the apparent conflict between intention and motivation as regards the private and public spheres. That is, even though individuals intend to implement safeguards against pollution to change an entire social environment because of high risk perception, the actions motivated by this perception and intention may have consequences for the private domain instead for a society. This possibility may be related to the "fatalistic" pursuit of individual solutions to collective problems—and the instilling of a "false sense of security" that can result from this pursuit undermines social mobilization aimed at action against haze-induced problems [69]. The residents prefer to use self-protection measures instead of engaging in deeds meant to change an entire society. We found that they have the intention (motivation) to behave responsibly for society but that their actual behaviors are often driven by self-benefit. Individuals are the main constituents of society, and without their involvement in environmental and energy-saving behaviors, corresponding regulations and policies would be costly and inefficient. Citizens should therefore be encouraged to adopt green consumption and prevent pollutant-generating events to help save society. The Chinese government can implement measures that effectively encourage residents to behave pro-environmentally and conserve energy through community activities. It should provide benefits to residents when they protect the environment and conserve energy; rewards can take the form of subsidies for the use of bicycles or the provision of cars run by renewable energy. In addition,

strengthening residents' knowledge of haze and energy saving can reduce their risk perception and encourage both self-protective behaviors and taking responsibility for changing society.

6. Conclusions

This study constructed a comprehensive theoretical model of the relationship among risk perception, motivation, and behavior with respect to involvement in environmental protection and energy saving. We explicitly incorporated demographic factors, residential distance to main roads, marital status, children, and 10 risk perception factors as critical predictors of residents' environmental protection and energy saving motivations and behaviors. Our results showed that the key predictors have significant correlations with both motivation and behavior. However, the correlation with privately oriented motivation is stronger than that with publicly oriented motivation. The key predictors can predict 36.8% of motivation related to the private domain and 30.5% of motivation associated with the public sphere. Such predictors also exhibit a stronger correlation with adaptive behaviors than mitigating behaviors, accounting for 55.0% of the former and only 8.6% of the latter. These results point to the fact that the residents are motivated to protect the environment for the benefit of society. The motivation related to the public domain is similar to that related to privacy, but the residents favor behaving for their benefit (adaptive behavior) rather than for society (mitigating behavior). Therefore, policy, regulation, and education should encourage environmental protection and energy-saving behaviors among the public. The findings led us to put forward a "risk perception-motivation–behavior change" policy target, wherein changes in behavior are induced by increasing residential responsibility under sufficient information from top authorities. This approach can be achieved through cooperation with top government departments and the provision of education to residents.

In this study, high risk perception leads to low motivation. To minimize such perception, residents should be given sufficient information on environmental and energy issues as this builds trust that can inspire individuals to think in a rational manner. Reduction can also be achieved by ensuring the accuracy of information and accordingly strengthen people's trust. By understanding the source of risk perception, residents can decrease risk by uniting communities. To encourage residents to act for society, education on social responsibility is necessary, but the benefits that residents can acquire in working for society should be clearly communicated. Social welfare related to environmental protection and energy saving can be established to provide incentives to residents. This "risk perception–motivation–behavior change" framework can contribute to evidence-based policymaking approaches to pro-environmental and energy-saving initiatives.

This work is limited by the fact that the motivational and behavioral factors were based on the situation in China. The related questionnaire items should be redesigned when the survey is used in other countries. Moreover, because of cultural differences, the results generated may differ for other areas in China, such as the southern region. An essential requirement, therefore, is to apply our risk perception, motivation, and behavior framework in investigations of other areas. In evaluating our behavioral change method, one of our important future endeavors is to conduct extensive behavioral experiments in different regions and countries to generate a behavioral change model that can be applied to various contexts.

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