Consumer knowledge in pro-environmental behavior

An exploration of its antecedents and consequences

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Abstract

Purpose – Environmental behavior studies suggest that knowledge, in addition to other psychological and social factors, can play an important role in consumers' environmental behavior change. The purpose of this paper is to understand the relationship between knowledge and various psychological factors which encourage consumers' participation in pro-environmental behaviors. The relationships that link an individual's attitudes toward science, environmental values, different types of knowledge (i.e. scientific facts, environmental facts, and subjective environmental knowledge), environmental risk perception, and willingness to pay (WTP) for the environment with pro-environmental behavior were examined.

Design/methodology/approach – Theoretically guided hypotheses and model were formulated and tested with multiple linear regression models. The study was based on measures and data obtained from the large-sample secondary database of the 2010 General Social Survey ($n = 2{,}044$).

Findings – Results indicated that while attitudes toward science had direct effects on knowledge of scientific facts and knowledge of environmental facts, environmental values showed effects on knowledge of environmental facts and subjective knowledge on environmental issues. The results also indicated that from different types of knowledge, subjective knowledge on environmental issues had effects on both environmental risk perception and WTP for the environment. Knowledge on environmental facts, on the other hand, was able to predict only environmental risk perception. The scientific factual knowledge did not show an effect on mediator of pro-environmental behavior. Also, subjective knowledge indicated indirect effects on pro-environmental behavior through environmental risk perception and WTP for the environment.

Originality/value – Although research on understanding factors influencing pro-environmental behaviors and potential relations to individual knowledge has grown in recent years, there has been very little attempt at distinguishing between different types of knowledge and investigating their potential roles in the context of environmentally relevant behaviors. This study will help understand the functioning of different types of consumer environmental knowledge and their impacts on pro-environmental behaviors more in depth.

Keywords Environmental values, Consumer knowledge, Environmental knowledge, Environmental risk perception, Pro-environmental behaviour, Willingness to pay for the environment

Paper type Research paper

Introduction

Most of the biggest challenges facing the world today are global and environmental: Climate change, food security, biodiversity, water security and energy security, to name but a few. These problems require science to fully understand and technological innovation to overcome, and the more minds and more labs we have working on them the better (Eben Harrell, March 31, 2011, Good News for Greens: Science Goes Global. Time Magazine).

World Journal of Science, Technology and Sustainable Development
Vol. 13 No. 4, 2016
pp. 328-352

2042-5945
DOI 10.1108/WJSTSD-01-2016-0004

The well-being of the planet Earth is in jeopardy. Rapidly increasing number of environmental problems and their detrimental impacts all around the world are signaling the urgency of finding immediate solutions. Since the majority of the environmental problems we are facing today are mostly the results of human activities, application of the possible solutions to these widespread and rapidly growing problems will need the full participation of individuals (Steg and Vlek, 2009). Receiving society's support to overcome these problems would be possible only if we can understand the factors affecting individuals' behaviors toward acting in a more ecologically conscious manner (e.g. buying ecologically friendly products, recycling, driving less frequently, saving water) and the mechanisms between them. Knowledge, in addition to numerous other factors, may be crucial in motivating one's behavioral change to engage in general pro-environmental behavior. Considering its possible effect on acting in a more environmentally cautious manner, individual knowledge is recently becoming more and more the focus of environmental behavior studies (e.g. Fraj and Martinez, 2006; Barr, 2007; Tan, 2011; Polonsky *et al.*, 2012). Although, the broader literature reports a positive relationship between knowledge and behavior (Park *et al.*, 1994), in the context of environmental behavior, this relationship is not as clear, and mixed empirical findings suggest a more complex relationship between knowledge and pro-environmental behaviors, which highlights the need for further research.

This study aims to grasp a better understanding of how knowledge and various other psychological factors might affect the consumers' pro-environmental behaviors. More particularly, the objective of this research is to understand the relationship between knowledge and other pschological factors which encourage consumers' participation in pro-environmental behaviors by constructing a model and examine the relationships that link an individual's environmental values, attitudes toward science, different types of knowledge (i.e. scientific facts, environmental facts, subjective environmental knowledge), environmental risk perception, and willingness to pay (WTP) for the environment with pro-environmental behavior. The study will help understand the functioning of consumer knowledge in the context of environmentally sensitive behaviors in more depth.

Knowledge is defined as the information substance in an individual's memory that impacts the method used for related selection (Gamble and Blackwell, 2001). Different kinds of knowledge have been identified by researchers (e.g. Brucks, 1985; Schahn and Holzer, 1990; Dodd *et al.*, 2005). According to Brucks (1985) and Dodd *et al.* (2005), there are two kinds of knowledge: objective and subjective. Objective knowledge, which is tested and approved, contributes to the knowledge organization as a factual knowledge and is kept in individual's memory. It generally reflects what a person knows about an object, product, or issue objectively. On the other hand, subjective knowledge which is self-rated, reveals the self-evaluation and/or perception of an individual about an object, issue, or a product. Different than this classification, the North American Association for Environmental Education's (NAAEE) publication on environmental literacy identifies five types of knowledge that should be considered in order to assess knowledge in environmental studies, which are identified as knowledge of: physical and ecological systems; social, cultural, and political systems; environmental issues; multiple solutions to environmental issues; and citizen participation and action strategies (Hollweg *et al.*, 2011). To be able to obtain realistic results as well as practical purposes, Hollweg *et al.* (2011) suggest including only the necessary and important components of knowledge in developing and assessing

frameworks for studies. In fact, as stated in Hollweg *et al.*'s study, McBeth *et al.* (2008, 2011) uses only the knowledge of physical and ecological systems and environmental issues as two components of environmental literacy in their National Environmental Literacy Assessment Project (NELA). For the purpose of this study, first, we will follow Hollweg *et al.*'s suggestion as well as McBeth *et al.*'s approach and examine two components of objective knowledge: physical and ecological systems knowledge, also called knowledge of scientific facts, and environmental issues knowledge, also named as knowledge of environmental facts. Second, in addition to these two types of objective knowledge, following Brucks (1985) and Dodd *et al.*'s (2005) classification, we will have subjective knowledge on environmental issues to cover all types of knowledge in the context of environment.

Although, research on understanding factors influencing pro-environmental behaviors and potential relations to individual knowledge has grown in recent years (e.g. Fraj and Martinez, 2006; Barr, 2007; Tan, 2011; Polonsky *et al.*, 2012), there has been very little attempt at distinguishing between different types of knowledge and investigating their potential impacts on environmental attitudes, such as risk perceptions and WTP for environment, and eco-sensitive behaviors. Hence, the major factors under investigation in this study will include the consumers' risk perception toward (environmental risk perception) and factual knowledge of (knowledge of environmental facts) ecological issues in general, their general attitudes toward (science attitudes) and factual knowledge of (knowledge of scientific facts) scientific issues, subjective knowledge on environment, their values, and WTP for the environment. The pro-environmental behavior will be examined as one outcome which will be made up from six different environmentally sensitive behaviors: buying pesticide-free fruits/vegetables, driving less for environmental reasons, avoiding products that are harmful to the environment, recycling cans/bottles, saving water, and reducing fuel use for environmental reasons.

