The crucial roles of biodiversity loss belief and perception in urban residents' consumption attitude and behavior towards animal-based products

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Abstract

Products made from animal fur and skin have been a major part of human civilization. However, in modern society, the unsustainable consumption of these products – often considered luxury goods – has many negative environmental impacts. This study explores how people's perceptions of biodiversity affect their attitudes and behaviors toward consumption. To investigate the information process deeper, we add the moderation of beliefs about biodiversity loss. Following the Bayesian Mindsponge Framework (BMF) analytics, we use mindsponge-based reasoning for constructing conceptual models and employ Bayesian analysis aided by Markov Chain Monte Carlo (MCMC) algorithms on a dataset of 535 Vietnamese urban residents. The results show that people's preference for using products made from animal skin/fur is negatively associated with perceived consequences of biodiversity loss when they believe biodiversity loss is real and a major problem. In contrast, if urban residents believe biodiversity loss is unreal or not a significant issue, the association between perceived consequences of biodiversity loss and personal preference happens in the opposite direction. The same effects of biodiversity loss perception on people's possession of skin/fur products was not found, indicating a more complex information process on behaviors compared to attitudes. Nevertheless, in the scenario that people believe biodiversity loss is not a significant issue, the higher the perceived consequences of biodiversity loss are, the greater number of animal-based products they likely own. Our results suggest that policymakers should not neglect the factor of personal belief besides knowledge and awareness in environmental campaigns.

Keywords: animal-based products; environmental perception; consumer behavior; biodiversity; Bayesian-Mindsponge Framework

1. Introduction

1.1. The issues of animal fur/skin consumption in modern human society

1.1.1. The natural and social demands for fur and leather

Humans in modern civilization are accustomed to the notion of using products made from animals' skin and fur: clothes, accessories, blankets, furniture, decorations, etc. However, in nature, humans are not the only species utilizing other species' body parts for self-interested purposes besides nutrition. In the animal kingdom, hermit crabs are well-known for their behavior of seeking and using empty mollusk shells. Various information processing abilities

help hermit crabs in finding suitable shells, which may involve complex cognitive processes such as fighting tactics for good shells and group arrangement for shell transferring (1). Another fascinating case is the species *Acanthaspis petax* – a type of assassin bug preying primarily on ants, often known for the camouflage of their nymphs which is mainly ant carcasses being carried on the back to help avoid predators by confusing them with unappetizing appearances (2).

Consumption behaviors in humans are much more cognitively complex and stem from individual desires and corresponding intentions. Similar to other biological information processing systems in nature, humans developed directional behaviors regarding bio-resources utilization. Early humans knew to use dead animals' skin and fur to protect their bodies from physical impacts and low temperatures. Evidence of bone tools and animal remains found in Morocco suggests that humans skinned animals for fur and leather clothing as early as 120,000–90,000 years ago (3). North Africa, 100,000 years ago – the start of the most recent ice age – might have been very cold at times, so people adopted clothing to prevent hypothermia and for comfort against the chill (4).

Besides natural survival, humans in complex societies also innovate for social survival purposes (5). Attractive appearances and possessions made from natural products, including animals, soon became an important part of human culture, including aspects such as aesthetics, social power, spirituality, etc. For example, fur has been considered luxurious goods from ancient times until today, both for its quality of utility and representation of social distinctions (6). In modern society, with a global population of approximately 8 million people, humanity's demand for animal skin and fur products has become much greater than in the tribal and medieval eras. The reasons for consumption change in different contexts, but the need has always been based on subjective intention – to protect one's physical body or increase one's mental/social value.

1.1.2. The harmful impacts of unsustainable consumption

Although biosphere integrity (which is determined by the rate of biodiversity loss), is one of two core planetary boundaries (7) that are acknowledged as being essential to the Earth system (8), biodiversity loss is still happening at an unprecedented rate on Earth. A 68 percent average drop in population size was observed in the monitored populations between 1970 and 2016, according to the 2020 global Living Planet Index (LPI), which tracked almost 21,000 populations of 4,392 species (9). In fact, many environmental scientists believe that we are already in the Sixth Mass Extinction event – mainly caused by humans' unsustainable activities, including consuming products made from fur and leather (10-13).

Animal-based products come from two main sources: domesticated or farmed animals and wild animals. Harvesting animal fur and leather from any sources unsustainably can lead to a significant decline in biodiversity (13). For example, the demand for leather products exerts a substantial demand on the livestock sector (e.g., cow farming) (13). The growing livestock production can, directly and indirectly, lead to biodiversity loss by causing ecosystem change and degradation (e.g., deforestation for expanding grazing and croplands, agriculture intensification, and desertification), climate change, the introduction of invasive species, and declining animal genetic resources (14). Meanwhile, poaching and trading wild animal for fashion products is a major driver of species decline. Although the majority of

animals used in fashion are captive-bred (e.g., crocodiles), some species are still caught mostly in the wild, such as monitor lizards and pythons (15, 16). Among 100 million animals reared and killed each year for the fur trade, 15% of them are wild-sourced. This high consumption has resulted in the extinction of the sea mink and Falkland Island foxes and threatened other carnivores, such as fur seals, vicuna, and otters (16).

Directly harvesting animal skin and fur as raw inputs not only threatens exotic wild animals' livelihood and reduces biodiversity levels, but it also creates other environmental impacts through product processing (17). For example, the industrial leather tanning process discharges a large amount of poorly biodegradable toxic wastewater (18, 19). Another famous example is the practice of farming minks for their fur. Mink farms can be the source of persistent organic pollutants and other metal pollution in nearby rivers and lakes (20). Additionally, this type of intense animal farming carries high risks of infectious diseases for both the animals and humans, such as the SARS-CoV-2 infection outbreaks in mink farms during the COVID-19 pandemic (21).

Overall, the current industrial system of making products from animal skin and fur is not only ethically questionable but also environmentally harmful (17). Despite the recent shift in awareness toward eco-fashion, a big part of the luxury and fashion industry involving fur products still caters to non-sustainable consumption (22). Wild fur harvesting (e.g. hunting, trapping) and trading have been much more restricted compared to earlier centuries, but regulations are not fully effective, leaving chances for continuous exploitation (23).

1.2. Psychological research approaches regarding animal fur/skin consumption

Given the negative environmental impacts of unsustainable animal-product consumption, psychological studies have been conducted from different approaches to examine the consumer side of the relationship. Consumption behaviors in humans are heavily determined by reasoned intentions compared to the more instinctual action in other animals. The Theory of Planned Behavior (TPB) – expanded from the earlier Theory of Reasoned Action (TRA) – is widely used in social sciences to examine the connection between human intention and behavior (24, 25).

