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Perceived health risk, environmental knowledge, and contingent valuation for improving air quality: New evidence from the Jinchuan mining area in China☆

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ABSTRACT

This study examined people's willingness to pay (WTP) for improving air quality obtained through contingent valuation method (CVM) in the context of the theory of planned behaviour. Following this theory, four indicators were developed to measure people's behavioural intentions for improving air quality; two of these indicators were correlated with contingent valuation survey. Structural equation modelling (SEM) was employed to estimate our Perception-based Behavioural Intention Model (PBIM) by using a cross-sectional data set of 759 residents of the Jinchuan mining area in Gansu Province, China. We found that Jinchuan residents' WTP for improving local air quality was significantly influenced by the perceived health risk of hazardous pollutants, environmental knowledge, socioeconomic status, current health condition, gender, work environment, and proximity to the pollution source. This study shows that SEM outperforms conventional CVM econometrically and in terms of the provision of relevant policy information.

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1. Introduction

Many cities in China are experiencing severe levels of air pollution associated with a rapid increase in energy consumption for industrial, residential, and motor vehicle use (Wang et al., 2006; Watts, 2005). A report published by the State Environmental Protection Administration of China (2006) showed that two out of five cities in China failed to meet the residential-area air quality standards, resulting in the exposure of their populations to the risk of adverse health effects. Wong (2013) found that air pollution led to 1.2 million premature deaths in China in 2010.

Jinchuan has the largest nickel resources in China. Nickel industries, including mining and smelting, dominate local economic development. The output of Jinchuan's nickel industries accounts for more than 90% of China's total nickel production. Approximately 70% of the government revenues of Jinchuan derive from Nickel industries (Jinchuan Yearbook, 2012). Nickel industries, however, also cause serious environmental issues, particularly air pollution, and Jinchuan has become one of the 10 most polluted cities in China (Wei, 2008). The suspended particles, sulphur dioxide, chlorine gas, and carbon dioxide discharged by nickel industries are the main pollutants of Jinchuan's air (Huang et al., 2009; Li and Zhao, 2004; Wei, 2008; Xiao, 2003). The first three pollutants increase the probability of respiratory and cardiovascular illnesses and lung cancer, and can even result in death (Bernstein et al., 2004; Dockery & Pope III, 2006; Kampa and Castanas, 2008). Carbon dioxide is the primary greenhouse gas (Olah et al., 2008).

The main objective of this study is to value Jinchuan residents' willingness to pay (WTP) for improving air quality. The value of improving air quality, however, cannot be directly observed through economic transactions and market data (Louviere et al., 2000; Mendelsohn and Olmstead, 2009). Thus, a hypothetical market (scenario) involving an improvement of air quality is constructed through the process of applying contingent valuation method (CVM).

CVM has been widely used to value people's preference for improving air quality. For instance, Carlsson and Johansson-Stenman (2000) studied individual WTP for improving air quality in Sweden with CVM and found that people's WTP increased according to income, wealth, and education. It was higher for men,

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members of environmental organizations, people living in big cities (which are, on average, more polluted), and people who owned a house or apartment. Using data from the state of Kerala in India, Baby (2009) estimated local people's WTP for avoiding health risks associated with suspended particulate matter (SPM) with CVM and found that WTP values increased with income, SPM levels, and visits to the doctor. Wang et al. (2006) assessed residents' WTP to improve air quality in the urban area of Beijing with CVM and found that WTP increased with income and education levels and decreased with household size and age. Wang and Zhang (2009) employed CVM to study the relationship between poor air quality and residents' WTP for improving air quality in the city of Ji'nan, China. They found that annual household income, expenditures on the treatment of respiratory diseases, and the number of workers in the family significantly influenced people's WTP.

With regards to the reliability of CVM, Arrow et al. (1993) concluded that contingent valuation provided reliable information on estimating the value of improving air quality;[1] moreover, they suggested that respondents' 'internal psychological processes' should not be ignored when responses to valuation questions are interpreted. People's internal psychological processes, however, still remain unexplained in a 'black box' of conventional CVM. Thus, it is essential to discern the effects of people's internal psychological processes on their WTP (Ajzen, 1991; Hammitt, 2013; Menon et al., 2008; Shogren and Taylor, 2008). For instance, Kotchen and Reiling (2000) conducted a contingent valuation survey in Maine and analysed the relationships among environmental attitudes, nonuse values for endangered species, and underlying motivations for contingent valuation responses. They found that pro-environmental attitudes associated with stronger reliance on ethical motives for species protection resulted in higher estimates of mean WTP.

Therefore, knowing how much people are willing to pay for improving air quality but ignoring whether they view the risks caused by air pollution as highly probable and having severely negative consequences will result in biased explanations regarding this WTP.

This study makes two primary contributions to the literature. First, we provide an empirical application of a traditional CVM and extend it by considering psychological factors-notably, environmental knowledge and risk perception. This results in a better understanding of respondents' decision-making processes (Temme et al., 2008) and improvement of the explanatory power of the CVM. Second, the reliability of contingent valuation measures is enhanced by using four indicators to measure Jinchuan residents' behavioural intention to improve local air quality and employing structural equation modelling (SEM) to complete the data analysis.

We found that perceived health risk, environmental knowledge, current health condition, socioeconomic status, proximity to the pollution source, work environment, and gender are important determinants of Jinchuan residents' WTP for improving air quality. Furthermore, the explanatory power of CVM is enhanced by considering perceived health risk and environment knowledge.

The paper is organized as follows. The next section introduces the background of behavioural intention, perceived health risk, and environmental knowledge. This is followed by a description of the type of SEM, the conceptual model, and its identification. The next section outlines the survey and presents the data and empirical results. Finally, we present conclusions and policy recommendations.

2. Background: behavioural intention, perceived health risk, and environmental knowledge

According to planned behaviour theory, *behavioural intention*, which is the immediate antecedent of people's behaviour, can be predicted with high accuracy by other psychological factors, such as attitudes, perception, and subjective norms. Thus, to improve the capacity to describe and predict contingent valuation, Barro and Lee (1996), Kerr and Cullen (1995), Luzar and Cosse (1998), and Bernath and Roschewitz (2008) suggested using the theory of planned behaviour as context and considering WTP as behavioural intention when examining WTP responses obtained through CVM.

The relationship between perceived risk and risk behaviour has aroused interest in people's (environmental) behavioural intention. This is because perceived risk in shaping people's behavioural intention has been a fundamental issue in environmental economics and psychology. Theories and empirical studies agree regarding the importance of risk perception in explaining people's risk-related behavioural intention. The social-psychology literature on behavioural research also has established risk perceptions as important predictors of behaviour and behavioural intentions (Ajzen, 1988; Fishbein and Ajzen, 1975). In other words, perceived health risk has been central to most health-specific behavioural theories (Weinstein, 1993), including the health belief model (Becker, 1974; Kirscht, 1988), subjective expected utility theory (Edwards, 1954), protection motivation theory (Maddux and Rogers, 1983), the theory of reasoned action (Fishbein and Ajzen, 1975), and the theory of planned behaviour (Ajzen, 1985). These theories agree that the motivation to take actions correlated with negative outcome depends on people's assessment about the likelihood that the negative outcome will occur.

The concept of 'perceived risk' is also popular in the field of economics. Bauer (1960) first introduced the concept into the marketing literature. Since then, perceived risk has also attracted substantial attention from environmental economists. In this line, Um et al. (2002) found that individuals' aversion to using tap water in South Korea was significantly influenced by their risk perception. Further, Nauges and Van Den Berg (2009) found that perceived health risk encouraged households in Sri Lanka to treat water carefully—that is, to boil or filter it before drinking. By analysing the economic health cost of exposure to wildfire smoke in the United States, Richardson et al. (2012) found that perception of air pollution levels had a positive and significant effect on households' averting activities.

The variable 'environmental knowledge' is often used in campaigns to improve behavioural intention. Researchers have shown that an individual's knowledge of environmental issues is important to decision-making within an environmental context (e.g., Hines et al., 1987; Hungerford and Volk, 1990; Marcinkowski, 1988). Environmentally conscious behaviour is possible only when people know what they can or could do. Without environmental knowledge, it is impossible to act in an environmentally friendly way. Vassanadumrongdee and Matsuoka (2005) conducted contingent valuation surveys in Bangkok to measure individuals' WTP for reducing mortality risk arising from air pollution and found WTP to be significantly and positively influenced by personal knowledge. This conclusion was also supported by Gil and Soler (2006), who studied consumers' knowledge and WTP for organic food products in Spain and found that this knowledge significantly influenced consumers' WTP for organic food production.