The study is based on measures and data obtained from the highly reliable large-sample secondary database of the General Social Survey (GSS). The main objectives of the study are to determine the role played by different types of knowledge in encouraging environmental attitudes (i.e. risk perception and WTP for the environment); determine predictor variables of pro-environmental behaviors; and see the impact of environmental values and attitudes toward science on different types of knowledge as predicting variables. The study develops and tests hypotheses by running casual models linking predictor variables to each identified outcome, and analyzes the results. Gaining a detailed understanding of individuals' different types of environmental knowledge and their impacts on behaviors will be important for policy makers, educators, as well as researchers who are in search of ways to human behavioral changes in order to combat environmental deterioration.

Literature review and hypotheses construction

Pro-environmental behavior (also called environmentally sensitive behavior, environmentally friendly behavior, eco-sensitive behavior, and environmentally responsible behavior), defined as efforts by individuals to limit damaging actions that can harm the physical and natural environment (Albayrak *et al.*, 2011), has become a research interest of many scholars (e.g. Kollmuss and Agyeman, 2002; Barr, 2007). According to Kollmuss and Agyeman (2002), pro-environmental behaviors such as decreasing resource and energy usage, using non-toxic materials, or decreasing waste

production can be influenced by many different factors. Researchers examining the origins of different environmental attitudes and behaviors come to a similar conclusion that potential predictors should be multi-dimensional and not based on a single factor (e.g. Cleveland *et al.*, 2005; Jansson *et al.*, 2010). From these factors, psychological constructs such as perceptions, knowledge, values, intentions and attitudes have been advocated as important determinants of pro-environmental behaviors and widely researched in the literature (e.g. Gilg *et al.*, 2005; Nilsson and Küller, 2000; Fraj and Martinez, 2006; Whitmarsh, 2009; Davis *et al.*, 2011; Polonsky *et al.*, 2012). However, this high volume of research did not lead to a clear conclusion in terms of the exact relationships between these psychological factors and pro-environmental behaviors.

For example, first line of research considers environmental values to be the most crucial predictor of the behavior toward the environment (Davis *et al.*, 2011). A number of studies have shown that individuals with positive personal values (high respect) toward the environment were more willing to behave ecologically friendly (Gilg *et al.*, 2005). Also, there have been findings that those who most value ecological concerns are likely to have higher environmentally friendly behaviors (Fraj and Martinez, 2006).

Another line of research looks at willingness (to protect or pay) as a determinant of environmentally friendly behaviors. For instance, Iwata's (2002) study showed an individual's willingness to protect the environment as a predictor variable and found a positive correlation with this variable and the person's environment-related behavior. Looking at some other variables, Gelissen (2007) tried to explain the causes of changing patterns of willingness to protect the environment by considering income and education levels as predictors and showed a strong association between these variables.

Additionally, Nilsson and Küller (2000) included and tested a different predictor, the environmental knowledge, in their models. In their studies that are focussing on travel behaviors of individuals, environmental knowledge was found to have an insignificant impact on the behavioral outcomes. According to Nilsson and Küller (2000), "[d]espite the weak link between factual knowledge and pro-environmental behavior, knowledge must be an operand in establishing environmental concern and should not be neglected" (p. 229). Similarly, some other researchers (Ölander and Thøgersen, 1995; Thøgersen and Ölander, 2002) underlined the importance of knowledge and suggested that those consumers with sufficient environmental information and task-related knowledge are able to make environmental inclined and more responsible decisions. For example, a study by Levine and Strube (2012) on college students showed that the students' knowledge about environmental issues and their intentions significantly and independently predicted the behavioral outcomes. However, this study also showed the environmental knowledge was not significantly related to attitudes.

Although these aforementioned studies examine and point out the importance of variety of psychological constructs (e.g. risk perceptions, environmental knowledge, values, intentions, attitudes) as important determinants of pro-environmental behaviors, it is not clear what sort of relationship exists between them or how they affect pro-environmental behavior of individuals. In order to bridge this gap, in the following sub-sections, we will identify each psychological construct under investigation with the relevant literature review and then develop resultant hypotheses for each.

Pro-environmental behavior

Pro-environmental behavior is defined as "behavior that harms the environment as little as possible, or even benefits the environment" (Steg and Vlek, 2009, p. 309). As pointed out by Gatersleben *et al.* (2002), many studies focus on a relatively limited set of behaviors in terms of their environmental impacts. Their limited scopes and associated results are mainly caused by considering only certain stages of the consumer behavior processes. Thus, it is crucial to focus on a wide variety of consumer behaviors at different stages of consumer behavior processes and to look at how they eventually impact our surroundings and significantly contribute to environmental problems.

The consumption process of consumers covers six stages, recognition of need and want, information search, evaluation of alternatives, purchase, use, and post-use (Belz and Peattie, 2009). Understanding the entire consumption process and its negative environmental consequences is essential to determine predictors of pro-environmental behaviors fully. For the purpose of this study, three stages of consumer behavior process are considered: purchase, usage, and post-use. Thus, the pro-environmental behavioral outcome is examined using six different environmentally sensitive behaviors that are covering these three stages of consumption: buying pesticide-free fruits/vegetables (purchase), driving less for environmental reasons (usage), avoiding products that are harmful to the environment (purchase), recycling cans/bottles (post-use), saving water (usage), and reducing fuel use for environmental reasons (usage).

Attitudes toward science

Definition of attitudes as it relates to science is unclear and inconsistent (Germann, 1988). Attitude, in general sense, is defined as "a learned predisposition to respond in a consistently favorable or unfavorable manner with respect to a given object" (Fishbein and Ajzen, 1975, p. 6). Thus, attitudes toward science can be justified as people's favorable or unfavorable predispositions toward science. According to Gardner (1975) and Osborne *et al.* (2003), the clear distinction should be made between "attitudes toward science" and "scientific attitudes" in those studies which attempt to focus on either one of these variables. While scientific attitudes is "a complex mixture of the longing to know and understand; a questioning approach to all statements; a search for data and their meaning; a demand for verification; a respect for logic; a consideration of premises and a consideration of consequences" and cognitive in nature, attitudes toward science are "the feelings, beliefs and values held about an object which may be the enterprise of science, school science, the impact of science on society or scientists themselves" (Osborne *et al.*, 2003, p. 6). In this study, we will be focussing on the latter, attitudes toward science.

Attitudes toward science of individuals have become more and more important in today's highly technologically advanced societies (Brossard *et al.*, 2005). High attitudes toward science can affect people's willingness to learn about issues that affect their personal lives, the well-being of their communities, and national and international issues such as environmental deterioration so they can make informed decisions. In fact, in their meta-analysis that covers 40 countries, Allum *et al.* (2008) review the relationship between public attitudes and public knowledge about science and find a positive correlation between general attitudes toward science and general knowledge of scientific facts. In another research conducted as an experimental study, Brossard *et al.* (2005) find the importance of participants' interest and awareness of the scientific process that could increase understanding of the scientific issues.

Because individuals would want to make informed decisions in their actions (Brossard *et al.* 2005), positive attitudes toward science would lead to search for

information and eventually a higher factual knowledge on environment-related issues. Therefore, the following hypotheses are put forward:

H1a. There is a positive relationship between individuals' attitudes toward science and knowledge of scientific facts.

H1b. There is a positive relationship between individuals' attitudes toward science and knowledge of environmental facts.