For example, applying TRA to consumer behavior toward apparel made from alligator leather – a controversial luxury product, Summers, Belleau and Xu (26) find that attitude toward performing the behavior, subjective norm, controversy perception (social acceptance), and fashion involvement are all predictors of female consumers' purchase intention. Paul, Modi and Patel (27) find that TPB mediates the relationship between environmental concern and green product purchase intention. By applying TPB, it is also found that intentions to buy and use eco-friendly faux leather apparel are pro-environmentalism and social responsibility – aspects of consumers' belief systems (28). In a similar model of reasoning, it is shown that social pressure is likely the most dominant factor in forming consumers' purchase intention on ethical fashion, while trust and knowledge also play important roles (29). Such sociopsychological influence may not be straightforward, as a study finds that status-seeking consumers have higher purchase intentions toward both genuine fur coats and faux fur alternatives; however, perceived stigma only affects genuine fur coats (30).

On the side of studying the relationship between people's attitudes toward biodiversity and their behaviors, exploring individuals' perceptions by examining related mental constructs is one of the main approaches (Bakhtiari, Jacobsen, Strange, & Helles, 2014; Fischer & Young, 2007). The consumer side has a direct and major influence on the supply chain of desired products. For example, the continued growth of illegal trading is largely attributed to urban markets' rising prices and demands for wildlife products and utilities (31, 32). Furthermore, studies have suggested that despite having only a cursory understanding of the terminologies used in science, the general public can develop profound and rich perspectives of biodiversity (33-36). Thus, examining how perceptions of biodiversity influence people's purchase behavior toward animal-based products can be a helpful approach.

1.3. An exploratory information-processing approach for studying the issue

Human behaviors may be driven by complex underlying psychological processes with many personal and social values interactions. While TPB is a good theoretical foundation for scientific investigations in this aspect, the present exploratory study needs a more flexible theoretical framework focusing on the information processing mechanism of the mind to delve deeper into the underlying psychological interactions. On the same basis as in TPB's logical model, we assess that Vuong's mindsponge theory (37, 38) is a more suitable theoretical framework for this study. Mindsponge-based reasoning helps study a human mind more systematically based on an information-processing approach, supporting the exploration of complex patterns of psychological and behavioral processes.

The mindsponge mechanism suggests that for information to appear in the human mind and affect subsequent thinking and behaviors, it has to pass through the subjective cost-benefit judgments of the mind (39, 40). Specifically, information is ejected from the mind if it is perceived as costly and absorbed into the mind if it is perceived as beneficial. Following this logic, we assumed that if people perceive biodiversity loss as costly by knowing its adverse consequences, they will be less likely to absorb information that is associated with biodiversity loss, such as using products made from animal fur and leather, resulting in more negative attitudes (personal preference) towards such products and actual consumption (ownership of fewer products). To investigate these assumptions in the context of Vietnam (see the reasoning below), we proposed the following research questions (RQs):

> RQ1: Are Vietnamese urban residents with higher perceived consequences of biodiversity loss less likely to be interested in consuming products made from animal fur and leather?
>
> RQ2: Do Vietnamese urban residents with higher perceived consequences of biodiversity loss obtain fewer numbers of products made from animal fur and leather?

However, human subjective cost-benefit judgments are greatly driven by the value system sculptured by their mindsets (or set of highly trusted values/beliefs), according to the mindsponge mechanism (39, 40). As a result, we also assumed that the effects of perception about biodiversity loss consequences on personal preference and ownership of products made from animal fur and leather would vary depending on their beliefs in biodiversity loss. In particular, it was expected that in the scenario that urban residents believe biodiversity loss is real and a major problem, the effects of biodiversity loss perception on personal

preference and actual consumption would exist; on the other hand, when urban residents believe biodiversity loss is not real or not a significant problem, the effects of biodiversity loss perception would not exist. To test this assumption, the third research question was proposed:

> RQ3: Do the effects of Vietnamese urban residents' biodiversity loss perception on their personal preference and actual consumption vary according to their beliefs about biodiversity loss?

It should be noted that urban residents in Vietnam were selected as samples for this study for three reasons. Firstly, Vietnam is a South-East Asian country located in the Indo-Burma biodiversity hotspot, but its situation of biodiversity loss is severe. Compared to the first Vietnam Red List published in 1992, the 2007 edition of the Vietnam Red List recognized 882 vulnerable and endangered species (418 animals and 464 plants), representing an increase of 22.33 percent (161 species) (41). Secondly, Vietnam is among the top five processing hubs for wildlife products, including products in the fashion category (e.g., furs and hide), according to an analysis of the 20-year UN Comtrade database's data (42). Thirdly, the association between urban residents' perception and their personal interests and actual consumption behavior related to fur and leather products in Vietnam remained understudied.

2. Materials and methods

2.1. Materials

The current study analyzed samples from a dataset of 535 Vietnamese urban residents' wildlife consumption behaviors, multifaceted perceptions and interactions with biodiversity-related concepts (43). Urban residents' responses were collected through an online survey within two months using Google Forms, from June 18 to August 8, 2021. Before filling in the questionnaire, respondents were asked to read and agree with the consent form that specifies the study aims, questionnaire components, and participant confidentiality. Because the survey collection was not funded, it is not bounded by any contractual duties and can completely prioritize the obligations to safeguard participants (44). Gift cards with a value ranging from $1 to $10 were sent to 200 randomly selected respondents when the survey collection was completed.

Initially, 581 responses were received. However, Nguyen (43) curated and removed unqualified data based on four criteria, resulting in 535 eligible responses from 34 urban areas across Vietnam. The omitting criteria are:

- people not from urban areas,
- people younger than 18 years old,
- duplicate responses (identified based on email address),
- suspected low-quality responses (identified based on the performance of "straightlining" and "select-all" behaviors) (45).

Most of the respondents resided in the two largest cities in Vietnam: Ho Chi Minh (64.86%) and Hanoi (Hanoi). 58.31% of the respondents were female, accounting greater percentage than their male counterparts (41.12 %). The average mean age was around 33.80. The education backgrounds of the respondents were relatively high, with 63.18% holding an

undergraduate degree and 21.87% acquiring a post-graduate degree. A majority of respondents reported that they spent most of their lives in urban zones (84.86%), while the remaining 10.09% and 4.86% of respondents spent most of their lifetime in suburban and rural areas, respectively. The respondents' occupational backgrounds were diverse, ranging from accountants, activists, and actors to employees, students, and retirees.

The dataset consists of six major categories, namely:

1) wildlife product consumption;
2) general biodiversity perceptions;
3) biodiversity at home and neighborhood;
4) public park visitation and motivations;
5) national park visitation and motivations; and
6) socio-demographic profiles.

In the current study, we utilized four variables that were generated from variables from the first and second categories. More details of the employed variables are presented in the next subsection.

2.2. Methods and validation

The current study employed the Bayesian Mindsponge Framework (BMF) analytics, which incorporates mindsponge-based thinking and the statistical power of Bayesian inference (46, 47). This subsection describes Bayesian analysis's advantages, especially when combined with the mindsponge mechanism.