[1] In 1993, a panel of prominent economists assembled by the National Oceanic and Atmospheric Administration issued a report assessing the reliability of CV for estimating nonuse values (Arrow et al., 1993).

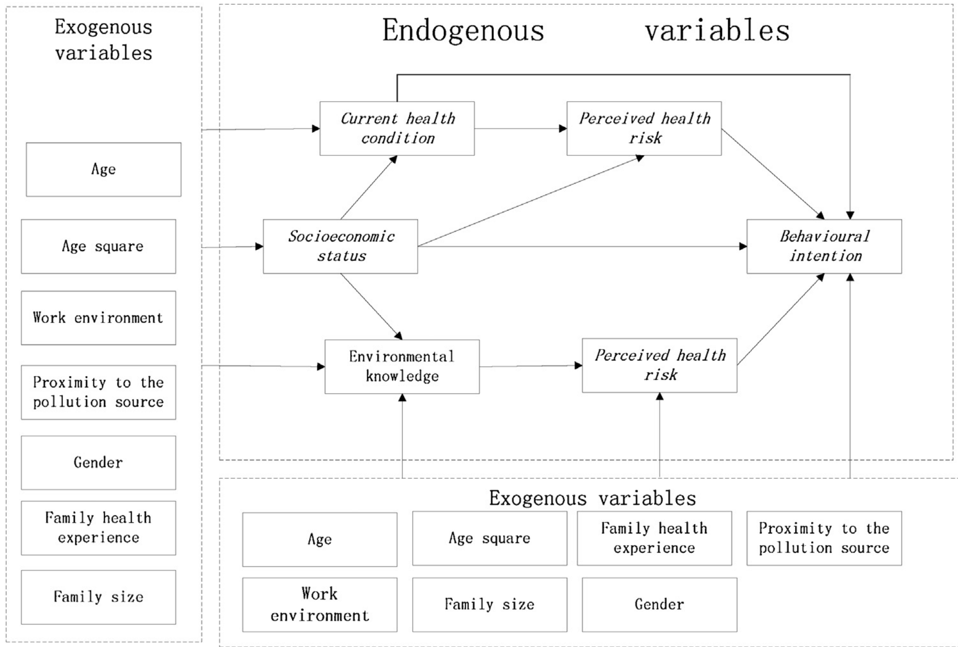


Fig. 1. The Perception based Behavioural Intention Model.

3. Model specification and identification

3.1. Structural equation modelling

To handle the three psychological factors discussed above—environmental knowledge, perceived health risk, and behavioural intention—and their explanatory variables (e.g., age, gender, work environment) and model of systems of relationships within one model framework, SEM was employed to complete the empirical estimation (Jöreskog and Sörbom, 1996).

A SEM is made up of three sub-models: two measurement models and the structural model (Jöreskog and Sörbom, 1996). Eqs. (1) and (2), which describe the relations between latent variables and their corresponding indicators, are the measurement models.

$$\boldsymbol{y} = \boldsymbol{\Lambda_y}\boldsymbol{\eta} + \boldsymbol{\varepsilon}\, with\, cov\, \boldsymbol{\varepsilon} = \boldsymbol{\Theta}_\varepsilon \quad (1)$$

$$\boldsymbol{x} = \boldsymbol{\Lambda_x}\boldsymbol{\xi} + \boldsymbol{\delta}\, with\, cov\,(\boldsymbol{\delta}) = \boldsymbol{\Theta}_\delta \quad (2)$$

Specifically, the variables $\boldsymbol{y}$ and $\boldsymbol{x}$ on the left side of the measurement equations are $(p \times 1)$ and $(q \times 1)$ vectors of observed endogenous and exogenous variables, respectively. The variables $\boldsymbol{\eta}$ and $\boldsymbol{\xi}$, which are on the right side of the measurement equations, are $(m \times 1)$ and $(n \times 1)$ vectors of latent endogenous and latent exogenous variables,[2] respectively. $\boldsymbol{\Lambda}_y$ and $\boldsymbol{\Lambda}_x$ constitute the $(p \times m)$ and $(q \times n)$ matrix, and they specify the relationship (loadings) between $\boldsymbol{y}$ and $\boldsymbol{x}$ and their corresponding latent variables of $\boldsymbol{\eta}$ and $\boldsymbol{\xi}$, respectively. $\boldsymbol{\Theta}_\varepsilon\,(p \times p)$ and $\boldsymbol{\Theta}_\delta\,(q \times q)$ are covariance matrices of $\boldsymbol{\varepsilon}$ and $\boldsymbol{\delta}$, which are the measurement errors of $\boldsymbol{y}$ and $\boldsymbol{x}$, respectively.

$$\boldsymbol{\eta} = \boldsymbol{B\eta} + \boldsymbol{\Gamma\xi} + \boldsymbol{\zeta}\, with\, cov\,(\boldsymbol{\xi}) = \boldsymbol{\Phi},\, cov\,(\boldsymbol{\zeta}) = \boldsymbol{\Psi} \quad (3)$$

Eq. (3) is the structural model that specifies the relationships among the latent variables. $\boldsymbol{B}$ is an $(m \times m)$ matrix that contains the structural parameters relating the endogenous variables to one another, and $\boldsymbol{\Gamma}$ is an $(m \times n)$ matrix containing structural coefficients relating the endogenous variables to the exogenous variables. $\boldsymbol{\zeta}$, also called a structural disturbance, is a random $(p \times 1)$ vector of errors with covariance matrix $\boldsymbol{\Psi}(p \times p)$. The covariance matrix of $\boldsymbol{\xi}$ is $\boldsymbol{\Phi}(n \times n)$.[3] For details on identification, estimation, testing, and model modification of an SEM, we refer to Bollen (1989) and Bollen and Noble (2011).

Using SEM has several advantages. First, SEM allows a closer correspondence between theory (which is formulated in terms of latent variables) and empirics (which are based on observed variables) (Oud and Folmer, 2008). Second, because the measurement errors of the explanatory variables are purged of the true latent variables in the measurement model, SEM reduces attenuation bias (bias towards zero) in the structural model. Finally, SEM reduces multicollinearity by taking strongly correlated observed variables as indicators of one latent variable in the measurement model. In the structural model, the latent variables are substituted for the strongly correlated observed variables (Folmer and Nijkamp, 1986).

3.2. Conceptual model

We present the conceptual model of our research in Fig. 1 and Eqs. (4)–(6). Our conceptual model contains five endogenous variables: *behavioural intention*, *perceived health risk*, *environmental knowledge*, *socioeconomic status*, and *current health condition*. Moreover, all of them are influenced by people's sociodemographic

[2] The latent variable, which is also called latent construct and cannot be observed directly, is commonly measured by multiple observed variables (also called manifest variables, items, or indicators).

[3] Note that it is possible to include intercepts in the measurement models and in the structural model. However, we standardize the variables below. Note also that directly observed variables can be included in the structural model by specifying an identity relationship between a latent variable and its indicator in the measurement model and fixing the measurement error at zero.

Table 1
Descriptive statistics for the observed exogenous variables.

Variables	Min	Max	Mean	S.D
Age (AGE)	21	78	44.11	11.4
Family size (FS)	1	6	2.95	0.78
Gender (GEN)	0	1	0.39	0.49
Current health condition(CHC)	1	5	3.68	0.85
Family health experience(FHE)	0	1	0.33	0.48

Education (EDU)	%	Household net income (CNY per month) (IN)	%
Primary school	6.30%	1000-2000	4.70%
Middle school	23.60%	2000-3000	15.30%
High school	25.30%	3000-4000	18.30%
Vocational school,	25.30%	4000-5000	19.10%
Bachelor's degree	19.10%	5000-6000	20.90%
Master's degree	0.40%	6000-7000	13.00%
Proximity to the pollution source (PPS) %		7000-8000	3.70%
Nearby smelting plants, severe air pollution (SAP)	29.60%	8000-9000	1.80%
		9000-10000	1.10%
Medium air pollution (MAP)	29.80%	More than 10000	2.00%
Far away from smelting plants, light air pollution (LAP, reference case)	40.60%	Current health condition	
Work environment (WE) %			
Non-JMC individuals (reference case)	59.55%		
Miners and smelter workers of JMC (MS)	18.18%		
JMC employee, but not miner or smelter worker (NMS)	22.27%		

Note: Source: Author's survey. **Family size:** number of family members living in the same house. **Current health condition**: respondent's self -evaluation of his/her own current health condition. (5=very good, 4=good, 3= no good, no bad, 2=bad, 1=very bad). **Family health experience**: 1 if the respondent or one or more of their family members have been hospitalized for cardiovascular diseases (e.g., hypertension, heart attack, chest pain, arrhythmia and miocardial infraction) or respiratory diseases (e.g., upper respiratory tract infection, bronchitis, pneumonia, asthma, and lung cancer), 0 otherwise. **Gender** is measured as a dummy variable (Male = 0, Female = 1).

characteristics, including age, age square, gender, family size, family health experience, work environment, and proximity to the pollution source.