Environmental values

One of the most crucial predictors of attitudes and behaviors toward environment is considered to be environmental values (Davis *et al.*, 2011). Values are defined as the criteria that people use to select and justify actions and assign worth to objects and the actions of others (Fraj and Martinez, 2006). Each person has her/his own specific values that are shaped by experiences and learning process. In the context of environmental behavior, the term has been used interchangeably with some other similar concepts such as environmental concern, ecological worldview, and environmental attitudes (Dunlap *et al.*, 2000).

In general, people can express their values through their actions. For example, a person with higher environmental values might buy more ecologically friendly products, recycle and take part in environmental protection activities. In fact, some studies have shown that individuals who expressed that their personal values included respect toward the environment were more willing to purchase ecologically friendly products (Gilg *et al.*, 2005). Furthermore, there have been findings that those who most value ecological concerns are likely to have higher environmentally friendly behaviors (Fraj and Martinez, 2006). However, as pointed out by Homer and Kahle (1988), values and behavioral outcomes cannot be considered a direct relationship. They state that most of the studies focussing on values and behaviors have shown that values do not have direct relationship with behavior. In fact, models used to predict pro-environmental behavioral outcome, such as theory of planned behavior and reasoned action paradigm used by Kaiser *et al.* (1999), the norm-activation model adapted by Thøgersen (1999), the value-belief-attitude-immediate sequence-behavior model used by Scott and Jobber (2000), and the awareness-information-decision-action model applied by Barr (2003), all show a similar pattern that moves from environmental values, attitudes, and knowledge to behavior.

Although environmental values can have an effect on how one may search and absorb the information related to environmental issues, the relationship between them would be mostly depend on the type of knowledge is being carried out. Thus, an individual's environmental values should play a role on environment-related knowledge, such as factual and subjective environmental knowledge. In their empirical research, Kaiser *et al.* (1999) find that intention to act pro-environmentally can be explained by environmental values and environmental knowledge well. This literature review on environmental values helps us to come up with second set of hypotheses. Hence, we put forth that:

H2a. There is a positive relationship between individuals' environmental values and knowledge of environmental facts.

H2b. There is a positive relationship between individuals' environmental values and subjective knowledge on environment.

Knowledge

According to Gamble and Blackwell (2001), knowledge is the information substance in an individual's memory that impacts the method used to evaluate and deduce related selection. From the consumer research perspective, it is accepted to be a characteristic that influences all of the decision process phases. There are different kinds of knowledge identified and explained by researchers (e.g. Brucks, 1985; Schahn and Holzer, 1990; Park *et al.*, 1994; Dodd *et al.*, 2005). For example, Brucks (1985), Park *et al.* (1994), and Dodd *et al.* (2005) conceptually defined two kinds of consumer knowledge: objective and subjective. Objective knowledge, which is tested and approved, contributes to the knowledge organization as a factual knowledge and is kept in individual's memory. It generally reflects what a person knows about an object, product, or issue objectively (Park *et al.*, 1994). On the other hand, subjective knowledge which is self-rated, reveals the self-evaluation and/or perception of an individual about an object, issue, or a product (Flynn and Goldsmith, 1999; Park *et al.*, 1994).

Different than the aforementioned consumer knowledge classification, the NAAEE's publication on environmental literacy identifies five types of knowledge on environmental situation or issues that should be considered in order to assess knowledge in environmental studies (Hollweg *et al.*, 2011). These are identified as knowledge of: physical and ecological systems; social, cultural, and political systems; environmental issues; multiple solutions to environmental issues; and citizen participation and action strategies. Because of the impracticality of assessing this many components, the study suggests including only the necessary and important ones in developing and assessing frameworks for studies. In fact, as stated in Hollweg *et al.*'s study, McBeth *et al.* (2008, 2011) uses only the knowledge of physical and ecological systems and environmental issues as two components of environmental literacy in their NELA.

From the environmental behavior research perspective, Schahn and Holzer (1990) defines two kinds of environmental knowledge as: factual environmental knowledge, that is environmental problem's definitions, causes, and consequences, e.g., what is climate change? and action related environmental knowledge, that is information regarding the human actions that could affect environment, e.g., what human behaviors affect climate change? The latter does not need to be based on facts and even subjective approaches to the issues can be considered under this category. The distinction of these two forms of environmental knowledge is important because human behavior is affected more by action related knowledge (also possibly abstract) rather than factual ones. Thus, in the context of environmental knowledge, distinguishing the knowledge about facts from knowledge about actions and abstract ones becomes crucial for understanding the real impacts on individual's behavior. This categorization of knowledge can also be seen as similar to Brucks (1985) and Dodd *et al.*'s (2005) objective and subjective knowledge differentiation.

For the purpose of this study, we will follow Hollweg *et al.*'s suggestion as well as McBeth *et al.*'s approach and examine two components of knowledge: physical and ecological systems, i.e., knowledge of scientific facts, and environmental issues, i.e., knowledge of environmental facts. Also, following Brucks (1985) and Dodd *et al.*'s (2005) classification, we will have: subjective knowledge on environmental issues to cover all types of knowledge in the context of environment.

How does knowledge affect pro-environmental behaviors? Because of the central role knowledge plays in many theoritical models of attitude-behavior relations (e.g. Ajzen and Fishbein's theory of planned behavior), it is also important to consider it as an

essential source of influence in adopting pro-environmental behaviors. For example, a general increase in a consumer's knowledge on the environment and the causes and impact of pollution can increase that individual's awareness level. This higher level of awareseness, on the other hand, can lead to favorable attitudes toward behaving pro-environmentally (Tan, 2011). In two of their studies, Ölander and Thøgersen (1995) and Thøgersen and Ölander (2002) came to a conclusion that sufficient amount of environmental information of consumers help them make appropriate and responsible choices in terms of environmental actions. Ngo *et al.* (2009) also supports this approach in his study on the determinants of environmentally responsible behaviors in the context of greenhouse gas reduction. Also, according to Hines *et al.* (1987), environmental knowledge has an impact on intentions to act in an environmentally way. In fact, their meta-analysis have shown an average correlation of 0.30 between environmental knowledge and behavior. Furthermore, in his conceptual work that covers a detailed literature review on determinants of green purchase behavior, Tan (2011) suggests using environmental knowledge as one of the determinants in empirical studies, in addition to some other important factors, such as environmental threat, environmental attitude, and green behavior attitudes.

Examining different categories of knowledge. Some researchers by examining the relationship between environmental knowledge and environmental behavior came to a similar conclusion that the impact of different kinds of knowledge on environmental behavior should be studied simultaneously (Hines *et al.*, 1987; Klerck and Sweeney, 2007; Raymond *et al.*, 2010). The reasoning behind this is the contradicting approaches and results in the environmental literature. For example, whereas, some studies found one type of knowledge more important than the others (e.g. abstract knowledge in Hines *et al.*, 1987) in terms of leading to pro-environmental behaviors, others found the contrary (e.g. abstract knowledge is not as important, Kaiser *et al.*, 1999; Stern, 1999; Barr, 2003).

The empirical study by Klerck and Sweeney (2007) on genetically modified (GM) food purchase behavior showed also the necessity of considering each knowledge type separately and examining them simultaneously. An important discovery derived from the study by Klerck and Sweeney was that the objective and subjective knowledge are distinct constructs with differential effects on perceived risk. Similar result was also suggested and supported by prior research on consumers' pro-environmental behavior (Fiske *et al.*, 1994; Raju *et al.*, 1995).