The BMF analytics endorses the parsimonious principle, which asserts the avoidance of complexity without necessity in designing research. For this reason, although models constructed based on mindsponge-based reasoning have high explanatory predictive power, they usually have few variables, resulting in a higher number of unknown parameters and uncertainties. Bayesian inference can complement this shortage, as it treats all properties (including unknown parameters and uncertainties) probabilistically (48), allowing us to focus solely on estimating models containing the issues of interest (46). Moreover, thanks to the development of computational power, Bayesian inference is nowadays aided by the Markov Chain Monte Carlo (MCMC) algorithms to compute posterior distributions. In particular, MCMC algorithms iteratively generate a large number of samples from the joint posterior distribution of the model's parameters, supporting the Bayesian inference in model fitting with high flexibility (49-51). This allows us to fit models with interaction terms (or non-linear relationships).

Researchers suggest that the flawed *p*-value is a major cause of the recent reproducibility crisis in social sciences and psychology (52, 53). Ronald Fisher developed the p-value to aid judgement of whether we should doubt the null hypotheses, but it is being treated as a dichotomous value in modern science (e.g., taking 0.05 as a threshold for rejecting the null hypothesis). According to Halsey, Curran-Everett, Vowler and Drummond (54), scientists should avoid making binary judgements based on *p*-values and instead employ other reliable options to assess statistical results, such as visual presentation of the estimated coefficients. Because estimation and visualization of credible intervals are key components of Bayesian analysis, it can be a useful alternative to the *p*-value approach.

Prior incorporation is a fundamental function of Bayesian analysis, which helps researchers to take into account prior knowledge (e.g., experience, intuition, former empirical evidence, theoretical ideas) to aid their estimation. Some researchers are concerned that the inclusion of subjectivity may allow analysts to manipulate probability calculations to obtain desired findings. To deal with this worry, we employed the uninformative priors that specify flat prior distributions to provide the least amount of prior information possible to the model estimation (55). Besides, we performed the "prior-tweaking" technique to test the robustness of the posterior results when priors are adjusted (56). The informative prior employed in this study is the normal distribution with a mean at 0 and deviation at 0.1, reflecting our disbelief in the proposed effects. The estimated model is considered robust if the posterior outcomes of the models using informative and uninformative priors are not much different.

In the current study, two models were constructed using five variables to answer the research questions stated in the Introduction.

$$SkinFurLike \sim BioLossCost + BioLossCost * UnrealBD + BioLossCost * InsignificantBD \quad (1)$$

$$SkinFurNum \sim BioLossCost + BioLossCost * UnrealBD + BioLossCost * InsignificantBD \quad (2)$$

The description of the analyzed variables is displayed in Table 1. Model 1 examines the impacts of urban residents' perceived consequences of biodiversity loss and its interactions with their belief about biodiversity loss on the preference to use products made from animals' skin/fur. Meanwhile, Model 2 examines similar impacts on the ownership of products made from animals' skin/fur. Regarding urban residents' belief about biodiversity loss, there are three scenarios:

1) The respondent thinks that biodiversity loss is not real
2) The respondent thinks that biodiversity loss is real but only a small problem (insignificant)
3) The respondent thinks that biodiversity loss is real and a major environmental problem (significant)

As we suspected that the impact of perceived consequences of biodiversity loss on the preference and ownership of products made from skin/fur is different depending on the scenario of belief. Thus, we inserted the interaction terms in the models to examine the differences. Specifically, the interaction between $BioLossCost$ and $UnrealBD$ was added in both models to examine the outcomes of preference and ownership in the first scenario, while the interaction between $BioLossCost$ and $InsignificantBD$ was added to examine the outcomes in the second scenario. When both the interaction terms are 0, the remaining effect of $BioLossCost$ on $SkinFurLike$ or $SkinFurNum$ represents the outcomes in the third scenario.

We employed several techniques to validate the simulated posteriors. The first step was validating the convergence of Markov's chains through the diagnostic statistics: effective sample size (n_eff) and Gelman shrink factor (Rhat). Commonly, if the n_eff value is greater than 1,000 and the Rhat value is equal to 1, the model's Markov chains can be deemed

convergent. Then, the convergence was also diagnosed through graphical figures, like trace plots, Gelman plots, and autocorrelation plots. Finally, the "prior-tweaking" technique was performed to check the model's robustness or sensitivity to prior modification.

All the Bayesian analyses were conducted using the **bayesvl** R package because of several values (57, 58). First, the package is free to use on the R software. Secondly, it generates vivid graphics, aiding the result presentation and interpretation. Last but not least, the package's operation method is easy to use and has high pedagogical values, supporting the replication of the results and promotion of Bayesian inference. All the data files and code snippets of this study are deposited at the following URL for the sake of transparency and other researchers' reproduction if necessary (59): https://osf.io/e6zku/

Table 1: Variable description

Variable	Meaning	Description	Type of variable	Value
SkinFurLike	Whether the respondent prefers to use products made from animal skin/fur	Generated from variable *A6* in the original dataset	Binary	1 = Yes 0 = No
SkinFurNum	The number of products made from animal skin/fur that the respondent owns	Generated from variable *A7* in the original dataset	Numerical	1 = Nothing 2 = 1-3 products 3 = 3-5 products 4 = More than 5 products
BioLossCost	Perceived consequences of biodiversity loss	Generated by averaging 13 variables indicating perceived consequences of biodiversity loss in the original dataset (from variable *B3_1* to *B3_13*). The Cronbach's Alpha of 13 variables is 0.939, indicating that they have very high internal reliability and can be grouped	Numerical	1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree

		into one dimension (or variable).		
UnrealBD	Respondent thinks that biodiversity loss is not real	Generated from variable *B2* in the original dataset	Binary	1 = Biodiversity loss is not real 0 = Biodiversity loss is real but only a small problem; Biodiversity loss is real and a major environmental problem
InsignificantBD	Respondent thinks that biodiversity loss is real but insignificant	Generated from variable *B2* in the original dataset	Binary	1 = Biodiversity loss is real but only a small problem 0 = Biodiversity loss is not real; Biodiversity loss is real and a major environmental problem

3. Results

3.1. Model 1: Preference of products made from skin/fur

In this subsection, we present the estimated results of Model 1. The model was fitted with the following setups of MCMC: 5,000 iterations, 2,000 warm-up iterations, and four Markov chains. All the estimated posteriors are shown in Table 2. For interpretation, we will use the estimated results using uninformative priors only to maintain the objectivity, while the estimated results informative priors are for robustness check.