Before going into detail, we observed that the studies on the relationship between *Behavioural intention* (*BI*) for improving air quality and *perceived health risk* caused by air pollution are limited; thus, we have expanded the scope of the literature review by also including some research on the relationship between *BI* and forms of environmental risks other than those that are related to air pollution. *BI*, which is a measure of a person's willingness (or relative strength of purpose) to execute certain behaviour (Ng and Paladino, 2009), is the main dependent variable of our conceptual model. To improve the reliability of measures, Ajzen (1991); Graefe et al. (1988), and Hrubes et al. (2001) suggested using multiple-item measures of *BI* rather than single-item measures. Thus, four indicators were developed in this study to test Jinchuan residents' *BI* for improving local air quality (Fig. 3).

Perceived health risk (PHR) is here conceptualized as the subjective assessment of the possibility of suffering negative health events over a specified period (Menon et al., 2008). It is assumed that the impact of *PHR* on *BI* is direct and positive. This hypothesis is supported by Brewer et al. (2007), who conducted a meta-analysis to assess the bivariate association between adult vaccination and *PHR* and found consistent relationships between risk perceptions and intentions of avoiding health risks. Five indicators were developed in this study to examine Jinchuan residents' *PHR* (Fig. 4).

Environmental knowledge (EK) is conceptualized as an individual's cumulative body of knowledge of the interdependency between human society and its natural environment (Berkes et al., 2000). It is generally considered as a prerequisite for other environmental psychological factors, such as environmental value, environmental attitude, and risk perception (Hungerford and Volk, 1990). Kitzmüller (2009) analysed data collected from Bowling Green, Ohio, and found that *EK* indirectly influences *BI* via environmental attitude. Thus, in our study, we hypothesize that *EK* indirectly influences *BI* through *PHR*. Eight indicators were developed in this study to test Jinchuan residents' *EK* (Fig. 5).

Current health condition (CHC) has been considered an important determinant of individuals' *BI* for improving air pollution (Elliott et al., 1999; Slovic, 1987). First, we hypothesize that *CHC* directly and positively influences *BI* for improving air quality. This is because people's behaviours in avoiding the negative effects of polluted air are embedded in daily life through their own health experiences (Bickerstaff, 2004). Additionally, people with poor health status would be concerned about the negative effects caused by air pollution and likely to adopt aversive behaviours (Elliott et al., 1999). Thus, we also postulate that *CHC* indirectly influences *BI* via risk perception. *CHC* is measured by a respondent's self-evaluation of his or her *CHC* (Table 1).

Socioeconomic status (SES), which is measured by income and education, is assumed to positively influence people's *BI* for improving air quality (Hammitt and Zhou, 2006; Wang and Zhang, 2009). That is, people with higher *SES* have more power to carry out their plans and achieve their goals. We also postulate that individuals with higher *SES* have higher levels of *EK, PHR,* and *CHC* than individuals with lower *SES* (Diamantopoulos et al., 2003; Kahn et al., 2009; Kim et al., 2017a; Ogunbode and Arnold, 2012).

Following the contingent valuation literature, respondents' sociodemographic characteristics, such as age, age square, family size, gender, family health experience, work environment, and proximity to the pollution source were all assumed to be important determinants of their *BI* for improving air quality. This is because each has been shown to be a valid predictor of *BI* aimed at reducing the negative health effects caused by environmental degradation (Abdalla et al., 1992; Bresnahan et al., 1997; Harrington et al., 1989; Laughland et al., 1996; Um et al., 2002). Moreover, *EK, PHR, CHC, and SES* are all postulated as endogenous and influenced by respondents' sociodemographic characteristics (Kim et al., 2017a, 2017b; Li et al., 2016, 2014).

In terms of Eqs. (1)–(3), the conceptual model is shown in Fig. 1 and reads as follows:

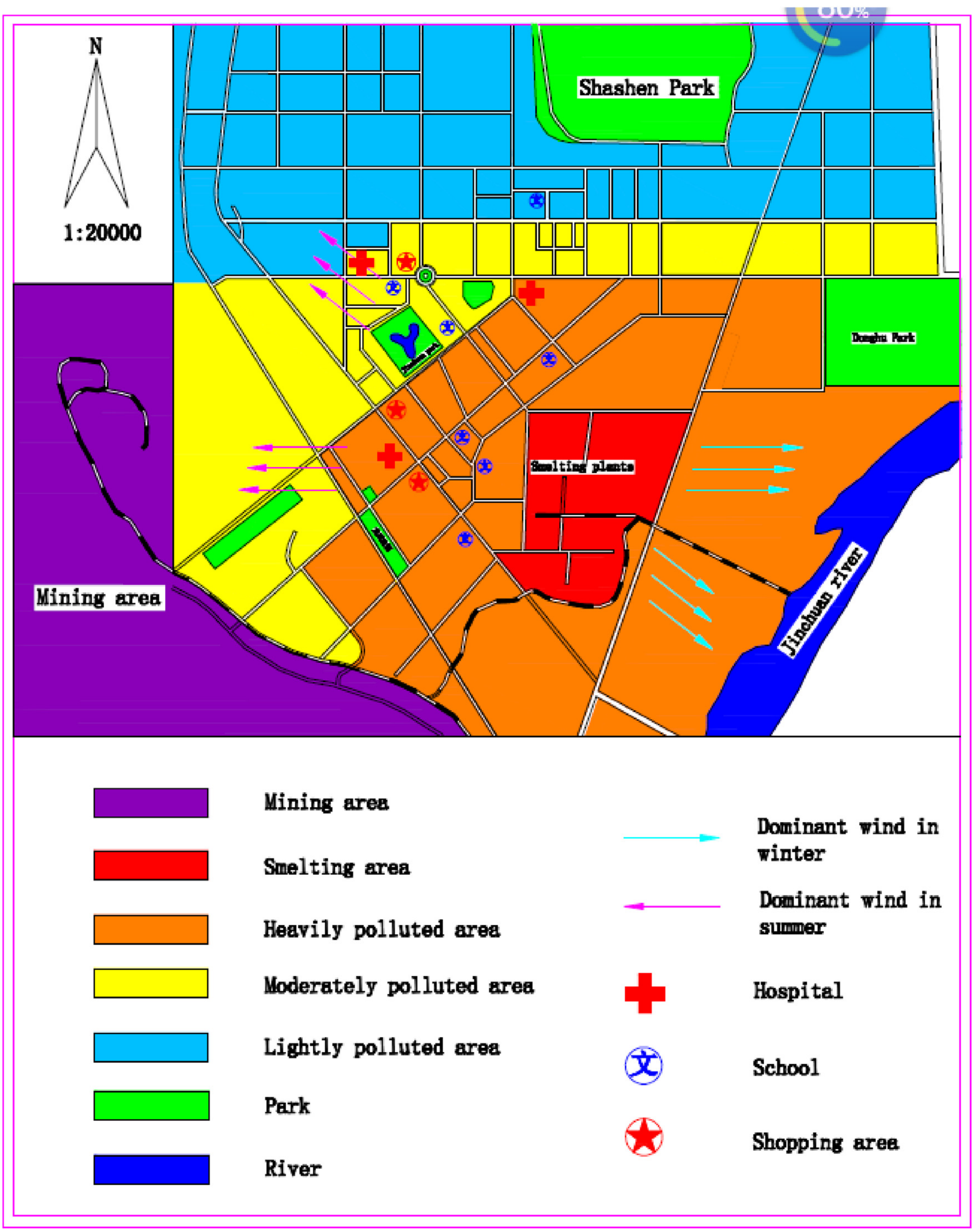
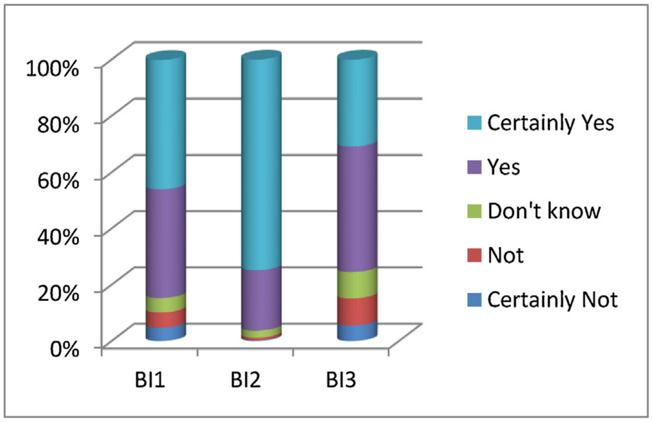