Scientific and environmental fact knowledge and pro-environmental behavior. People should be able to make informed decisions regarding scientific issues (Brossard *et al.*, 2005) and environmental matters that affect their everyday lives, well-being of communities they belong, as well as national and international issues such as environmental and personal health. From the consumer behavior perspective, both scientific and environmental knowledge lead to consumers' consciousness and problem awareness, and thus, considered as significant factors in the norm-activation process (Ngo *et al.*, 2009). Also, researchers suggest that the acquired knowledge is used by consumers so that they can estimate the results of their selections or possible consequences of choosing those options (Stern, 1999; Thøgersen, 1999; Scott and Jobber, 2000). However, the exact connection of knowledge and environmental behavior is not clear in the literature.

Using the theory of reasoned action as a guiding framework, Polonsky *et al.* (2012) tested the relationships between carbon and environmental knowledge, environmental

attitude, and behavior of US consumers. This empirical study's findings suggested that there is a positive relationship between general and carbon-specific factual knowledge, environmental attitudes, and general and carbon-specific behaviors (Polonsky *et al.,* 2012). These studies considered only one type of environmental knowledge.

As mentioned earlier, various studies which report a positive and significant relationship between factual knowledge and environmental attitudes/behavior demonstrated that in the consumer's decision-making process concrete information and factual knowledge work much better than general information and abstract knowledge (Kaiser *et al.*, 1999; Stern, 1999; Barr, 2003). According to them, factual knowledge about the environment is necessary to build up some kind of attitudes toward the environment and associated ecological behavior. In their study on environmentally friendly purchase behavior (buying organic wine), Barber *et al.* (2009) tested the impacts of both objective and subjective environmental knowledge on environmental attitude and reported that the objective environmental knowledge was positively related to the environmental attitude. Similar result also came from Klerck and Sweeney's (2007) study on GM food consumption. Their results confirmed the strong relationship between the objective knowledge and consumer's perceived risk with respect to GM food. According to the study, subjective knowledge was not as important. In another research that focusses on different types of waste management behavior (reduction, reuse, and recycling), Barr (2007) found that the most important predictors of reduction and reuse behaviors were the underlying environmental knowledge, values, and concern-based variables. Although, in all cases knowledge was important, the effect of abstract knowledge was generally weak, whereas concrete (factual) knowledge was more significant (Barr, 2007). Although, these studies' results are important, it is not possible to generalize their outcomes for all pro-environmental behaviors in general since they may or may not hold true for other environmental behavior contexts. Thus, further research is needed considering all behaviors as one condensed outcome.

In an international comparison study across the USA, Great Britain, West Germany, Russia, and Japan, Weaver (2002) looked at the effects of various background characteristics and knowledge on pro-environmental attitudes and showed that pro-environmental attitudes (toward the consequences of human actions on the environment and human health, also called as environmental risk perception) are correlated with environmental knowledge and scientific knowledge. Their study also showed that such relationship occurs among all the countries examined, with some variation in significance and direction of influence (Weaver, 2002).

Although, aforementioned studies report positive relationship between factual knowledge and environmental attitudes/behavior, there are some other studies that report no relationship between them. For example, Tanner and Kast's (2003) study reported that while the action associated knowledge was positively related to pro-environmental behavior (green food purchases), the factual knowledge was not a predictor of the examined behavior. In another study, Ellen (1994) reported that an individual's level of objective knowledge was predictive only for recycling behavior, and other examined behaviors were not predicted by it (i.e. source reduction, political action to reduce waste).

Subjective environmental knowledge in the literature. In terms of subjective knowledge, the studies also show different results. Kaiser *et al.* (1999) state that when

the relationship between knowledge and behavior appears to be stronger this is generally not related to factual knowledge about the environment but rather to subjective and behavior related knowledge. In fact, subjective environmental knowledge (i.e. respondent's perceived knowledge toward the environment) has been reported significantly correlated to concerns about the environment (Tan, 2011). It is also found that subjective knowledge could influence general eco-sensitive purchase behavior, buying recycled paper products, recycling, source reduction, reducing waste, and political actions on protecting environment (Ellen, 1994). Ellen (1994) reported that an individual's level of perceived knowledge was an important indicator of recycling, source reduction and political action to reduce waste.

Making it more challenging, in their study on environmentally friendly wine purchase behavior, Barber *et al.* (2009) reported a negative relationship between perceived environmental knowledge and environmental attitudes. According to this study, increased subjective environmental knowledge of the consumers would lead to less positive attitudes toward environment which cause less purchase of environmentally sensitive products. With this notion, Hwang *et al.* (2000) pointed out higher environmental knowledge should not be seen as a definite guarantee of a more positive environmental behavior.

Knowledge and WTP. A few studies in the literature found that knowledge has a predictive power on WTP for the environment. For example, some studies' results confirmed there is a clear relationship between consumers' levels of knowledge and consumption of organic foods and their WTP a premium price for these products (e.g. Mesías Díaz *et al.*, 2012; Gil and Soler, 2006). However, Laroche *et al.*'s (2001) study on segmentation of consumers who were willing to pay more for environmentally friendly products showed that knowledge of environmental facts (named as eco-literacy) was not related to consumers' WTP more for sensitive products. The contradictory nature of the abovementioned findings warrants future research. The preceding review and discussion on knowledge lead us to following hypotheses:

H3. There is a positive relationship between individuals' knowledge of scientific facts and their environmental risk perception.

H4a. There is a positive relationship between individuals' knowledge of environmental facts and their environmental risk perception.

H4b. There is a positive relationship between individuals' knowledge of environmental facts and their WTP for the environment.

H5a. There is a positive relationship between individuals' subjective environmental knowledge and their environmental risk perception.

H5b. There is a positive relationship between individuals' subjective environmental knowledge and their WTP for the environment.

Environmental risk perception

According to Stern and Dietz (1994), perceived risks "can be seen as perceived negative consequences to things people value, including personal health and safety, the health and safety of other human beings, and the welfare of other species and the biosphere" (p. 79). Environmental risks (also called ecological risks) are defined as threats to the natural environmental system and species' health and productivity. Perceived environmental risk, on the other hand, can be defined as an individual's judgment on

how performing a certain kind of activity or a lifestyle could cause a risk for the environment (likelihood of risk – the probability of facing harm) (McDaniels *et al.*, 1997).

According to Banarjee and McKeage (1994), green consumers strongly believe that current environmental conditions are deteriorating and realize the risks associated with not behaving in environmentally cautious way. Follows and Jobber (2000) state that if consumers believe the consequences of their consumption will be detrimental for the environment, they may alter purchase habits and buy environmentally sensitive products. Conversely, individuals who do not engage in environmentally friendly behavior (e.g. not purchasing eco-friendly goods, recycling, or saving water) perceive that ecological problems will not need any human behavior alteration, with the notion that those problems can "resolve themselves." So, for them, the risk does not exist as a result of their actions, and even if they exist as an outcome, they are not that severe to worry about. Thus, according to Laroche *et al.* (2001) an individual's risk perception about the ecological conditions might influence that person's WTP more for eco-friendly products because they see a connection between those problems and their actions. Paralleling to this notion, Klerck and Sweeney's (2007) empirical study finds a mediating role of perceived risk between knowledge and behavior which impacts the behavioral outcome positively. Hence, we hypothesize:

H6a. There is a positive relationship between individuals' environmental risk perception and their WTP for the environment.

H6b. There is a positive relationship between individuals' environmental risk perception and their pro-environmental behavior.