Table 2: Model 1's simulated posteriors

Parameters	Uninformative priors				Informative priors reflecting disbelief on effects			
	Mean	SD	*n_eff*	*Rhat*	Mean	SD	*n_eff*	*Rhat*

Constant	-1.18	0.62	5871	1	-1.36	0.45	4592	1
BioLossCost	-0.19	0.20	5268	1	-0.11	0.14	4632	1
*BioLossCost*UnrealBD*	0.33	0.21	7895	1	0.16	0.15	8424	1
*BioLossCost*InsignificantBD*	0.29	0.16	6975	1	0.18	0.13	7214	1

It can be seen from Table 2 that all the diagnostic statistics show a good signal of model convergence. In particular, the parameters' *n_eff* values are larger than 1,000, and *Rhat* values are equal to 1. The convergence of Markov chains can also be confirmed by the trace plots, Gelman plots, and autocorrelation plots. Figure 1 illustrates that all the Markov chains fluctuate stationarily around a central equilibrium, indicating the convergence of simulated samples after the warm-up period (before the 2,000th iteration). The Gelman shrink factors in the Gelman plots dropping rapidly to 1 and the decline of autocorrelation levels in autocorrelation are other signals warranting the convergence of Model 1 (see Figures 2 and 3, respectively).

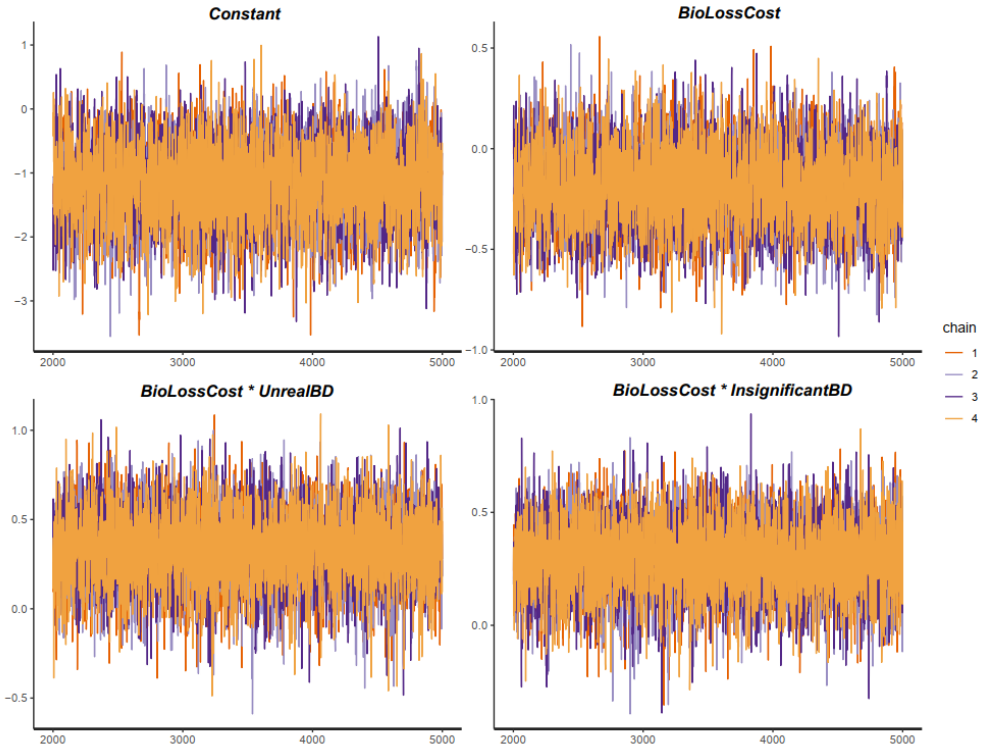

Figure 1: Model 1's trace plots

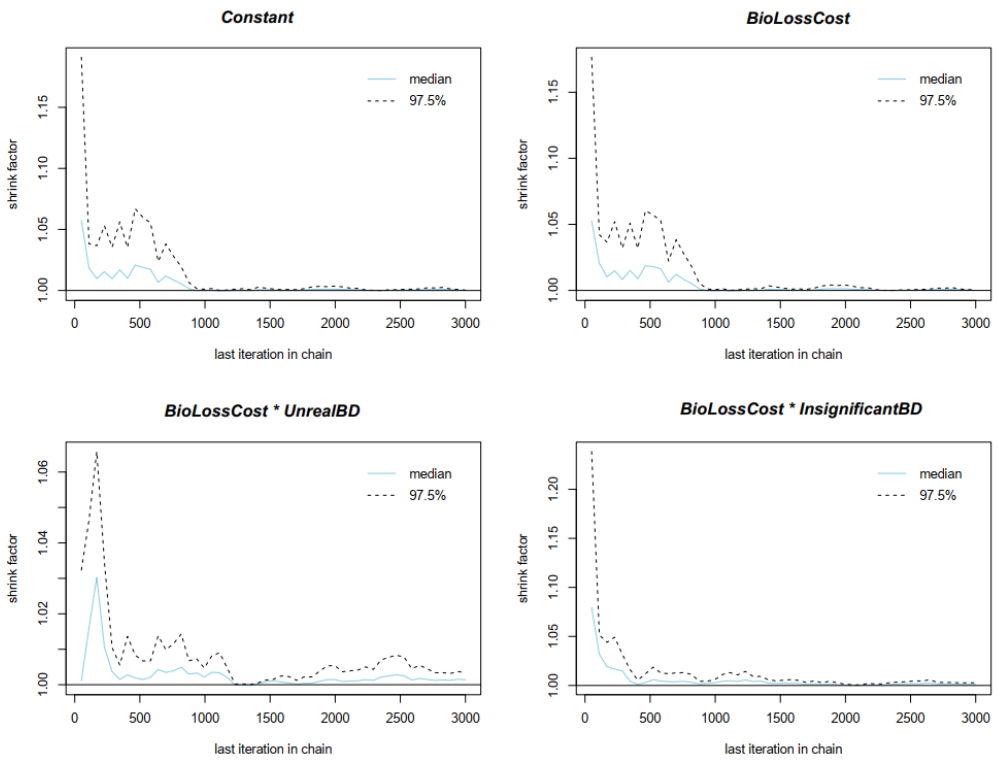

Figure 2: Model 1's Gelman plots

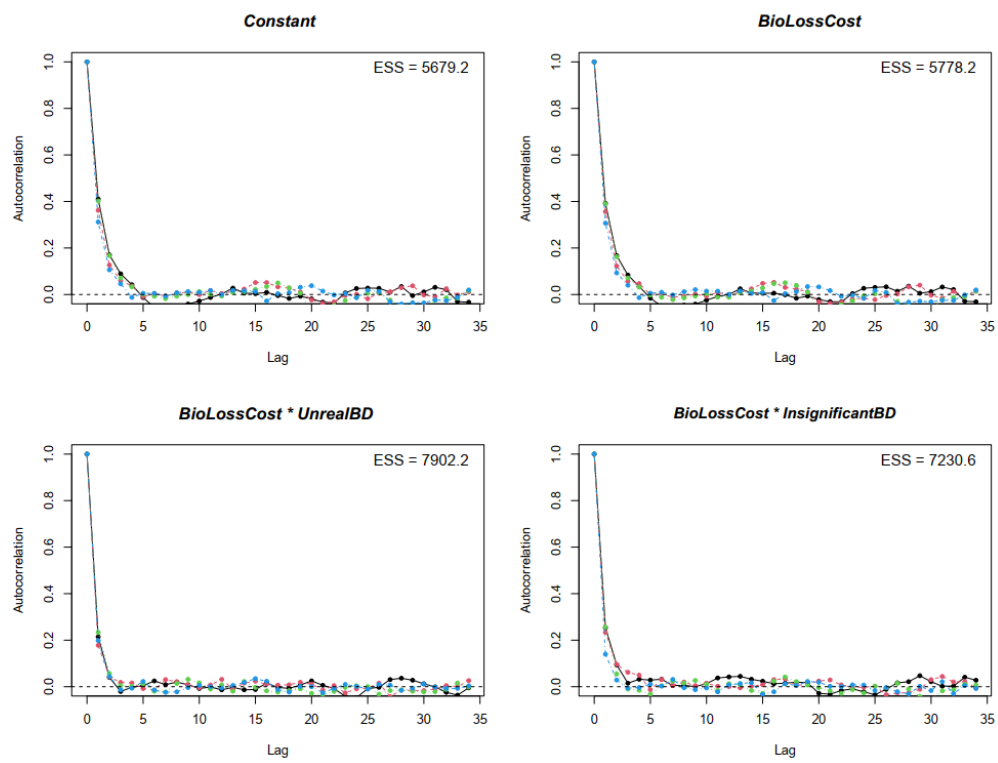

Figure 3: Model 1's autocorrelation plots

The estimated posterior results using uninformative priors show that *BioLossCost* has a negative impact on *SkinFurLike* ($\mu_{BioLossCost}$= -0.19 and $\sigma_{BioLossCost}$= 0.20), while *BioLossCost*UnrealBD* and *BioLossCost*InsignificantBD* have positive impacts on *SkinFurLike* ($\mu_{BioLossCost*UnrealBD}$= 0.33 and $\sigma_{BioLossCost*UnrealBD}$= 0.21; $\mu_{BioLossCost*InsignificantBD} = 0.29$ and $\sigma_{BioLossCost*InsignificantBD} = 0.16$). Figure 4 displays the posterior distributions of three coefficients. Specifically, although a large part of *BioLossCost*'s distribution lies on the negative side of the origin, a small proportion of it is still distributed on the positive side, indicating that the negative effect of *BioLossCost* on *SkinFurLike* only has moderate reliability. The absolute value of the parameter's mean and standard deviation also confirms the moderate reliability (0.19 compared to 0.20). In contrast, most of the distributions of *BioLossCost*UnrealBD* and *BioLossCost*InsignificantBD* are located on the positive side of the origin, suggesting the high reliability of the effects.

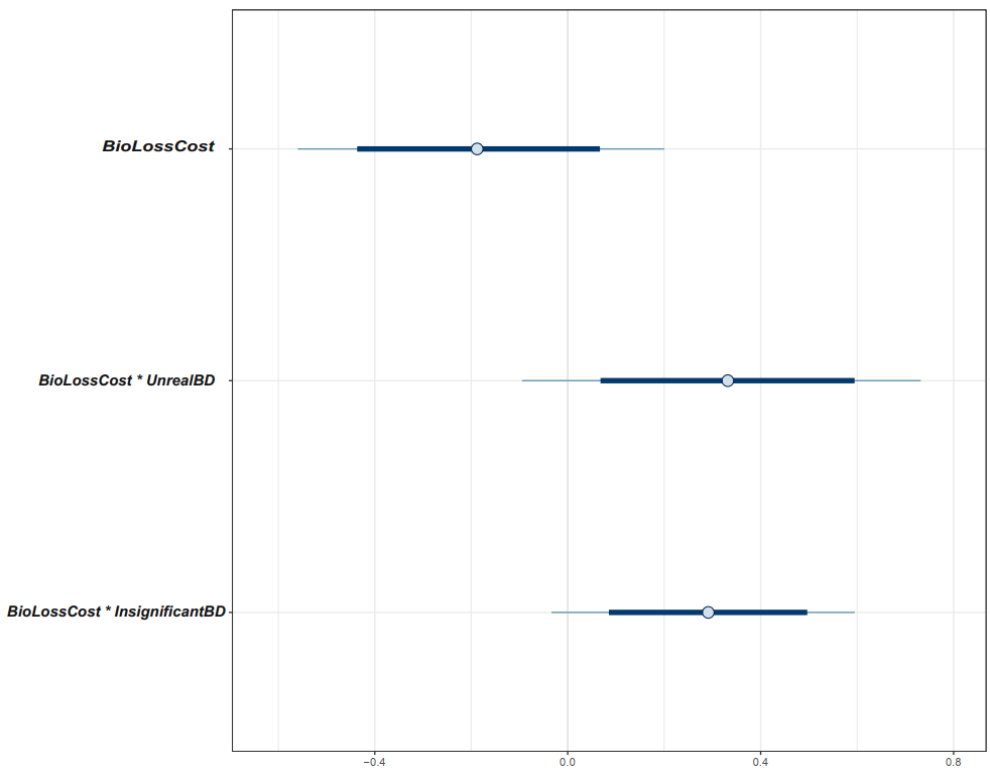

Figure 4: Posterior distributions of Model 1's parameters

