Residents’ adoption intention of formaldehyde air purifier: the role of perceived values

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Abstract. Indoor formaldehyde is widely existed which poses a threat to residents’ physical health. In order to eliminate the risk of formaldehyde pollutant, individuals usually adopt formaldehyde air purifiers. In this empirical study, we aim to investigate individuals’ adoption intention of formaldehyde air purifier from the perspective of consumption values. Grounded in the Protective Action Decision Model, our research framework underlines the mechanism through which one’s personal knowledge and risk perception affect the perceived functional and non-functional values of formaldehyde air purifiers and subsequently impact the adoption intention. A survey is conducted to validate our model. This research contributes to the literature by enriching current understanding of individuals’ protective behavioral intention in the context of indoor formaldehyde.

Keywords: Formaldehyde air purifier, Consumption value, Risk perception.

1. Introduction
Formaldehyde is a common indoor pollutant that is hazardous to human health [3]. In recent years, the residential interior decoration has become a significant source that continuously release formaldehyde [20, 30]. Therefore, people tend to be anxious about its potential threats to the indoor air quality and to the health of the family. To cope with this issue, individuals usually adopt purification devices to degrade the formaldehyde, such as air purifiers and fresh air systems [12]. However, some people insist that these measures are hardly effective, and the most practical method is to increase the ventilation of indoor air by opening the windows [30]. Therefore, residents have different attitudes toward indoor formaldehyde purification equipment. This study aims to understand individuals’ adoption intention toward formaldehyde purifier equipment and the underlying mechanism. In particular, we employ the Protective Action Decision Model (PADM) as our theoretical basis, since it could provide a structured method that allows us to examine how the risk situation of indoor formaldehyde affect individuals’ internal perceptions and then lead to protective behavioral intentions [16]. Moreover, given that adopting
formaldehyde air purifier is actually a consumption process, we borrow insights from the theory of consumption values to examine individual’s value perception that drives the adoption intention.

2. Research Background and Proposition Development

The Protective Action Decision Model (PADM) is a comprehensive theoretical framework that describes individuals’ response to risk situations [16]. As shown in figure 1, the model encompasses the process of individuals’ receiving of environmental cues, information communication, internal perceptions, decision making and behavioral response [16]. In a nutshell, it posits that individuals who are exposed to actual or potential risk situations receive cues of risks from a certain external source, and such information contributes to their risk perceptions, which finally lead to protective behavior intentions [13, 14]. PADM has been widely applied in risk management research. It serves as theoretical basis for research on individuals’ protective behavior in the face of a variety of risk events. For example, it could explain individuals’ purchase intention of anti-smog air purifiers [28, 29], residents’ anti-nuclear behavioral intention [31] and consumers’ behaviour in the context of product recall [26]. Therefore, drawing from PADM, we treat residents’ adoption intention of formaldehyde air purifier as a response to the risks from indoor environment. Further, this response is influenced by individual’s perception of the value of the formaldehyde air purifier, triggered by environmental risk cues.

2.1. Functional value and non-functional value

Consumption value theory puts that individuals’ intention to adopt a product is driven by a function of multiple consumption values [21]. As a green product, the value of a formaldehyde air purifier is twofold: functional and non-functional [21, 10]. Functional value means “perceived utility acquired from a product’s capacity for functional, utilitarian, or physical performance” [21]. It relates to the utilitarian attributes of a product, reflected by its performance and quality [23]. Therefore, a formaldehyde air purifier realizes functional value if it could reduce formaldehyde and improve air quality effectively. Moreover, functional value also concerns product quality, such as the reliability, stability and workmanship of the artefact. Researchers suggest that functional value is a major driver of individuals’ adoption intention of a product [21].

Non-functional value is multi-faceted, associated with individuals’ psychological and social needs [10]. Sweeney et al. (2001) propose two types of non-functional value: emotional value and social value [23]. On one hand, emotional value reflects a product’s ability to affect one’s mental feelings or affective states. In this regard, a formaldehyde air purifier, apart from its functional performance, could relieve...
individuals’ anxiety and fear of the harmful indoor air, and give them psychological comfort. On the other hand, social value is achieved when adopting a product enhances one’s social self-concept. Social influence has been identified as a significant influencer of individuals’ behavioral intention [6]. People are naturally inclined to conform with the positive expectations of others from the social group they belong to. If using a certain formaldehyde air purifier could enhance one’s social appearance or make him/her better fit into the social group, the social value of the formaldehyde air purifier is achieved. In conclusion, we put forward the following propositions.