WTP for the environment

Another determinant of pro-environmental behavior we will be testing is one's WTP for the environmental well-being. These actions could be paying taxes to protect environment, paying higher prices for eco-friendly goods, or reducing the lifestyle in order to help overcome environmental deterioration.

Other than a number of studies on consumer demand and WTP for environmentally friendly products (e.g. Loureiro *et al.*, 2002; Laroche *et al.*, 2001; Yue *et al.*, 2010), the WTP for general environmental well-being has been also studied extensively in the environmental behavior literature (e.g. Iwata, 2002; Bulte *et al.*, 2005; Torgler and Garcia-Valiñas, 2007). Most of these studies suggest a positive relationship between people's willingness to do various sacrifices (e.g. paying higher prices or taxes) for the environment and behaviors. For example, Iwata's (2002) study represents an individual's willingness to accept sacrifices for the environment as a predictor variable and finds a positive correlation with that individual's environment-related behavior. This approach helps us to identify our next hypothesis:

H7. There is a positive relationship between individuals' WTP for the environment and their pro-environmental behaviors.

Methodology

Conceptual model

Based on the above hypotheses, we built a conceptual model for the study. The model is illustrated in Figure 1.

According to the proposed model, both attitudes toward science and environmental values should influence environmental facts knowledge. Also, attitudes toward science

should influence scientific facts knowledge, and environmental values should effect subjective environmental knowledge. Furthermore, scientific facts, environmental facts, and subjective environmental knowledge should influence environmental risk perception and two types of factual knowledge (i.e. scientific, environmental) should impact WTP the environment. Environmental risk perception should also lead to WTP the environment. As can be seen in Figure 1, different types of knowledge are expected to mediate the effects of attitudes toward science and environmental values on environmental risk perception and WTP the environment, and environmental risk perception and WTP for the environment are expected to mediate the effects of three types of knowledge on environmental behavior. In other words, the proposed model specifies direct relationships between three exogenous variables (attitudes toward science and environmental values) and scientific facts, environmental facts, and subjective environmental knowledge. Three types of knowledge are hypothesized as influencing environmental risk perception and two types of knowledge are hypothesized as influencing WTP for the environment, which in turn both risk perception and WTP influence personal pro-environmental behavior directly.

On the basis of literature review and hypothesis construction in the previous section, six regression models were developed for statistical testing:

$$\text{Pro-environmental behavior} = a_1 + b_{11}\ \text{environmental risk perception} + b_{12}\ \text{willingness to pay for environment} + e_1 \quad (1)$$

$$\text{Willingness to pay for envr.} = a_2 + b_{21}\ \text{environmental risk perception} + b_{22}\ \text{envr. fact knowledge} + b_{23}\ \text{subjective envr. knowledge} + e_2 \quad (2)$$

$$\text{Environmental risk perception} = a_3 + b_{31}\ \text{scientific fact knowledge} + b_{32}\ \text{envr. fact knowledge} + b_{33}\ \text{subjective envr. knowledge} + e_3 \quad (3)$$

$$\text{Scientific fact knowledge} = a_4 + b_{41}\ \text{attitudes towards science} + e_4 \quad (4)$$

$$\text{Environmental fact knowledge} = a_5 + b_{51}\ \text{attitudes towards science} + b_{52}\ \text{environmental values} + e_5 \quad (5)$$

$$\text{Subjective environmental knowledge} = a_6 + b_{61}\ \text{environmental values} + e_6 \quad (6)$$

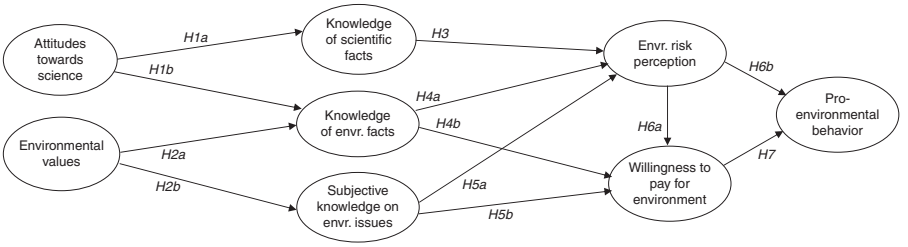


Figure 1.
Model of the study "Antecedents and consequences of consumer knowledge and its effects on pro-environmental behavior"

where a is the regression constant; b the path coefficient (i.e. standardized regression coefficient, β weight); e the causes outside the model.

Data

The study is based on measures and data obtained from the 2010 National Opinion Research Center (NORC) GSS of the University of Chicago, which includes a set of environmental items. The GSS is a bi-annual nationally representative full-probability weighted sample set of the US adult population compiled by NORC. The survey addresses topics such as environment, civil liberties, family, mortality, socioeconomic status, social control, and race. It is designed to support social indicator research with modules touching upon various current and emerging issues. The GSS data set is considered to be as one of the largest and most reliable data sources with its generally high response rates compared to other national surveys (GSS, 2010). The 2010 GSS interviewed a national sample of 2,044 respondents.

Measures

Using the relevant questions in the 2010 GSS, we developed scales where possible in order to measure variables in the model of the study. Variables and survey measures used for the study are shown in Table I. For attitudes toward science (SCIAT), GSS survey questions those related to individuals' beliefs and approaches toward science were used. Nine-question items, such as benefits of scientific research outweigh harmful results, interested in new scientific discoveries, science and technology give more opportunities to next generation, etc. (see Table I for complete list of items). The items used three-point Likert scale answer choices (e.g. 1 = benefits are greater, 2 = benefits and harms are equal, 3 = harmful results are greater). Every item was recoded to have answer choice with high number as high science attitudes. Three of the items overlap with Brossard *et al.*'s (2005) attitude toward science scale, which was developed as a modified version of the National Science Foundation's (National Science Board, 1996) attitude toward organized science scale (ATOSS), with slight wording differences. Brossard and colleagues measured attitudes toward science scale with four items. The Cronbach α reliability coefficient was found as 0.76.

For environmental values (ENVAL), the GSS's environmental value related survey questions were used to come up with an appropriate single measure. Eight-question items used for this variable such as environment effects everyday life, environmental threats are exaggerated, worry too much about progress harming environment not enough economy and jobs, do what I can to help environment, there are more important things in life than saving environment, etc. (see Table I). The answer choices were given as five-point Likert scale format, with the range of responses 1 being "strongly agree" to 5 being "strongly disagree." The GSS uses 8, 0, and 9 answer choices for "don't know," "inapplicable," and "no answer," respectively. Scale items of some of the questions were reversed (i.e. environment effects everyday life, do what I can to help environment) to create consistency between items. Also, answer options were recoded to have high numbers indicating high environmental value and low numbers indicating low environmental value. We calculated Cronbach's α coefficient to evaluate the unidimensionality of the environmental value scale items and found 0.72.