When being simulated using informative priors reflecting our disbeliefs in the associations between predictor and outcome variables, the degrees of parameters' mean values decrease. Still, their patterns remain similar to the simulated results using uninformative priors. Therefore, it is plausible to say that the effects' patterns of *BioLossCost*, *BioLossCost*UnrealBD*, and *BioLossCost*InsignificantBD* are robust, or not sensitive to prior adjustment.

For interpretation of the estimated results, we calculated the probabilities of being interested in consuming products made from animal skin/fur. Because the outcome variable of Model 1 (*SkinFurLike*) is a binary variable, so we employed the probability calculation

method of the binary logit model for estimation. Moreover, as Bayesian analysis treats all parameters probabilistically, we selected the mean value of the distribution because it has the highest probability of happening. As a result, the logit model of Model 1 is as follows:

$$\ln\left(\frac{\pi_{Yes}}{\pi_{No}}\right) = -1.18 - 0.19 * BioLossCost + 0.33 * BioLossCost * UnrealBD + 0.29 * BioLossCost * InsignificantBD$$

From this model, we can estimate the empirical probability of being interested in consuming products made from animal skin/fur of people who believe biodiversity loss is unreal and strongly agree on the consequences of biodiversity loss by the following equation:

$$\pi_{Yes} = \frac{e^{(-1.18-0.19*BioLossCost+0.33*BioLossCost*UnrealBD+0.29*BioLossCost*InsignificantBD)}}{1+e^{(-1.18-0.19*BioLossCost+0.33*BioLossCost*UnrealBD+0.29*BioLossCost*InsignificantBD)}} = \frac{e^{(-1.18-0.19*4+0.33*4*1+0.29*4*0)}}{1+e^{(-1.18-0.19*4+0.33*4*1+0.29*4*0)}} = 0.35 = 35\%$$

Similar formulas were applied to other scenarios to visualize the probabilities of being interested in consuming products made from animal skin/fur displayed in Figure 5. In the scenarios where people believe biodiversity loss is not real or biodiversity loss is real but insignificant, the more they perceive the consequences of biodiversity loss, the higher probability of being keen on products made from animal skin/fur (green and blue lines, respectively). Moreover, people who do not believe in the existence of biodiversity loss have a greater likelihood of being interested in the products. In the scenario that people think biodiversity loss is real and a major problem, the more they perceive the consequences of biodiversity loss, the less preferable they are to products made from animal skin/fur (yellow line). In general, the effects of perceived biodiversity loss on the preference of consuming products made from animal skin/fur are divergent between people who deem biodiversity loss a major issue and those who do not.