Fig. 2. Heavily, moderately and lightly polluted areas of the Jinchuan mining area.
Note: the dominant wind directions are from the east and south-east during summer and from west and north-west during winter.
Source: JEQMR (2011), Wei (2008) and Li et al., (2014)



BI4	
Max	1000
Min	0
S.D	20
Mean	102

Fig. 3. Statistics for the indicators of Behavioural intention.
Note: **BI1**: Would you like to pay environmental taxes (e. g., raising fuel or automobile taxes) for improvement of air quality of Jinchuan. **BI2:** Would you like to walk or ride bicycle to work place for improvement of air quality of Jinchuan? **BI3**: Would you like to pay extra money per month for improvement of air quality of Jinchuan. **BI4:** What is the maximum your household per month would like to pay for improvement of air quality of Jinchuan?
Source: Author survey

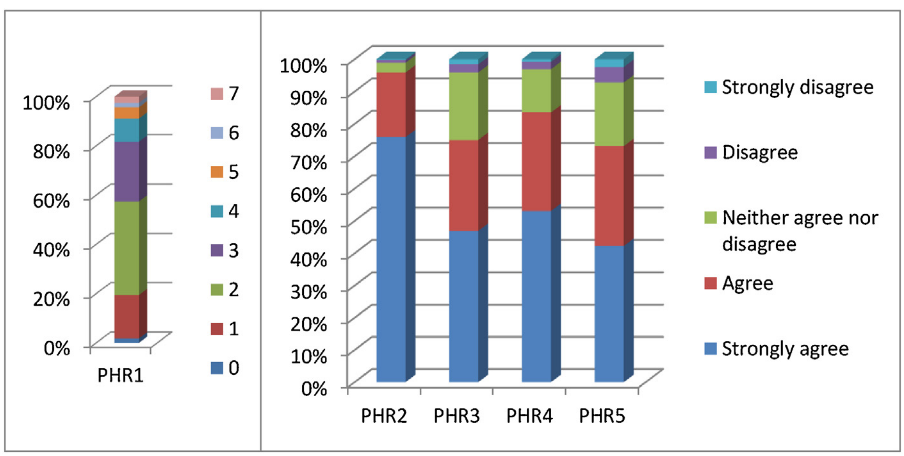


Fig. 4. Frequency distribution of the indicators of Perceived health risk.
Note: **PHR1**: what do you perceive as the average number of days per week Jinchuan's air was heavily polluted during the past year? **PHR2**: Jinchuan's air pollution increases the likelihood of suffering from respiratory illnesses. **PHR3**: Jinchuan's air pollution increases the likelihood of suffering from cardiovascular illnesses. **PHR4**: Jinchuan's air pollution increases the likelihood of suffering from lung cancer. **PHR5**: Jinchuan's air pollution increases the likelihood of suffering from death.
Source: Author survey

The Measurement Model

$$\begin{bmatrix} BIL1 \\ \vdots \\ BIL4 \\ PHR1 \\ \vdots \\ PHR5 \\ EK1 \\ \vdots \\ EK8 \\ CHC \\ IN \\ EDU \end{bmatrix} = \begin{bmatrix} \lambda^y_{1\,1} & 0 & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ \lambda^y_{4\,1} & 0 & 0 & 0 & 0 \\ 0 & \lambda^y_{5\,2} & 0 & 0 & 0 \\ 0 & \lambda^y_{6\,2} & 0 & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & \lambda^y_{9\,2} & 0 & 0 & 0 \\ 0 & 0 & \lambda^y_{10\,3} & 0 & 0 \\ 0 & 0 & & 0 & 0 \\ \vdots & \vdots & \vdots & \vdots & \vdots \\ 0 & 0 & \lambda^y_{17\,3} & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & \lambda^y_{19\,5} \\ 0 & 0 & 0 & 0 & \lambda^y_{20\,5} \end{bmatrix} \times \begin{bmatrix} BI \\ PHR \\ EK \\ CHC \\ SES \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \vdots \\ \varepsilon_4 \\ \varepsilon_5 \\ \vdots \\ \varepsilon_9 \\ \varepsilon_{10} \\ \vdots \\ \varepsilon_{17} \\ 0 \\ \varepsilon_{19} \\ \varepsilon_{20} \end{bmatrix} \quad (4)$$

$$\begin{bmatrix} AGE \\ AGE^2 \\ GEN \\ FS \\ FHE \\ MAP \\ SAP \\ NMS \\ MS \end{bmatrix} = \begin{bmatrix} 1&0&0&0&0&0&0&0&0 \\ 0&1&0&0&0&0&0&0&0 \\ 0&0&1&0&0&0&0&0&0 \\ 0&0&0&1&0&0&0&0&0 \\ 0&0&0&0&1&0&0&0&0 \\ 0&0&0&0&0&1&0&0&0 \\ 0&0&0&0&0&0&1&0&0 \\ 0&0&0&0&0&0&0&1&0 \\ 0&0&0&0&0&0&0&0&1 \end{bmatrix} \times \begin{bmatrix} AGE \\ AGE^2 \\ GEN \\ FS \\ FHE \\ MAP \\ SAP \\ NMS \\ MS \end{bmatrix} + \begin{bmatrix} 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \\ 0 \end{bmatrix} \quad (5)$$

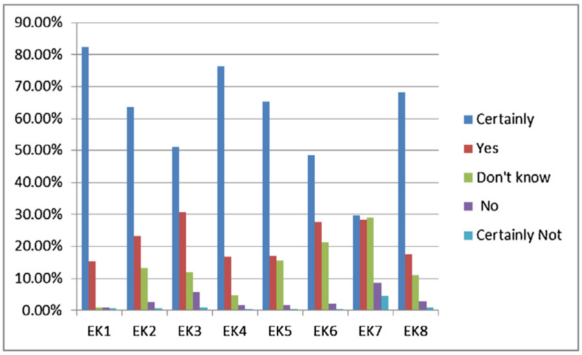


Fig. 5. Frequency distribution of the indicators of Environmental Knowledge.
Note: EK1: Do you acknowledge that Jinchuan suffers from air pollution?. **EK2**: Do you acknowledge that Jinchuan suffers from industrial solid waste? **EK3**: Do you acknowledge that Jinchuan suffers from water pollution? **EK4**: Do you acknowledge that environmental issues in Jinchuan are mainly caused by local industrial activities? **EK5**: Do you acknowledge that sulfur dioxide is one of the main air pollutants of Jinchuan? **EK6**: Do you acknowledge that suspended particle matter is one of the main air pollutants in Jinchuan?. **EK7**: Do you acknowledge that carbon dioxide is one of the main air pollutants of Jinchuan? **EK8**: Do you acknowledge that chlorine gas is one of the main air pollutants of Jinchuan?
Source: Author survey.

The Structural Model

$$\begin{bmatrix} BI \\ PHR \\ EK \\ CHC \\ SES \end{bmatrix} = \begin{bmatrix} 0 & \beta_{12} & 0 & \beta_{14} & \beta_{15} \\ 0 & 0 & \beta_{23} & \beta_{24} & \beta_{25} \\ 0 & 0 & 0 & 0 & \beta_{35} \\ 0 & 0 & 0 & 0 & \beta_{45} \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \times \begin{bmatrix} BI \\ PHR \\ EK \\ CHC \\ SES \end{bmatrix}$$

$$+ \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} & \gamma_{16} & \gamma_{17} & \gamma_{18} & \gamma_{19} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} & \gamma_{26} & \gamma_{27} & \gamma_{28} & \gamma_{29} \\ \gamma_{31} & \gamma_{42} & \gamma_{33} & \gamma_{34} & \gamma_{35} & \gamma_{36} & \gamma_{37} & \gamma_{38} & \gamma_{39} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} & \gamma_{46} & \gamma_{47} & \gamma_{48} & \gamma_{49} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} & \gamma_{56} & \gamma_{57} & \gamma_{58} & \gamma_{59} \end{bmatrix}$$

$$\times \begin{bmatrix} AGE \\ AGE^2 \\ GEN \\ FS \\ FHE \\ MAP \\ SAP \\ NMS \\ MS \end{bmatrix} + \begin{bmatrix} \zeta_1 \\ \zeta_2 \\ \zeta_3 \\ \zeta_4 \\ \zeta_5 \end{bmatrix} \quad (6)$$

3.3. Identification

A prerequisite for estimation of Eqs. (4)–(6) is that they are identified. One condition for the identification of Eqs. (4)–(6) is that measurement scales should be assigned to all latent variables, including *BI, PHR, EK,* and *SES.* This can be achieved by fixing the variances of the latent variables, usually at 1, or by fixing one measurement coefficient for each latent variable, usually also at 1. In our study, we apply the first method (Byrne, 2013; Hoyle, 2011).