For knowledge of scientific facts (KNWSCI) and knowledge of environmental facts (KNWENVR) measurements, GSS survey questions related to these two constructs were used. Part of the questionnaire used in the GSS survey asks respondents about their opinion on a series of statements describing some basic scientific and

Variable	GSS survey measures
Attitudes toward science – SCIAT (9 items) $\alpha = 0.757$	Benefits of scientific research outweigh harmful results
	Respondent has clear understanding of scientific study
	Interested in new scientific discoveries
	Interested in environmental issues
	Interested in space exploration
	Science and technology give more opportunities to next generation
	Benefits of nanotechnology outweigh harmful results
	Interested in medical discoveries
	Scientific research is necessary and should be supported by federal government
Environmental values – ENVAL (8 items) $\alpha = 0.715$	Environment effects everyday life
	Environmental threats are exaggerated (R)[a]
	People worry too much about progress harming environment not enough economy and jobs (R)
	Do what I can to help environment
	There are more important things in life than saving environment (R)
	It is too difficult to do anything about environment (R)
	People worry too much about environment, too little economy (R)
	Concerned about environment
Knowledge of scientific facts[c] – KNWSCI (13 items) $\alpha = 0.731$ False $\rightarrow$ 0; True $\rightarrow$ 1	The universe began with a huge explosion (T)[b]
	Father gene decides sex of baby (T)
	The continents have been moving (T)
	The earth goes around the sun (T)
	Electrons are smaller than atoms (T)
	Human beings developed from animals (T)
	The center of earth is very hot (T)
	Lasers work by focussing sound waves (F)
	All radioactivity is man-made (F)
	Antibiotics kill viruses as well as bacteria (F)
	Ordinary tomatoes do not contain genes, while genetically modified tomatoes do (F)
	The cloning of living things produces genetically identical copies (T)
	How long the earth goes around the sun (answer choices: 1 = one day (F), 2 = one month (F), 3 = one year (T), 4 = other time period (F), 8 = do not know (F), 0 = IAP-inapplicable, 9 = no answer)
Knowledge of environmental facts[c] – KNWENVR (5 items) $\alpha = 0.864$ False $\rightarrow$ 0; True $\rightarrow$ 1	Effect of global warming: polar bears become extinct (T)
	Effect of global warming: Inuit no longer follow traditional way of life (T)
	Antarctic penguins are threatened (T)
	Effect of global warming: northern ice cap melt (T)
	Effect of global warming: sea level flood coastal areas (T)
Subjective knowledge – SBJKNW (2 items) $\alpha = 0.766$	How much do you feel to:
	Know about the causes of environment issues
	Know about the solutions to environmental issues
Environmental risk perception – RISKENVR (7 items) $\alpha = 0.824$	Car pollution danger to environment
	Pesticides danger to environment

(*continued*)

Table I.
Variables and survey measures used for the study

Variable	GSS survey measures
	Industrial air pollution danger to environment
	Nuke power danger to environment
	Water pollution danger to environment
	Rise in the world's temperature caused by climate change is dangerous for the environment?
	Modifying the genes of certain crops is dangerous
Willingness to pay for envr. – WILPAYENVR (3 items) $\alpha = 0.838$	Willingness to pay higher prices for environmental protection
	Willingness to pay higher taxes for environmental protection
	Willingness to accept cut in living standards for environmental protection
Pro-environmental behavior – PEB (6 items) $\alpha = 0.769$	How often do you:
	Recycle cans and bottles
	Buy pesticide-free fruits and vegetables
	Avoid purchasing products
	Drive less for environmental reasons
	Reduce fuel for environmental reasons
	Save water for environmental reasons

Notes: [a](R) denotes reversed scale items; [b](T) and (F) denote true and false answer choices, respectively; [c]all items are measured with three- or five-point Likert Scale unless answers choices are True/False. Knowledge index developed following Klerck and Sweeney (2007)

Source: Survey measures obtained from the General Social Survey (GSS, 2010)

Table I.

environmental facts. It was possible to determine respondents' scientific and environmental fact knowledge from the answers to these questions. Following Klerck and Sweeney (2007), knowledge of scientific facts and knowledge of environmental facts were measured using two different index constructed from responses to 13 and five questions, respectively. For knowledge of scientific facts, each of the 13 items, and for knowledge of environmental facts, each of the five items were coded on a nominal scale (correct or incorrect), and the number of correct items used to form a factual knowledge index, with a maximum score of 13 for knowledge of scientific facts and 5 for knowledge of environmental facts with minimum value of 0 for both. The questions that were negatively worded (the correct answer was "false") were recoded. All items had a "don't know" response option, and these were coded as incorrect answers in each case with the reasoning that for an item assessing factual knowledge, a "don't know" response is incorrect. The Cronbach's α for knowledge of scientific facts index is 0.73, and for knowledge of environmental facts is 0.86.

The next data used for subjective knowledge of environmental issues (SBJENVR) scale consisted two items: "How much do you feel you know about the causes of these sorts of environmental problems? Please tell me what you think, where 1 indicates you feel you know nothing at all and 5 indicates you feel you know a great deal," and "And how much do you feel you know about solutions to these sorts of environmental problems? Please tell me what you think, where 1 indicates you feel you know nothing at all and 5 indicates you feel you know a great deal." The Cronbach α reliability coefficient was found 0.77.

For environmental risk perception (RISKPERP), the GSS's different environmental threat focussed survey questions were examined and five of them used to come up

with an appropriate single measure. The questions used were car pollution danger to environment, pesticides danger to environment, industry air pollution danger to environment, nuclear power danger to environment, and water pollution danger to environment with the response options that range from 1 "strongly agree" (or extremely dangerous) to 5 "strongly disagree" (or not dangerous at all). For the consistency, all five-point Likert scale items are reversed. Cronbach's α for environmental risk perception is 0.82.

The next variable, WTP for the environment (WILPAYENVR), measured with three relevant questions from the GSS survey questionnaire, stating that: how willing you are to pay higher prices, pay higher taxes, and accept cut in living standards for environmental protection. The answer options were given as: 1 = very willing, 2 = fairly willing, 3 = neither willing nor unwilling, 4 = not very willing, 5 = not at all willing, 8 = do not know, 9 = no answer, 0 = IAP. All questions are reversed to make high number as high WTP for the environment. We found 0.84 Cronbach's α for WTP for the environment scale.

Lastly, the data for the outcome variable capturing pro-environmental behavior (PEB) gathered from personal behaviors toward environment were given as: recycle can bottles, buy pesticide-free fruits and vegetables, avoid purchasing products that are harmful to the environment, drive less for environmental reasons, save water, and use less fuel. The arithmetic mean of these variables provided a combined PEB value for each individual. The reliability analysis of the scale items for the environmentally sensitive behavior gave a Cronbach's α reliability coefficient value of 0.77.

Missing data were replaced using estimate maximization method for each variable. The gender distribution of the sample of 2,044 respondents was: 56.4 percent women and 43.6 percent men.

Results

A summary of descriptive statistics and correlation matrix for the variables of pooled data are provided in Table II. In order to explain each outcome variable by identified predictor variables, a series of multiple regression analyses was performed. A summary of results is displayed in Table III.

The first regression equation including the factor attitudes toward science (SCIAT) affecting individuals' knowledge of scientific facts (KNWSCI) is significant with an R^2 value of 0.155. Standardized β coefficient for the SCIAT→KNWSCI link (0.394, $p = 0.000$) is significant. So, for the first regression analysis that tests predictor of scientific fact knowledge, the direct effect of attitudes toward science (*H1a*) is significant and, as hypothesized, the analysis shows a positive relationship. Hence, *H1a is* supported.