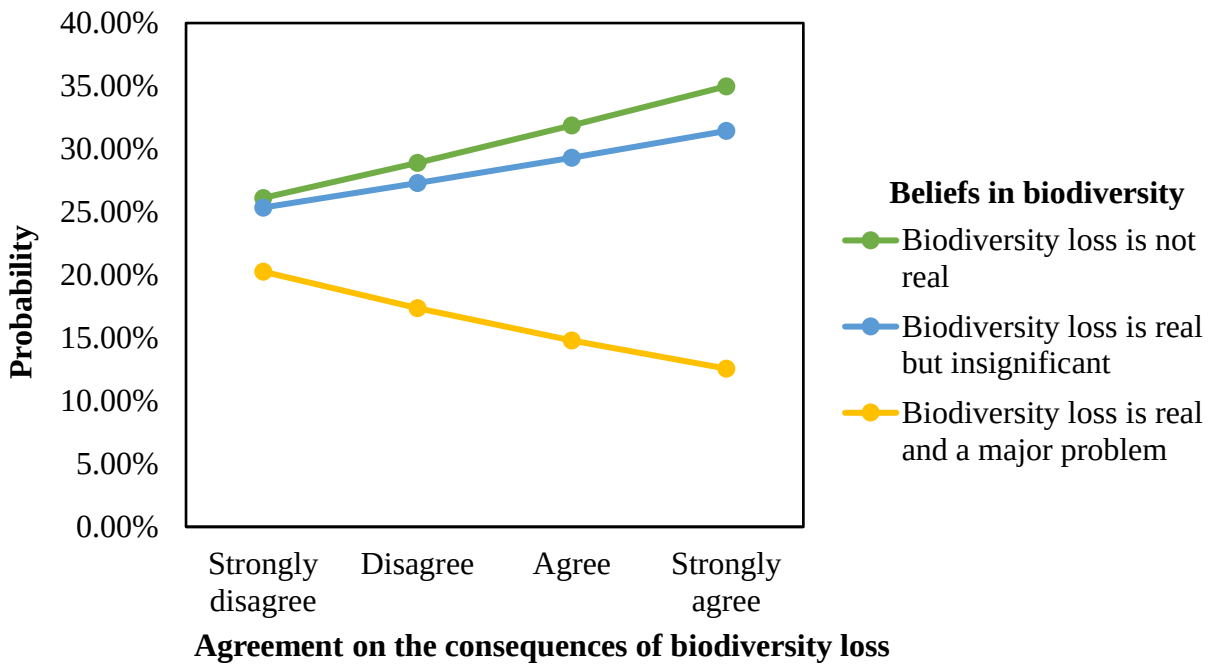

Figure 5: Probabilities of being interested in products made from animal fur and leather based on different biodiversity loss belief and perception scenarios

3.2. Model 2: Ownership of products made from skin/fur

Model 2 was fitted with the following setups of MCMC: 5,000 iterations, 2,000 warm-up iterations, and four Markov chains. The estimated posterior results of the model are presented in Table 3 together with their convergence diagnostic values.

Table 3: Model 2's simulated posteriors

Parameters	Uninformative priors				Informative priors reflecting disbelief on effects			
	Mean	SD	*n_eff*	*Rhat*	Mean	SD	*n_eff*	*Rhat*
Constant	1.15	0.12	6286	1	1.15	0.12	6821	1
BioLossCost	0.02	0.04	6273	1	0.02	0.04	6891	1
*BioLossCost*UnrealBD*	0.00	0.05	10202	1	0.00	0.05	10667	1
*BioLossCost*InsignificantBD*	0.12	0.04	9852	1	0.12	0.04	9724	1

The diagnostic values of Model 2 indicate a good convergence signal of the Markov chains. All parameters' *n_eff* values are higher than 6,000, and *Rhat* values are equal 1. The trace

plots (see Figure 6), Gelman plots (see Figure 7), and autocorrelation plots (see Figure 8) also confirm the convergence of the model simulation, suggesting that posterior results can be interpreted.