Apart from assigning measurement scales to latent variables, the order and rank conditions also need to be met for identification. The latter may be tedious to check. However, estimation of Eqs. (4)–(6) can be done by a variety of software packages, of which LISREL 8 (Jöreskog and Sörbom, 1996) and Mplus (Muthén and Muthén, 2010) are probably the best known and can give indications of the identification problems of Eqs. (4)–(6) by evaluating the information matrix at the minimum of the fitting function. If the estimated information matrix is singular, Eqs. (4)–(6) are not identified (Silvey, 1975). Moreover, LISREL 8 and Mplus can also be used to obtain modification indices, which make suggestions about model improvement by freeing fixed or constrained parameters.

4. Empirical results

4.1. Survey and data collection

The survey data were collected from the Jinchuan mining area in Gansu Province, China, in August 2012. Because the questionnaire was eight pages long, face-to-face interviews were conducted. Before the survey, a pilot survey was carried out. The questionnaire was adjusted, corrected, and reworded based on the results of the pilot survey. Interviewers were trained and selected from a group of college students at Gansu Nonferrous Metallurgy College in Jinchuan based on their understanding of the environmental issues in Jinchuan and of the local language.

The sample was stratified and selected from permanent residents of Jinchuan who had 'Hukou'[4] and had lived in this area for at least 10 years. Interviewees were family heads and were above 21 years of age. The data were collected in two steps. First, the Jinchuan mining area was divided into three sub-areas based on the level of air pollution (corresponding to the distance from the local smelting plants): severely polluted, moderately polluted, and lightly polluted (JEQMR, 2011; Wei, 2008; see Fig. 2). Second, the interviewees in each area were randomly selected. One or two households per 100 households were selected; thus the proportion of interviewees from each area represented the area's proportion of the overall region. The total sample size was 759. The response rate was about 90%, which is high but not uncommon in China (see Grant et al., 2004; Zhang et al., 2008). Moreover, apart from questions on socioeconomic and demographic characteristics, interviewees were also questioned about their *EK, PHR,* and *BI* for improving air quality (see Figs. 3–5 for details).

4.2. Descriptive statistics

From our 800 questionnaires, 41 (5.12%) were rejected because they were incomplete. There was no evidence of nonrandom dropout. Descriptive statistics are presented in Table 1 and Figs. 3, 4, and 5.

Four indicators were developed to measure Jinchuan residents' *BI* for improving air quality.[5] First, respondents' intention for improving air quality was tested by two noncontingent valuation questions (BI1 and BI2), which are indicated in Fig. 3. As also shown in Fig. 3, over 80% of the respondents would like to take actions to improve the air quality of Jinchuan by paying an environmental tax or using environmentally friendly transportation. Second, Jinchuan residents' WTP for improving air quality (contingent valuation scenario) was elicited by another two questions (BI3 and BI4). Each respondent was first asked whether he or she would like to pay extra money per month to improve Jinchuan's air quality. A 5-point scale ranging from 1 (certainly not) to 5 (certainly yes) was used to answer this question. If respondents did not answer 'certainly not' or 'not', an initial bid amount was randomly selected from a set of initial values. The respondent was then asked a follow-up question, for which the bid amount depended on his or her response to the

[4] *Hukou*, which is a system of household registration in mainland China, contains a person's information (e.g., name, parents, spouse, date of birth) and can identify a person as a resident of an area.

[5] Traditionally, in psychology, people's (environmental) behavioural intention is measured by asking about the likelihood of exhibiting the (environmental) behaviour in question.

initial bid. If he or she responded ‘yes’ to the initial bid, the follow-up bid was twice as large as the initial bid; if he or she responded ‘no’ to the initial bid, the follow-up bid was half as large as the initial bid. Following the two dichotomous-choice questions, we finally asked respondents to state their maximum WTP for improving the air quality of Jinchuan (Hammitt and Zhou, 2006). Fig. 3 shows that a large majority (approximately 80%) of respondents would be willing to pay extra money for improving air quality (BI3) and that their maximum WTP varies between 0 to 1000 CNY per month, with a mean value of 102 CNY.

Following Sjöberg et al. (2004) and Egondi et al. (2013), two domains of Jinchuan residents’ *PHR* caused by air pollution were examined; perceived risks caused by exposure in density and the hazardousness of pollutants were measured by asking participants to express their opinions and answer five questions. For the perceived risk of exposure in density, respondents were asked to answer the following question: *What is the average number of days per week you perceived the air in Jinchuan to be heavily polluted during the past year*? Fig. 4 shows that the majority (62.1%) answered ‘medium polluted’ (2 or 3 days a week), whereas some answered ‘lightly polluted’ (0 or 1 day a week, 18.3% of respondents) and ‘heavily polluted’ (4 or more days a week, 19.6% of respondents). Regarding the perceived risk caused by hazardous pollutants, respondents were asked their opinion about the extent to which Jinchuan’s air pollution increased the probability of suffering from four major types of health problems. A 5-point scale was used, with 1 indicating ‘strong negative opinion’ and 5 indicating ‘strong positive opinion’. The results showed that the rank of perceived impacts from serious to light were respiratory illnesses (95.9%), lung cancer (83.6%), cardiovascular illnesses (75%), and death (73.1%).

Respondents’ knowledge concerning Jinchuan’s environmental issues was measured by eight indicators (Fig. 5). Each indicator was measured on a 5-point scale ranging from 1 (strongly disagree) to 5 (strongly agree). The first three indicators (EK1–EK3) tested respondents’ knowledge of general environmental issues in Jinchuan. As can be seen from Fig. 5, over 80% of the respondents agreed or strongly agreed that air pollution, industrial solid waste, and water pollution are environmental issues affecting Jinchuan. Moreover, 93.2% believed that Jinchuan’s environmental problems are mainly caused by local industrial activities (EK4). Another four indicators were developed to measure people’s knowledge of the main pollutants in Jinchuan’s air. Fig. 5 shows that over 55% of the respondents either strongly agreed or agreed that chlorine gas, sulphur dioxide, suspended particles, and carbon dioxide are the main pollutants of Jinchuan’s air.

Before going into detail, we emphasize that in order to facilitate comparison of the effects of different variables, estimated coefficients were standardized or beta coefficient. Standardized coefficients, which can be directly compared, give the standard deviation change in a dependent variable due to a standard deviation change of an explanatory variable. As mentioned above, *BI* is a latent variable measured by four indicators: BI1, BI2, BI3, and BI4 (see Fig. 3 for definitions). To obtain percentage changes of people’s WTP for improving air quality (BI4), we took natural logarithms of its scores and relabelled it as BIL4. As some outcomes of BI4 are equal to zero, we increased all scores by 1. Hence BIL4 = ln (BI4 + 1). Note that we also relabelled BI1, BI2, and BI3 as BIL1, BIL2, and BIL3, respectively, but did not log-transform them.

Figs. 3–5 show that the categorical indicators of *BI, PHR,* and *EK* are highly skewed and nonnormally distributed. Therefore, weighted least squares based on the matrix of polychoric correlations was employed to estimate Models (4)–(6). As a first step, the full conceptual model (Initial Model) presented by Eqs. (4)–(6) was estimated.[6] The estimated results of the measurement models of the Initial Model (see Tables A1–A3 in Appendix A) show that the reliability of PHR1 was very low (0.02), and this indicates that PHR1 measures a different dimension from the other four indicators (PHR2–PHR5; Bollen, 1989). Therefore, the latent variable *PHR* was split into two latent variables: (a) *PHR* caused by the intensity of exposure (*Exposure*) and (b) *PHR* caused by the hazardousness of pollutants (*Hazardousness*). *Exposure* was measured by PHR1, and *Hazardousness* was measured by PHR2–5. Note that this split was supported by Sjöberg et al. (2004) and Egondi et al. (2013).