Variable	SCIAT	ENVAL	KNWSCI	KNW ENVR	SBJKNW	RISK PRCP	WILPAY ENVR	PEB	Mean	SD
SCIAT	1	0.088**	0.394**	0.200**	0.103**	0.031	0.062**	0.055*	2.52	0.215
ENVAL		1	0.070**	0.069**	0.308**	0.405**	0.510**	0.409**	3.27	0.508
KNWSCI			1	0.175**	0.095**	−0.011	0.025	0.019	7.93	1.974
KNWENVR				1	0.047*	0.043	0.032	0.031	4.56	0.659
SBJKNW					1	0.044*	0.231**	0.257**	2.74	0.774
RISKPRCP						1	0.313**	0.331**	3.56	0.559
WILPAYENVR							1	0.332**	2.83	0.896
PEB								1	2.18	0.545

Notes: $n = 2,044$. *,**Correlation are significant at 0.05 and 0.01 level (two-tailed), respectively

Table II. Descriptive statistics and correlation matrix

Hypotheses	R^2	(*F*-Sig.)	Std. β	*p*-value	Results
H1a: SCIAT → knowledge of scientific facts	0.155	(0.000)	0.394	0.000	Supported
H1b: SCIAT → knowledge of environmental facts	0.043	(0.000)	0.196	0.000	Supported
H2a: ENVAL → knowledge of environmental facts	0.043	(0.000)	0.052	0.017	Supported
H2b: ENVAL → subjective knowledge on envr. issues	0.095	(0.000)	0.308	0.000	Supported
H3: KNWSCI → Envr. risk perception	0.004	(0.037)	-0.023	0.306	Not supported
H4a: KNWENVR → Envr. risk perception	0.004	(0.037)	0.045	0.044	Supported
H4b: KNWENVR → willingness to pay for envr.	0.145	(0.000)	0.009	0.655	Not supported
H5a: SBJKNW → Envr. risk perception	0.004	(0.037)	0.044	0.048	Supported
H5b: SBJKNW → willingness to pay for envr.	0.145	(0.000)	0.217	0.000	Supported
H6a: RISKPERP → willingness to pay for envr.	0.145	(0.000)	0.303	0.000	Supported
H6b: RISKPERP → pro-environmental behavior	0.168	(0.000)	0.252	0.000	Supported
H7: WILPAYENVR → pro-environmental behavior	0.168	(0.000)	0.253	0.000	Supported

Note: All hypotheses tested at $p < 0.05$

Table III.
Summary of regression results

The second regression analysis with two predictor variables of attitudes toward science (SCIAT) and environmental values (ENVAL) with knowledge of environmental facts (KNWENVR) as an outcome is significant ($p = 0.000$), with an R^2 value of 0.043. Standardized β coefficients for the SCIAT→KNWENVR link (0.196, $p = 0.000$) and for the ENVAL→KNWENVR link (0.052, $p = 0.000$) are both significant. Since the direct effects of attitudes toward science (*H1b*), and environmental values (*H2a*) on the knowledge of environmental facts are significant, *H1b* and *H2a* are both supported.

The results of the next regression analysis that considers subjective knowledge on environmental issues (SBJKNW) as an outcome and environmental values as predicting variables show an R^2 value of 0.095. Standardized β coefficient for the ENVAL→SBJKNW link (0.308, $p = 0.000$) is significant. Thus, *H2b* is supported.

The next regression equation including the three knowledge factors, i.e., knowledge of scientific facts, knowledge of environmental facts, and subjective knowledge on environmental issues, affecting environmental risk perception (RISKPERP) is significant with an R^2 value of 0.004. The regression results show significant standardized β coefficients for the KNWENVR→RISKPERP link (0.045, $p = 0.044$) and SBJKNW→RISKPERP (0.044, $p = 0.048$). The KNWSCI→RISKPERP (−0.023, $p = 0.306$) link is not significant. Hence, *H4a* and *H5a* are supported, whereas *H3* is not.

The regression of three factors, i.e., knowledge of environmental facts, subjective knowledge on environmental issues, and environmental risk perception, affecting WTP for environment (WILPAYENVR) is significant ($p = 0.000$) with an R^2 value of 0.145. Although, standardized β coefficients for the SBJKNW→WILPAYENVR link (0.217, $p = 0.000$) and RISKPERP→WILPAYENVR link (0.000, $p = 0.303$) are both significant, KNWENVR→WILPAYENVR link (0.009, $p = 0.655$) is not. Thus, *H5b* and *H6a* are supported but *H4b* is not.

Finally, the last regression of environmental risk perception and WTP for environment both affecting pro-environmental behavior (PEB) is significant ($p = 0.000$) with an R^2 value of 0.168. Standardized β coefficients for the RISKPERP→PEB link (0.252, $p = 0.000$) and for the WILPAYENVR→PEB (0.253, $p = 0.000$) are both significant. Since the direct effects of environmental risk perception (*H6b*) and WTP for environment (*H7*) on the pro-environmental behavior are significant, *H6b* and *H7* are both supported.

Regression path diagram (with β values) showing the model of the influence of attitudes toward science, environmental values, three different types of knowledge,

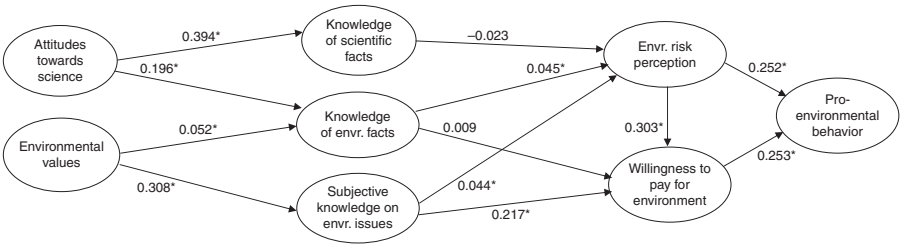
environmental risk perception, and WTP for the environment on pro-environmental behavior is illustrated in Figure 2.

Discussion and conclusion

The results of the study showed that environmental risk perception and WTP for the environment accounted for approximately 16.8 percent of the variance in the pro-environmental behaviors. This tells us that the pro-environmental behaviors of the individuals are affected moderately by the environmental risk perception they carry and their WTP for environmental conditions. Significant direct effects of WTP for the environment ($b = 0.253$) and environmental risk perception ($b = 0.252$) in the model can explain people's decisions on acting environmentally sensitive way are the cause and effect of their environment-related attitudes. Significant direct effects of both WTP for the well-being of the environment and environmental risk perception also tell us that pro-environmental behaviors, such as purchasing environmentally friendly products, recycling, green consumption, driving less, and reducing waste, are all a reflection of a change in people's environmental perceptions, how they see the threats related to environment, and their willingness to take responsibility and make contributions (e.g. paying premium for an eco-sensitive product) whenever possible. These results support the findings of the studies of Laroche *et al.* (2001), suggested the significant relationship between WTP for the environment and pro-environmental behavior, and Klerck and Sweeney (2007), found a mediating role of perceived risk between knowledge and behavior which impacts the behavioral outcome positively.

This study also reveals that individuals' WTP for the environment and environmental risk perceptions are positively correlated. This result echoes the findings of Follows and Jobber (2000) that showed when a consumer believes there will be harmful environmental consequences of their consumption behavior; they may alter that certain behavior. According to the results of their study, worrying about environmental consequences of the behavior may cause individuals' intention to change.