P1 Perceived functional value significantly affects an individual’s intention to adopt a formaldehyde air purifier.

P2 Perceived non-functional value significantly affects an individual’s intention to adopt a formaldehyde air purifier.

2.2. Risk perception

Risk perception refers to people’s expectations of the adverse physical and social impacts caused by a risk event [15]. The PADM posits that individual’s risk perception plays a significant role in affecting the behavioral intention [16]. In this research, risk perception particularly refers to individuals’ perceived health-related risks caused by indoor formaldehyde. Risk perception signifies the process in which individuals’ perception of risk cues produce psychological impacts, thereby influencing the protective behavioral intentions [4, 16]. People with various risk perceptions could experience different cognitive processing of a given situation [8, 29]. Therefore, one’s perception of risk would affect the subjective evaluation of the value of formaldehyde air purifier.

P3a Risk perception of formaldehyde significantly affects an individual’s perceived functional value of the formaldehyde air purifier.

P3b Risk perception of formaldehyde significantly affects an individual’s perceived non-functional value of the formaldehyde air purifier.

2.3. Risk knowledge and product knowledge

According to the PADM, in a threatening event, such as indoor formaldehyde, the social information and individuals’ personal knowledge together affect their responses by stimulating them to reflect on the situation [15]. A person’s knowledge always plays a significant role in the decision-making process [7]. Therefore, this study identifies risk knowledge and product knowledge as influencers of individuals’ value perception of the formaldehyde air purifier and risk perception of formaldehyde. Specifically, risk knowledge refers to one’s experiential and expert knowledge of formaldehyde, whereas product knowledge relates to ones’ knowledge of formaldehyde air purifier. Individuals’ risk perceptions and behavioral responses are usually related to the recency and intensity of their previous experiences with risks and events [16, 25]. The knowledge of risk can create a type of cognitive bias, which escalates the level of risk perception about potential or real dangers [9, 26, 27]. For example, Deguen et al. (2012) suggested that risk knowledge affects one’s risk perception of air pollution [5]. Likewise, individuals with higher level of formaldehyde knowledge would experience stronger fear, because they are aware of its negative consequence. In this case, they would perceive higher utility of the formaldehyde air purifier. Therefore, their perception of the value of formaldehyde air purifier is enhanced.

P4a Risk knowledge significantly affects an individual’s perceived functional value of the formaldehyde air purifier.

P4b Risk knowledge significantly affects an individual’s perceived non-functional value of the formaldehyde air purifier.

P4c Risk knowledge significantly affects an individual’s risk perception of formaldehyde.

Product knowledge is another critical factor that affect consumer’s cognition toward a product [2]. Individuals with higher levels of product knowledge have better cognitive capacity and greater discernment to evaluate a specific product [1]. Therefore, residents who have sufficient knowledge of formaldehyde air purifier would have a high cognitive level that allows them to gain a better understanding of its functions and values. Moreover, individuals with knowledge of formaldehyde air
purifier are more likely to recognize the hazard of formaldehyde. Thus, their risk perception of formaldehyde would be accented.

- **P5a** Product knowledge significantly affects an individual’s perceived functional value of the formaldehyde air purifier.
- **P5b** Product knowledge significantly affects an individual’s perceived non-functional value of the formaldehyde air purifier.
- **P5c** Product knowledge significantly affects an individual’s risk perception of formaldehyde.

In conclusion, we propose our research model, as depicted in Figure 2.

![Figure 2. Research Model](image)

3. Research methodology

3.1. Measurement development
A questionnaire-based empirical study is used to test our research model. The measurements for each construct were adapted mainly from existing research but were modified to fit current research context. Specifically, in the preliminary stage, we reviewed related literature to obtain the seminal scales of reference variables. Also, we interviewed those who are familiar with formaldehyde air purifiers to contextualize the items. Then, an expert review was conducted to refine the wording of instrument items. Their feedback provided the basis for revising the construct measures and modifying the wordings and item sequence. The final set of items and the corresponding sources are provided in Table 1. For all measurements, a seven-point Likert-type scale ranging from “strongly disagree” to “strongly agree” was employed.
Table 1. Measurements