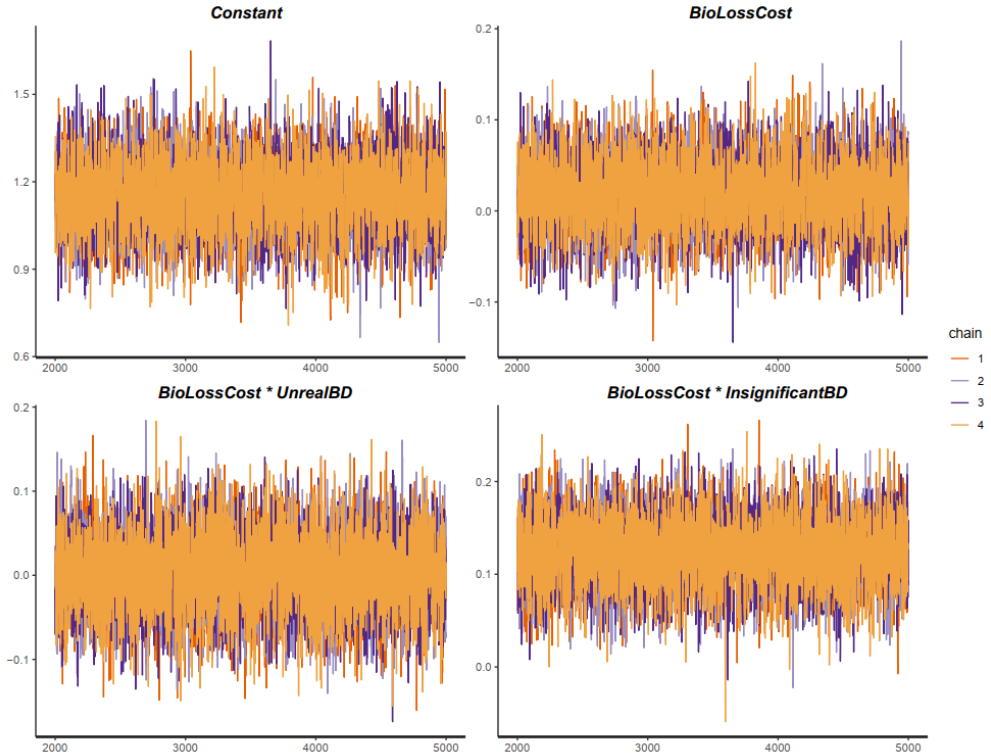

Figure 6: Model 2's trace plots

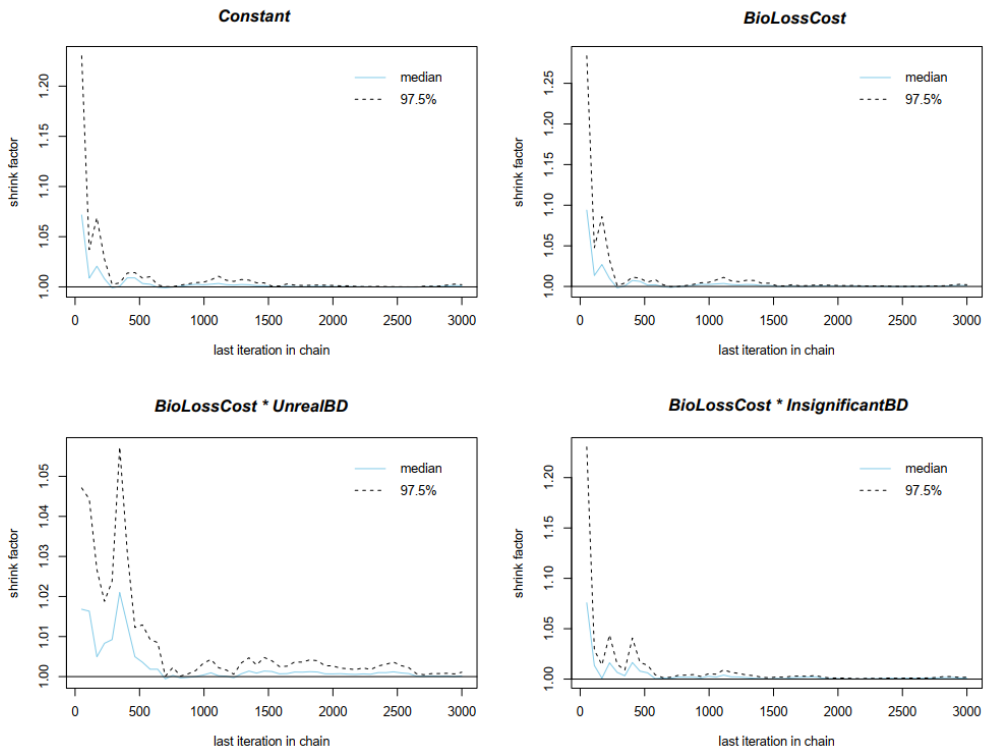

Figure 7: Model 2's Gelman plots

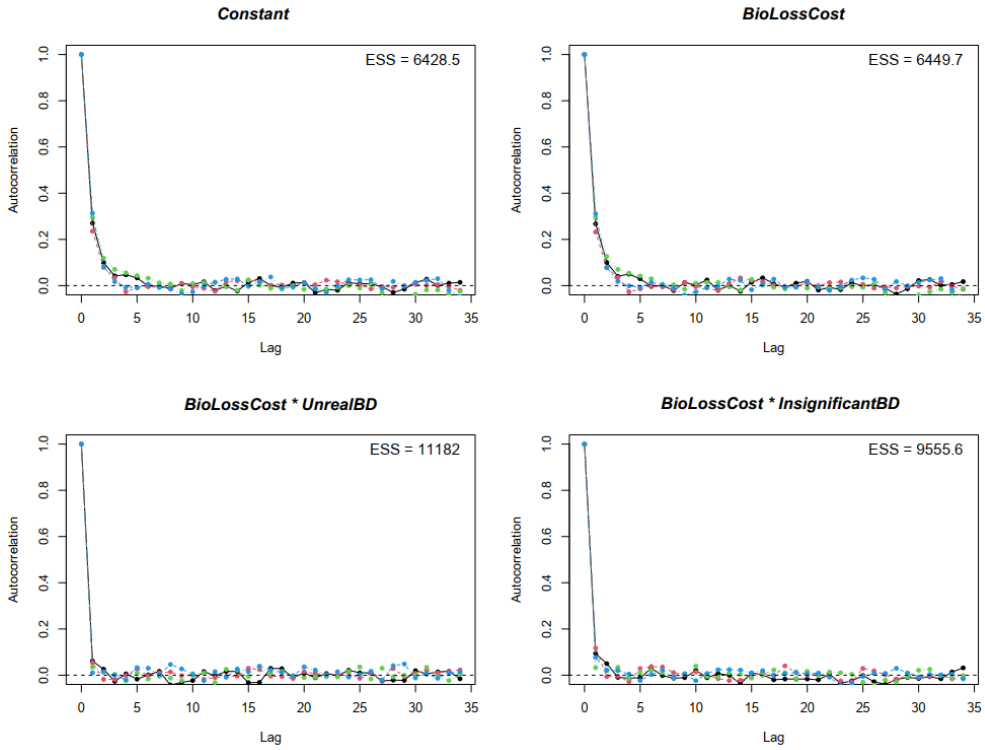

Figure 8: Model 2's autocorrelation plots

The analysis reveals that *BioLossCost*UnrealBD* has no impact on *SkinFurNum* ($\mu_{BioLossCost*UnrealBD}$= 0.00 and $\sigma_{BioLossCost*UnrealBD}$= 0.05). *BioLossCost* and *BioLossCost*InsignificantBD* are positively associated with *SkinFurNum* ($\mu_{BioLossCost}$= 0.02 and $\sigma_{BioLossCost}$= 0.04; $\mu_{BioLossCost*InsignificantBD}$= 0.12 and $\sigma_{BioLossCost*InsignificantBD}$= 0.04). These effects' patterns are robust even when the priors are modified to reflect our disbelief in the effects.