Table 2
Overall goodness- of -fit indices.

Fit index	Value	Cut off value
$\chi2$/DF	1.20	<3.00
Goodness-of-fit index(GFI)	0.97	>0.90
Adjusted goodness-of-fit index (AGFI)	0.96	>0.90
Standardized root mean square residual (SRMR)	0.031	<0.08
Root mean square error of approximation (RMSEA)	0.045	<0.08

Another outcome of the estimated Initial Model was that several explanatory variables of five endogenous variables were highly insignificant. We deleted the variables with insignificant coefficients in a stepwise procedure, starting with the one with the largest p-value (stepwise backward elimination). This gave us the Final Model. (For illustrative purposes, we also included some of the insignificant variables in the Final Model [see Table 4].) We discuss the Final Model below.

The overall goodness-of-fit indices of the Final Model are presented in Table 2, that is, the $\chi2$/DF (DF denoting degrees of freedom), the Goodness-of-Fit statistic (GFI), the Adjusted Goodness-of-Fit statistic (AGFI), the Standardized Root Mean Square Residual (SRMR) and the Root Mean Square Error of Approximation (RMSEA) (see Byrne, 1998; Jöreskog and Sörbom, 1996; Ouyang, 2009). All the indices met their critical values, indicating that the Final Model had a good fit.

The estimated measurement models are presented in Table 3, which contains, for each indicator, its loadings, standard error, and reliability (R^2). Table 3 indicates that the loadings of all indicators are significant at 1% or less.

The structural model is presented in Table 4. It shows that *Hazardousness* positively and significantly influences people’s *BI* for improving air quality. However, the impact of *PHR* due to *Exposure* on *BI* is highly insignificant. This indicates that Jinchuan residents’ *BI* for improving air quality is not sensitive to the level of exposure. However, their perception of health risk caused by hazardous air pollutants, which is the perception of the negative outcome of air pollution, motivates them to take actions to reduce corresponding health risks. Moreover, *CHC*, as hypothesized, significantly and positively impacts *BI* for improving air quality; however, its indirect impact on *BI* via *PHR* is insignificant. In line with the conceptual model, *EK* positively and significantly influences latent *PHR*.

In line with Wang and Zhang (2009), *SES* positively and significantly influences people’s *BI* for improving air quality. Moreover, the positive impacts of *SES* on *CHC* and *EK* suggest that individuals with higher SES can have better health status and can acquire a better understanding of the nature of environmental issues, including those in Jinchuan (Diamantopoulos et al., 2003; Kahn et al., 2009; Lee et al., 2009; Ogunbode and Arnold, 2012).

[6] Weighted least squares (WLS), sometimes called inverse probability weighting, eliminates the need for exclusion restrictions, though WLS does require the model to satisfy the ignorability assumption (Wooldridge, 2002). That is, under the key assumption that selection bias is ignorable, an inverse probability weighting scheme generally provides extra information and identifies the population parameters (Blundell and Powell, 2007; Fitzgerald et al., 1998; Khan and Lewbel, 2007).

Table 3
Measurement model.

Latent variables	Indicators	Coefficient	Standard errors	R-square
Behavioral intention (BI)	BHL1	0.41	0.04	0.17
	BHL2	0.32	0.05	0.10
	BHL3	0.51	0.04	0.26
	BHL4	0.30	0.04	0.09
Exposure	PHR1	1.00	0.02	1.00
Hazardousness	PHR2	0.60	0.03	0.36
	PHR3	0.52	0.03	0.27
	PHR4	0.62	0.03	0.38
	PHR5	0.55	0.03	0.30
Environmental knowledge (EK)	EK1	0.52	0.04	0.27
	EK2	0.46	0.03	0.22
	EK3	0.39	0.03	0.15
	EK4	0.48	0.04	0.23
	EK5	0.55	0.04	0.31
	EK5	0.46	0.03	0.22
	EK7	0.31	0.03	0.09
	EK8	0.44	0.03	0.19
Socioeconomic status (SES)	Education	0.47	0.05	0.19
	Income	0.43	0.04	0.24

Table 4
Structural model.

Variables	*BI*	*Exposure*	*Hazardousness*	*EK*	*CHC*	*SES*
Behavoiural intention (BI)						
Exposure	0.03					
	(0.04)					
Hazardousness	0.13**					
	(0.05)					
Environmental knowledge (EK)		0.14***	0.67***			
		(0.03)	(0.09)			
Current health condition (CHC)	0.11***					
	(0.04)	(0.02)	(0.04)			
Socioeconomic status (SES)	0.42***	0.05	0.09	0.43***	0.14***	
	(0.10)	(0.04)	(0.07)	(0.08)	(0.04)	
Age (AGE)	0.07**			0.07**		-0.12***
	(0.03)			(0.03)	(0.02)	(0.03)
Age-square (AGE^2)	0.02			0.03		
	(0.03)			(0.03)	(0.02)	(0.03)
Gender (GEN)					-0.05***	0.01
	(0.03)				(0.02)	(0.03)
Family size (FS)	-0.06*		-0.08***			0.12***
	(0.03)		(0.03)		(0.02)	(0.03)
Family health experience (FHE)	0.01		0.05		-0.20***	
	(0.03)		(0.03)		(0.02)	(0.03)
Medium air pollution (MAP)	0.02	0.09***	0.05	0.01		-0.19***
	(0.05)	(0.02)	(0.04)	(0.04)	(0.02)	(0.05)
Severe air pollution (SAP)	0.10**	0.20***	0.03	0.10*	0.01	-0.32***
	(0.04)	(0.02)	(0.04)	(0.04)	(0.03)	(0.05)
JMC employee, but not miner or smelter worker (NMS)				0.03	-0.15***	0.43***
				(0.05)	(0.03)	(0.05)
Miners and smelter workers of JMC (MS)				0.11*	-0.15***	0.22***
				(0.05)	(0.03)	(0.05)
R-square	0.26	0.05	0.52	0.19	0.08	0.27

Notes: Standard errors in parenthesis. *, **and *** :10%, 5% and 1% level, respectively.

We now turn to the sociodemographic characteristics. Age and age square both positively influence *BI* for improving air quality, although age square was not significant, indicating that Jinchuan's elders have a stronger intention for improving air quality to make life safer for themselves than do younger people (Firoozzarea and Ghorbani, 2011). Family size has a negative influence on *BI* for improving air quality; this shows that a larger family has relatively less intention to improve air quality because of the associated running costs (i.e., budgetary constraints; Belhaj Fraj, 2003 Moffat, 2011). Proximity to the pollution source, as measured by two dummies-medium air pollution and severe air pollution (light air pollution is the reference case)-had a positive impact on *BI* for improving air pollution, but only severe air pollution was significant. Apparently, people living farther away from smelting plants are less exposed to air pollution than those who live nearby and would like to take less action to reduce air pollution (Bickerstaff and Walker, 2001; Combest-Friedman et al., 2012; Riddel and Shaw, 2006). Work environment, family health experience, and gender are not important determinants of *BI* for improving air quality.

In addition to *EK*, family size significantly influences *Hazardousness*, indicating that a larger family implies a bigger capacity to absorb risks (Ajetomobi and Binuomote, 2006; Amaefula et al., 2012). Moreover, the estimated results show that proximity to the pollution source positively influence *Exposure* and *Hazardousness*, although the latter is insignificant. The rationale is that respondents who live farther away from smelting plants are less exposed to

Table 5
Total effects.