| Measurements: Scale strongly disagree (1) – strongly agree (7) |
|-------------------------------------------------------------|
| **Functional value [23]**                                   |
| 1. I think the formaldehyde air purifier has consistent quality. |
| 2. I think the formaldehyde air purifier is well made.       |
| 3. I think the formaldehyde air purifier has an acceptable standard of quality. |
| 4. I think the formaldehyde air purifier has poor workmanship. |
| 5. I think the formaldehyde air purifier would not last a long time. |
| 6. I think the formaldehyde air purifier would perform consistently. |
| **Non-functional Value [23]**                              |
| **Emotional value**                                         |
| 1. I think the formaldehyde air purifier is one that I would enjoy. |
| 2. I think the formaldehyde air purifier would make me want to use it. |
| 3. I think the formaldehyde air purifier is one that I would feel relaxed about using. |
| 4. I think the formaldehyde air purifier would make me feel good. |
| 5. I think the formaldehyde air purifier would give me pleasure. |
| **Social value**                                            |
| 1. I think the formaldehyde air purifier would help me to feel acceptable. |
| 2. I think the formaldehyde air purifier would improve the way I am perceived. |
| 3. I think adopting the formaldehyde air purifier would make a good impression on other people. |
| 4. I think the formaldehyde air purifier would give me social approval. |
| **Risk knowledge [17, 26]**                                |
| 1. I know the cause of formaldehyde.                        |
| 2. I know the cause of formaldehyde more than other people around me. |
| 3. I browse websites or newspapers about formaldehyde.     |
| **Product knowledge [17, 26]**                              |
| PK1 I am knowledgeable about formaldehyde air purifier.     |
| PK2 I know formaldehyde air purifier more than other people around me |
| PK3 I read magazines or websites of formaldehyde air purifier. |
| PK4 I am the primary decision maker to buy a formaldehyde air purifier. |
| **Risk perception [27]**                                   |
| 1. Formaldehyde threats to personal physical health.       |
| 2. Formaldehyde threats to personal psychological health.   |
| 3. Formaldehyde threats to children’s growth.              |
| 4. Formaldehyde threats to personal or family life.        |
| 5. Formaldehyde threats to my work efficiency and family daily life. |
| **Intention to adopt formaldehyde air purifier [18, 24]**   |
| 1. I intend to adopt a formaldehyde air purifier.           |
| 2. I plan to adopt a formaldehyde air purifier.             |
| 3. I predict I would adopt a formaldehyde air purifier.     |
| 4. It is highly likely I would adopt a formaldehyde air purifier. |