The study results also show that from all three types of knowledge examined, subjective knowledge has the most predicting power on pro-environmental behaviors through environmental risk perception and WTP for the environment. Similar to many



Notes: Regression path diagram (with β values) showing the model of the influence of attitudes toward science, environmental values, three different types of knowledge, i.e. knowledge of scientific facts, knowledge of environmental facts, and subjective knowledge on environmental issues, environmental risk perception, and willingness to pay for the environment on pro-environmentally behavior. Most links/effects are significant except the knowledge of scientific facts → environmental risk perception; and knowledge of environmental facts → willingness to pay for environment path coefficients. *Significant at $p < 0.05$

Figure 2. Regression path diagram with β values

of the prior research findings that examine and report a positive correlation between individuals' environmental risk perception, concern, or attitudes and their subjective knowledge on the environment (e.g. Ellen, 1994; Kaiser *et al.*, 1999; Tan, 2011), the results of this study also reveal the associations hold true for environmental risk perception, WTP for the environment and pro-environmental behavior.

As hypothesized, the study results also underline the importance of factual environmental knowledge in order to carry out pro-environmental behaviors through increased environmental risk perception. According to Burger *et al.* (2008), an individual's risk perception accumulates through different steps, such as acquisition of information, elucidation, and synthesis of various information related to subject matter, and understanding of information considering previous knowledge, attitudes, and perceptions. Other than the direct influence of environmental factual knowledge on risk perception, this approach also explains the relationship between subjective environmental knowledge and environmental risk perception since it provides synthesis of various information related to environmental problems. Thus, we can state that it would be possible to increase people's environmental risk perceptions by providing wide spectrum information on environmental facts and issues. This increased perception of the environmental risk can direct individuals to act in a more eco-friendly manner.

Although the effects of factual and subjective environmental knowledge on environmental risk perception were supported, we need to recognize that these effects were very minimal (R^2 value of 0.004). One explanation of this could be the variety of determining factors of risk perception other than environmental knowledge. In fact, according to the European Commission (2014), knowledge cannot be considered as the sole factor determining risk perception of individuals, "rather, risk perception is a complex product of innate biases as well as social, cultural, political and emotional factors" (p. 5). These factors could be both individual and collective, as well as intrinsic and learned, which all interact and create individuals' perceived risks (Renn, 2008). For example, according to the European Commission (2014), differences in cultural background, social values and trust, personal beliefs and interests, intuitive reasoning, and worldviews all play crucial roles in determining differences in risk perception of individuals. Thus, future studies can focus on different determinants of risk perception other than knowledge in the context of pro-environmental behaviors of consumers.

As stated previously, high attitudes toward science can affect individuals' willingness to learn about issues that affect their personal lives, the well-being of their surroundings, and national and international issues such as environmental deterioration which could lead them to make informed decisions. The results of this study proved that the people who are carrying high attitudes toward science in fact are also highly knowledgeable on scientific realities, possibly as a result of their willingness to learn more on the issues. This result parallels the finding of Allum *et al.* (2008) who reported a positive correlation between general attitudes toward science and knowledge of scientific facts. However, our results did not show the factual knowledge being transferred into risk perception as hypothesized. It is possible that general scientific knowledge, that is not directly related to environmental issues could lead to other informed consumer decisions. Thus, future research is needed considering different types of pro-environmental behaviors and possible effects of factual scientific knowledge.

Lastly, environmental values examined in the study showed significant effect on people's attitudes to act in an ecologically cautious manner through increased subjective and objective (factual) environmental knowledge which lead them to have higher attitudes toward the actions. This tells us a person with higher environmental values might buy

more ecologically friendly products, recycle and take part in environmental protection activities because they search for information and become more knowledgeable (or think that they are knowledgeable as presented in subjective environmental knowledge) on environmental issues. Furthermore, people's higher values toward the environment showed their willing to pay for environment through subjective environmental knowledge. In a way, this supports the suggestion by Homer and Kahle (1988), who stated that values and behavioral outcomes cannot be considered a direct relationship. Here, we found the importance of mediating factors, such as subjective and objective environmental knowledge, environmental risk perception, and WTP for the environment, in the relationship between environmental values and pro-environmental behaviors.

Our study points to several interesting areas of future research. The results of the study show that the assessment of the relationship between different variables may need more explanatory items in the model. For instance, according to Nordlund and Garvill (2002), the decision to act in an environmentally friendly manner may involve clashing interests, such as the interests of the immediate individual vs those of the long-term collective. The individual benefits obtained from driving less or purchasing products that are pesticide-free are more significant than recycling cans and bottles. Thus, examining each behavioral outcome separately might be important to understand if perceived benefits from a specific action impact individuals' decision on behaving in that certain manner. Further analyses could better explain each pro-environmental behavior if they are included in the model as separate outcomes. Research is also needed on longitudinal analysis of changes/trends in pro-environmental behaviors and their determinants over time as knowledge on certain issues increases. For instance, it would be valuable to look at different educational programs in place and see if providing necessary information on environment and science-related issues can change the attitudes of individuals toward acting in a more eco-friendly manner. Also, cultural differences may play an important role on gathering and restoring information on scientific and environmental facts as well as individuals' perception on how well they think they know about environmental issues (subjective environmental knowledge). In this study, we examined the importance of different types of knowledge by looking at US consumers. There is a research path open for the future studies which can look at different societies and cultures and compare and contrast them to understand the role of cultural differences in effecting different types of knowledge in the context of pro-environmental actions.

Managerial implications

The importance of environmental values, environmental knowledge (subjective and objective/factual), environmental risk perception, and WTP for the environment, found in this study has notable managerial implications. First of all, government and non-government agencies should try to understand community's values and concerns carefully in order to engage with each individual and provide necessary information. As Hance *et al.* (1989) suggest, agencies have responsibility of identifying and understanding the values and concerns of the communities in addition to explaining risks to the public. Furthermore, because public perceptions of risk influence policymaking, it is important to understand predicting factors of environmental risk perception, such as subjective knowledge of individuals on environmental issues, in order to come up with appropriate policies that would lead to more pro-environmental actions at the individual level. Increasing the public knowledge on environmental issues can eliminate misperceptions which could help to prevent poor policies.

Effective communication methods to provide necessary information on environmental issues may be useful in shifting the public's understanding of environmental facts and perception of environmental risks. It is useful to know by communication experts that in order to effectively engage with public, it is necessary to understand that individuals perceive environmental issues differently, and that their perception of environmental risk is shaped by various factors, such as environmental factual and subjective knowledge as found in this study. Thus, we can state that it would be possible to increase people's environmental risk perceptions by providing wide spectrum information on environmental facts and issues.

Particularly, as noted by Wiedemann *et al.* (2013), communicating cause and effect related to the facts and issues could be important in influencing risk perception. In the context of environmental risk perception, this kind of communication can help individuals to identify results of their environmentally significant behaviors and possible solutions to prevent negative outcomes of these particular actions. Scientific and regulatory institutions, therefore, need to strive for greater cooperation and must work together to foster more effective communication strategies to reach out to consumers.

Lastly, in order to receive more public support and see better results from environmental policies, risk communication should be regarded as a two-way process (European Commission, 2014). Developing a system which facilitates a constant exchange between scientists, policy makers, and the public will result in policies that are widely supported by many individuals. One of the methods that was suggested to be valuable as a means to communicate risks with consumers has been social media. As suggested by Rutsaert *et al.* (2013), social media offers an incomparable opportunity in vast public networks by providing instant, up-to-date information with two-way communication capabilities. It is a highly useful platform that can be used to improve societies' environmental values, risk perception, attitudes, and knowledge related to the environment by instituting an ongoing dialogue.

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