Variables	*BI*	*Exposure*	*Hazardousness*	*EK*	*CHC*	*SES*
Behavoiural intention (BI)						
Exposure	0.03					
	(0.04)					
Hazardousness	0.13**					
	(0.05)					
Environmental knowledge(EK)	0.09**	0.14***	0.67***			
	(0.04)	(0.03)	(0.09)			
Current health condition (CHC)	0.11***					
	(0.04)	(0.02)	(0.04)			
Socioeconomic status (SES)	0.48***	0.11***	0.38***	0.43***	0.14***	
	(0.08)	(0.03)	(0.09)	(0.08)	(0.04)	
Age (AGE)	0.02			0.02	-0.03*	-0.12***
	(0.03)	(0.01)	(0.02)	(0.03)	(0.02)	(0.03)
Age-square (AGE^2)				0.02	-0.04**	
	(0.03)	(0.01)	(0.02)	(0.03)	(0.02)	(0.03)
Gender (GEN)	-0.07*	0.01	0.01	0.01	-0.05**	0.01
	(0.03)	(0.01)	(0.02)	(0.02)	(0.02)	(0.03)
Family size (FS)		0.01**		0.05**	0.01	0.12***
	(0.03)	(0.00)	(0.01)	(0.01)	(0.01)	(0.03)
Family health experience (FHE)		0.01	0.05		-0.20***	
	(0.03)	(0.01)	(0.03)	(0.01)	(0.02)	(0.03)
Medium air pollution (MAP)	-0.07***	0.07***		-0.08*		-0.20***
	(0.02)	(0.02)	(0.05)	(0.05)	(0.04)	(0.02)
Severe air pollution (SAP)	-0.04**	0.17***				-0.32***
	(0.02)	(0.02)	(0.05)	(0.04)	(0.02)	(0.05)
JMC employee, but not miner or smelter worker (NMS)	0.19***	0.05***	0.18***	0.21***	-0.09***	0.43***
	(0.04)	(0.01)	(0.05)	(0.05)	(0.03)	(0.05)
Miners and smelter workers of JMC (MS)	0.10***	0.04***	0.16***	0.20**	-0.12***	0.20**
	(0.03)	(0.01)	(0.04)	(0.05)	(0.03)	(0.05)

Notes: Standard errors in parenthesis. *, **and *** :10%, 5% and 1% level, respectively.

air pollution and have a lower level of risk perception than those who live nearby (Bickerstaff and Walker, 2001; Combest-Friedman et al., 2012; Riddel and Shaw, 2006).

The positive effect of age on *EK* suggests that older individuals-who in virtually all cases have spent most of their lives in Jinchuan-have better knowledge of Jinchuan's environmental issues (Al Khamees and Alamari, 2009; Aminrad et al., 2011). *EK* is also positively and significantly associated with proximity to the pollution source and the work environment. Apparently, higher objective air pollution exposure levels, particularly for people who live close to smelting plants or work in a highly polluted mining facility, have stronger motivation to learn about Jinchuan's environmental issues. In addition, for Jinchuan Mining Company (JMC) employees, especially miners and smelter workers, this is possibly because they know more about the input and output of the smelting process[7] than do non-JMC individuals (Doria Mde et al., 2009; Juang et al., 2010).

CHC links to work environment with the JMC staff being more likely to report worse health status than other citizens in the Jinchuan mining area. This suggests that higher air pollutant exposure in workplaces will lead to worse health status (Kim et al., 2017a, b; Isen et al., 2017). Major gender differences in self-reported health status are also found in our study, as men reported better health status than women. This is possibly because women have a lower pain threshold and tolerance, a greater ability to discriminate, and a propensity to assign higher pain ratings (Berkley, 1997). Family health experience negatively influences individuals' *CHC*, indicating that an individual's self-reported health status is strongly correlated with family members' health status. This is because individual and family members can share the social environment, including functional relationships such as caregiving, as well as socioeconomic circumstances, such as income and wealth, which are linked to barriers and opportunities for healthy living and improved individual health status (Rausa, 2008; Walsh, 1996). This is in line with the positive effect of family size on the family head's *SES*.

Age and age square both negatively influence *SES*, suggesting that young people in the Jinchuan mining area have a higher *SES*. This is possibly because young people have been the recipients of better education and older adults have fewer options for continued income. Older adults are at risk of rising costs of living, which may place them at an economic disadvantage and potentially at lower *SES* levels (Butrica et al., 2008; Cahill et al., 2013). *SES* is negatively and significantly correlated with proximity to the pollution sources, showing that areas where low-*SES* communities live experience a higher concentration of air pollutants. One possible explanation for low-level exposure being linked to higher *SES* is that people with a higher *SES* level have a greater capacity to live in low-pollution areas (Maas et al., 2006). We also found that JMC staff members had a higher *SES* level than non-JMC individuals; this is because individuals working at JMC earn a higher salary due to the harsh work environment. Moreover, JMC has a higher concentration of highly educated individuals who are employed to operate advanced mining and smelting devices (Jinchuan Yearbook, 2012).

Table 5 and Table 6 present the standardized total and indirect effects of all variables on all endogenous variables. Specifically, the indirect effect is the effect of an endogenous or exogenous variable on an endogenous variable through intervening endogenous variables, and the total effect is the sum of the direct and indirect effects (Jöreskog and Sörbom, 1996). At first glance, Table 5 indicates that *SES* is the most important determinant of *BI*, with a total effect of 0.48. Next is Work environment. *Hazardousness* and *CHC* significantly influence *BI*, with total effects of 0.13 and 0.11, respectively. Gender significantly influences *BI*, with a total effect of -0.07. Proximity to the pollution source significantly and negatively affects *BI*. Age, family health experience, and family size have insignificant total effects on *BI*.

EK has the largest total effect on *Hazardousness* (0.67), followed by *SES* (0.38). Work environment significantly influences

[7] JMC is the source of Jinchuan's environmental issues.

Table 6
Indirect effects.

Variables	*BI*	*Exposure*	*Hazardousness*	EK	*CHC*	*SES*
Behavoiural intention (BI)						
Exposure						
Hazardousness						
Environmental knowledge(EK)	0.09^{**}					
	(0.05)					
Current health condition (CHC)	0.01					
	(0.01)					
Socioeconomic status (SES)	0.06^{**}	0.06^{***}	0.29^{***}			
	(0.02)	(0.02)	(0.07)			
Age (AGE)	-0.05^{***}		0.01	-0.05^{**}	-0.02^{**}	
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	
Age-square (AGE^2)			0.01			
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	
Gender (GEN)		0.01	0.01	0.01	0.01	
	(0.02)	(0.01)	(0.02)	(0.02)	(0.02)	
Family size (FS)	0.05^{**}	0.01^{**}	0.05^{***}	0.05^{***}	0.02	
	(0.02)	(0.00)	(0.02)	(0.02)	(0.01)	
Family health experience (FHE)		0.01				
	(0.02)	(0.01)	(0.02)	(0.01)	(0.01)	
Medium air pollution (MAP)	-0.09^{***}	-0.02^{*}	-0.07^{*}	-0.08^{***}	-0.03^{***}	
	(0.03)	(0.01)	(0.04)	(0.02)	(0.01)	
Severe air pollution (SAP)	-0.14^{***}			-0.14^{***}	-0.05^{***}	
	(0.03)	(0.01)	(0.04)	(0.03)	(0.01)	
JMC employee, but not miner or smelter worker (NMS)	0.19^{***}	0.05^{***}	0.18^{***}	0.18^{***}	0.06^{***}	
	(0.04)	(0.01)	(0.05)	(0.03)	(0.02)	
Miners and smelter workers of JMC (MS)	0.10^{***}	0.04^{***}	0.15^{***}	0.09^{***}	0.03^{**}	
	(0.03)	(0.01)	(0.04)	(0.03)	(0.01)	

Notes: Standard errors in parenthesis. *, **and *** :10%, 5% and 1% level, respectively.

Hazardousness. Proximity to the pollution source is the most important determinant of *Exposure*, followed by *EK*, *SES*, and work environment. Family size affects *Exposure*, with a total effect of 0.01.

SES is the most important determinant of *EK*, with a total effect of 0.43. JMC employees but not miners or smelter workers (NMS) and miners and smelter workers (MS) have better *EK* than individuals not affiliated with the mining company, with total effects of 0.21 and 0.20, respectively. Family size influences *EK*, with a total effect of 0.05.

Family health experience is the most important determinant of *CHC*, with a total effect of -0.20. Next is *SES*, with a total effect of 0.14. NMS and MS negatively and significantly influence *CHC*, with total effects of -0.09 and -0.12, respectively. Age and gender negatively and significantly influence *CHC*, with total effects of -0.03 and -0.05, respectively.

NMS and MS have higher *SES* than individuals who are not affiliated with JMC, with total effects of 0.43 and 0.20, respectively. People living in lightly polluted areas have a higher *SES* level. Age and family size influence *SES*, with total effects of 0.12 and 0.12, respectively.

We now turn to people's WTP for improving air quality, which is the fourth indicator of *BI*. The total effects of variables on WTP based on our SEM model are presented in Table 7. Further, to illustrate its strengths relative to conventional contingent valuation approaches, we compared the SEM results to the estimate of the reduced form models without latent exogenous variables (see Table 7).