3.2. Data collection
The sample of this study is gathered nationwide in China. To increase the efficiency, an electronic questionnaire was adopted. We use a professional online survey platform, www.wjx.cn, to create an online questionnaire, and then distribute the link of the survey via mainstream social media platforms such as Wechat. The online survey lasts for two months.
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References
[1] A. Biswas, D. L. Sherrell, The influence of product knowledge and brand name on internal price standards and confidence, Psychol. & Mark., 10 (1), (1993) 31 - 46.
[2] C. Chang, The interplay of product class knowledge and trial experience in attitude formation. J. Advertising, 33 (1), (2004) 83 - 92.
[3] Y. Chen, B. Chen, The combined effect of indoor air quality and socioeconomic factors on health in northeast china. Appl. Sci., 10 (8), (2020) 2827.
[4] P. Cheng, J. Wei, and Y. Ge, Who should be blamed? The attribution of responsibility for a city smog event in china. Nat. Hazards 85 (2), (2017) 669 – 89.
[5] S. Deguen, C. Se’gala, G. Pe’drono, M. Mesbah, A new air quality perception scale for global assessment of air pollution health effects. Risk. Anal., 32 (2012) 2043 – 2054.
[6] M. Deutsch, H. B. Gerard, A study of normative and informational social influences upon individual judgment. The J. of abnormal and social psych., 51 (3), (1955) 629 - 636.
[7] I. Fazey, J. A. Fazey, J. G. Salisbury, D. B. Lindenmayer, S. Dovers, The nature and role of experiential knowledge for environmental conservation. Environ. Conserv., 33 (1), (2006) 1 - 10.
[8] S. Forsythe, C. Liu, D Shannon, L.C. Gardner, Development of a scale to measure the perceived benefits and risks of online shopping. J. Interactive Market. 20 (2), (2006) 55 – 75.
[9] T. Grothmann, A. Patt A, Adaptive capacity and human cognition: the process of individual adaptation to climate change. Glob. Environ. Change, 15 (2005) 199 – 213.
[10] L. Han, S. Wang, D. Zhao, J. Li, The intention to adopt electric vehicles: driven by functional and non-functional values. Transport Res A-Pol, 103 (2017) 185 - 197.
[11] B. B. Johnson, Testing and expanding a model of cognitive processing of risk information. Risk. Anal., 25 (2005) 631 - 50.
[12] H. U. Jun, X. Jiang-Rong, L. I. Liang-Liang, S. Y. Zhou, T. Y. Peng , Experimental study on air purifier’s purification efficiency for indoor formaldehyde, J. Anal. Sci., (2013)
[13] M. K. Lindell, R. W. Perry, Communicating environmental risk in multiethnic communities. Sage, Thousand Oaks, 2004.
[14] M. K. Lindell, J. C. Lu, C. S. Prater, Household decision making and evacuation in response to Hurricane Lili, Nat Hazards Rev, 6 (4) (2005) 171 - 179.
[15] M. K. Lindell, S. N. Hwang, Households’ perceived personal risk and responses in a multi-hazard environment, Risk Anal, 28 (2) (2010) 539 – 556.
[16] M. K. Lindell, R. W. Perry, The protective action decision model: Theoretical modifications and additional evidence, Risk. Anal., 32 (4) (2012) 616 – 632.
[17] K. Mason, T. Jensen, S. Burton, D. Roach, The accuracy of brand and attribute judgments: the role of information relevancy, product experience, and attribute-relationship schemata, J. Acad .Mark. Sci., 29 (2001) 307 – 317.
[18] P. A. Pavlou, M. Fygenson, Understanding and predicting electronic commerce adoption: an extension of the theory of planned behavior, MIS Quarterly, 30 (1) (2006), 115 - 143.
[19] R. W. Perry, M. K. Lindell, Volcanic risk perception and adjustment in a multi-hazard environment, J. Volcanol. Geotherm. Res., 172 (2008) 170 – 178.
[20] T. Salthammer, S. Mentese, R. Marutzky, Formaldehyde in the indoor environment, Chem. Rev., 110 (4) (2010), 2536 - 2572.
[21] J. N. Sheth, B. I. Newman, B. L. Gross, Why we buy what we buy: a theory of consumption values, J. Busi. Res., (22) (1991) 159 - 170.
[22] C. M. R. Smerecnik, I. Mesters I, M. J. J. M. Candel, Risk perception and information processing: The development and validation of a questionnaire to assess self-reported information
processing, Risk. Anal. 32 (2012) 54 – 66.

[23] J. C. Sweeney, G. N. Soutar, Consumer perceived value: The development of a multiple item scale, J. Retailing, 77 (2) (2001) 203 - 220.

[24] V. Venkatesh, M. G. Morris, G. B. Davis, F. D. Davis, User acceptance of information technology: toward a unified view, MIS Quarterly, 27 (3) (2003) 425 - 478.

[25] G. Wachinger, O. Renn, C. Begg, C. Kuhlicke, The risk perception paradox—implications for governance and communication of natural hazards, Risk Anal., 33 (6) (2013) 1049 - 1065.

[26] J. Wei, M. Zhao, F. Wang, P. Cheng, D. Zhao, An empirical study of the Volkswagen crisis in China: customers’ information processing and behavioral intentions, Risk Anal. 36 (2016) 114 – 129.

[27] J. Wei, W. Zhu, D. Marinova, F. Wang, Household adoption of smog protective behavior: a comparison between two chinese cities. J Risk Res. 20 (7) (2017), 846 - 867.

[28] X. Wu, X. Hu, W. Qi, D. Marinova, X. Shi, Risk knowledge, product knowledge and brand benefits for purchase intentions: experiences with air purifiers against city smog in china. Human and Ecological Risk Assessment: An International Journal, 30 (2018), 1 - 22.

[29] X. Wu, W. Qi, X. Hu, S. Zhang, D. Zhao, Consumers’ purchase intentions toward products against city smog: exploring the influence of risk information processing. Natural Hazards. 88 (2017) 611 – 632.

[30] W. Ye, X. Zhang, J. Gao, G. Cao, X. Zhou, X. Su, Indoor air pollutants, ventilation rate determinants and potential control strategies in chinese dwellings: a literature review. Sci. of the Total Environment, 586 (2017), 696 - 729.

[31] W. Zhu, J. Wei, D. Zhao, Anti-nuclear behavioral intentions: The role of perceived knowledge, information processing, and risk perception. Energy. Pol., 88 (2016) 168 – 177.