In Table 7, the R-square and adjusted R-square of WTP (SEM) are 0.09[8] and 0.08, which are two times more than the R-square of WTP without the latent variables counterparts of 0.04 and 0.03, respectively. These results indicate that SEM has more explanatory power than its alternative. Another important difference is that in contrast to SEM, where gender, work environment, and proximity to the pollution source are significant, they are not significant in the reduced form model. This demonstrates that SEM provides more information on how people's sociodemographic characteristics influence their intentions for improving air quality than its alternative. However, the most important difference between the two classes of models is that SEM provides information on the impacts of *Hazardousness* and *EK* on WTP, which is instrumental for policy design, as shown in the conclusions.

5. Summary and conclusions

To increase the understanding of contingent valuation results, this study took the theory of planned behaviour as a context and considered WTP as the indicator of behavioural intention to examine responses obtained through a CVM (Rekola and Pouta, 2005). Based on a cross-section data set of 759 households in the Jinchuan mining area, we assessed Jinchuan residents' behavioural intention for improving air quality. The primary focus of this paper was the impact of internal psychological factors-notably, perceived health risk and environmental knowledge-on people's WTP for improving air quality. We considered the effects of both subjective and objective measures of health risk caused by air pollution on WTP.

Our main finding was that Jinchuan residents have a strong willingness to reduce air pollution. Over 80% of the respondents were found willing to pay an environmental tax or to take environmentally friendly transportation, and approximately 80% of residents were found willing to spend extra money each month to reduce air pollution.

Another important finding was that psychological factors, notably PHR and EK in CVM, increased the explanatory power of WTP. PHR, EK, gender, SES, proximity to the pollution source, work

[8] The R square of WTP is low. Note that low R squares are quite common in cross-section analyses in social science. Although a low R square indicates that many other factors than the ones included in the model affect the dependent variable, it does not necessarily mean a poor estimation of the ceteris paribus relationships between the dependent variable and explanatory variables (Wooldridge, 2012). That is, if the zero conditional mean assumption is met, then the estimator of the impacts of the explanatory variables on the dependent variable is unbiased.

Table 7
Total effects of variables on WTP.

Variables	WTP (SEM)	WTP without latent variables
Behavoiural intention (BI)	0.42***	
	(0.04)	
Exposure	0.01	
	(0.02)	
Hazardousness	0.05 **	
	(0.02)	
Environmental knowledge (EK)	0.04 **	
	(0.02)	
Current health condition (CHC)	0.05**	0.10***
	(0.02)	(0.02)
Socioeconomic status (SES)	0.21***	
	(0.03)	
Income		0.06***
		(0.02)
Education		0.10***
		(0.02)
Age (AGE)	0.01	-0.03
	(0.01)	(0.02)
Age-square ()	0.01	-0.02
	(0.01)	(0.02)
Gender (GEN)	-0.03*	-0.03
	(0.01)	(0.02)
Family size (FS)	-0.01	0.01
	(0.01)	(0.02)
Family health experience (FHE)	0.01	0.03
	(0.01)	(0.02)
Medium air pollution (MAP)	0.01	-0.04
	(0.02)	(0.03)
Severe air pollution (SAP)	0.07**	0.02
	(0.02)	(0.03)
Miners and smelter workers of JMC (MS)	0.08***	0.01
	(0.01)	(0.03)
JMC employee, but not miner or smelter worker (NMS)	0.04***	0.01
	(0.01)	(0.04)
R-square	0.09	0.04
Adjust R-square	0.08	0.03

Notes: Standard errors in parenthesis. *, **and ***: 10%, 5% and 1% level, respectively.

environment, and CHC are important determinants of WTP. In particular, two domains of PHR-perceived risk caused by exposure level and hazardous pollutants-are positively correlated with people's intention to improve air quality. However, only an assessment based on final negative outcomes caused by air p-ollution (*Hazardousness*) significantly influenced WTP. This indicates that Jinchuan residents are sensitive to the perception of negative health outcomes caused by air pollution rather than to the exposure level. This may also suggest that our results can be seen as a behavioural intention targeted at a proposed policy for improving air quality and as an expression of people's understanding and assessment of air pollution.

Evidence from this study also suggests that reducing air pollution is an important policy measure to improve people's welfare. PHR has significant effects on BI for improving air quality. Moreover, we found that EK is an important moderator of BI. Therefore, information on air pollution should be disclosed to the public. For this purpose, a new environmental management institution, which includes government, scientific institutions, the mining and smelting company, and citizens' organizations, should be created. The institution should respond to public concerns and stimulate dialogue and cooperation between participants.

The present study can be extended in several ways because it focuses on only the relationship between air pollution and people's behavioural intention for improving air quality. However, apart from air pollution, nickel industries also cause water pollution and solid waste in the Jinchuan region. It would be interesting to analyse how overall environmental degradation affects people's BI for improving environmental quality. Further, it would be interesting and important, both from a theoretical and a policy perspective, to further develop the notions of BI, family health experience, PHR, and EK and to test their indicators.

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Conflict of interest

We declare that we have no conflict of interest.

Appendix A. The estimated Initial model

Table A1
Measurement model.

Latent variables	Indicators	Coefficient	Standard errors	R-square
Behavioral intention (BI)	BHL1	0.41	0.04	0.17
	BHL2	0.32	0.05	0.10
	BHL3	0.51	0.04	0.26
	BHL4	0.30	0.04	0.09
Perceived health risk (PHR)	PHR1	0.16	0.03	0.02
	PHR2	0.60	0.03	0.36
	PHR3	0.52	0.03	0.27
	PHR4	0.62	0.03	0.38
	PHR5	0.55	0.03	0.30
Environmental knowledge (EK)	EK1	0.52	0.04	0.26
	EK2	0.46	0.03	0.24
	EK3	0.39	0.03	0.18
	EK4	0.48	0.04	0.22
	EK5	0.55	0.04	0.30
	EK5	0.46	0.03	0.23
	EK7	0.31	0.03	0.12
	EK8	0.44	0.03	0.19
Socioeconomic status (SES)	Education	0.45	0.05	0.22
	Income	0.43	0.04	0.18

Table A2
Structural model.

Variables	*BI*	*PHR*	*EK*	*CHC*	*SES*
Behavoiural intention (BI)					
Perceived health risk (PHR)	0.09				
	(0.05)				
Environmental knowledge (EK)		0.66***			
		(0.09)			
Current health condition (CHC)	0.10**				
	(0.04)	(0.04)			
Socioeconomic status (SES)	0.51***	0.13*	0.47***	0.15***	
	(0.11)	(0.09)	(0.08)	(0.04)	
Age (AGE)	0.08**	0.01	0.07**		-0.12***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)
Age-square (AGE^2)	0.02	0.01	0.04		
	(0.03)	(0.03)	(0.03)	(0.02)	(0.03)
Gender (GEN)		0.02	0.03	0.05***	
	(0.04)	(0.03)	(0.03)	(0.02)	(0.03)
Family size (FS)	-0.08**	-0.08**			0.14***
	(0.03)	(0.03)	(0.03)	(0.02)	(0.04)
Family health experience (FHE)		0.05	0.02	-0.20***	
	(0.04)	(0.03)	(0.03)	(0.02)	(0.04)
Medium air pollution (MAP)	0.01	0.07	0.02	0.01	-0.20***
	(0.05)	(0.05)	(0.04)	(0.02)	(0.05)
Severe air pollution (SAP)	0.12**	0.06	0.12*	0.03	-0.33***
	(0.05)	(0.05)	(0.05)	(0.03)	(0.05)
Miners and smelter workers of JMC (MS)			0.01	-0.16***	0.45***
	(0.07)	(0.06)	(0.06)	(0.03)	(0.06)
JMC employee, but not miner or smelter worker (NMS)		0.01	0.09	-0.16***	0.23***
	(0.06)	(0.06)	(0.06)	(0.03)	(0.05)
R-square	0.29	0.52	0.20	0.08	0.30

Notes: Standard errors in parenthesis. *, **and *** :10%, 5% and 1% level, respectively.

Table A3
Overall goodness- of -fit indices.

Fit index	Value	Cut off value
$\chi 2$/DF	1.2	<3.00
Goodness-of-fit index(GFI)	0.97	>0.90
Adjusted goodness-of-fit index (AGFI)	0.96	>0.90
Standardized root mean square residual (SRMR)	0.03	<0.08
Root mean square error of approximation (RMSEA)	0.049	<0.08

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