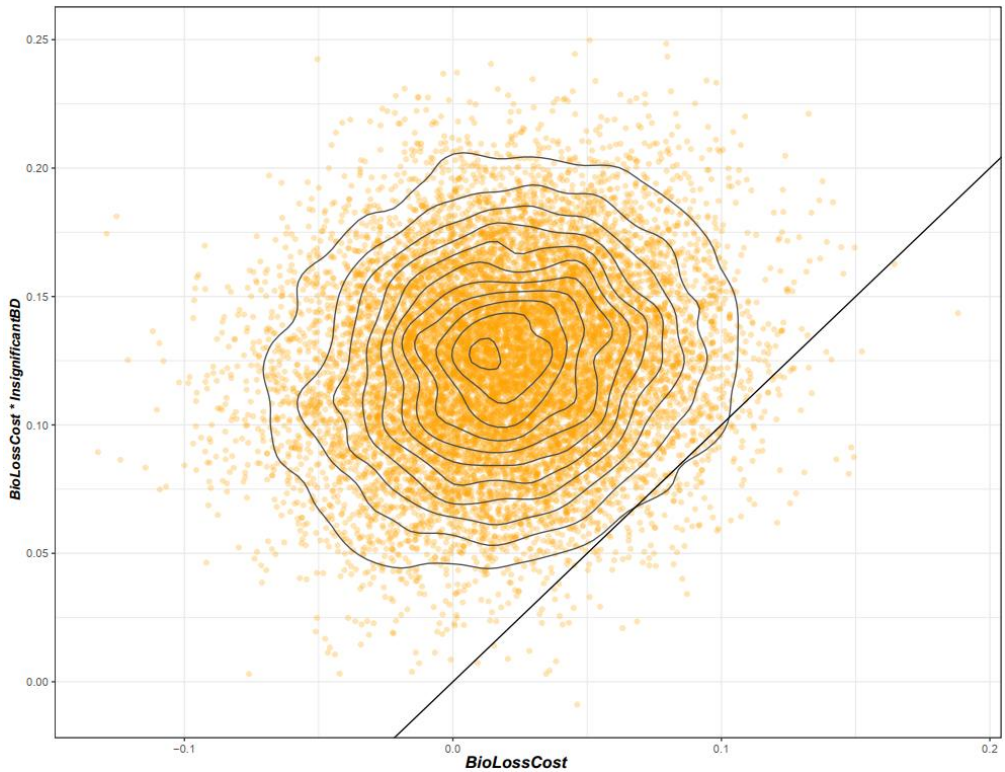

Figure 9: Model 2's two-dimensional density plot of *BioLossCost* and *BioLossCost*InsignificantBD*

The association between *BioLossCost* and *SkinFurNum* is not reliable as the coefficient's absolute mean value is much lower than the standard deviation value (0.02 compared to 0.04). In contrast, the association between *BioLossCost*InsignificantBD* is highly reliable, with the absolute mean value being three times higher than the standard deviation value (0.12 compared to 0.04). The reliability of both associations can be checked through their posterior distributions in Figure 9. Specifically, most of the simulated samples of *BioLossCost* are located around the origin of the *x*-axis, displaying an ambiguous pattern of *BioLossCost*'s effect on *SkinFurNum*. Meanwhile, almost all the simulated samples of *BioLossCost*InsignificantBD* are located on the positive side of the *y*-axis's origin, confirming that the effect is highly reliable.

For easier interpretation of the results, we plot the estimated number of owned products according to the urban residents' beliefs and perceptions about biodiversity loss consequences (see Figure 10). For people who believe biodiversity loss is not a significant issue, the more strongly they agree on the consequences of biodiversity loss, the more likely they are to own more products made from skin/fur (blue line). In contrast, for people who

believe in biodiversity loss as a major problem and those who do not believe in biodiversity loss, the number of owned products does not change according to the perception about biodiversity loss consequences (yellow line overlapping green line). In general, the divergent effects of perceived biodiversity loss consequences on the ownership exist between two groups of people:

1) People who believe in biodiversity loss but think that it is a small problem
2) People who believe in biodiversity loss and think that it is a big problem

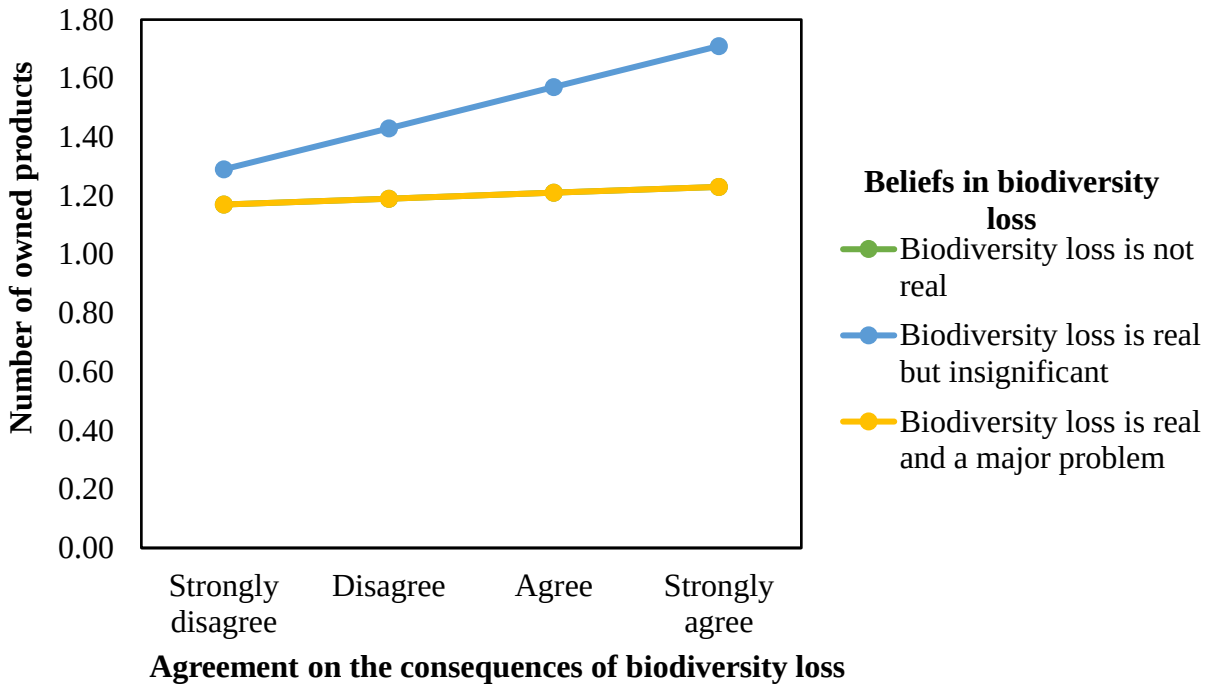

Figure 10: The number of owned products based on different biodiversity loss belief and perception scenarios

4. Discussion

The current study is the first study to examine the associations between biodiversity loss perception and personal preference, and actual ownership of Vietnamese urban residents. BMF analytics was performed on a dataset of 535 Vietnamese urban residents for conducting the study.

The results of Model 1 show that people's preference for using products made from animal skin/fur is negatively associated with perceived consequences of biodiversity loss. This is in alignment with other studies on the relationship between knowledge about the natural environment and pro-environmental attitudes (60-64). However, we found that if a person believes that biodiversity loss is not real or insignificant, the above effect is reversed. In other words, for those who do not believe in the actual existence or impacts of biodiversity loss, the more they agree with the consequences of biodiversity loss, the more they prefer fur/skin products. At first glance, this may appear counterintuitive, but it will become

plausible when we look at the urban residents' subjective cost-benefit evaluation involving the role of beliefs in relation to knowledge.

In a straightforward relationship, perceptions of negative consequences should make a person less likely to have a preference for behaviors that cause such impacts due to the perceived costs. However, this is only true if such consequences are already accepted as trusted values in one's mindset. In other words, one needs to believe in the value of a piece of knowledge for it to be properly used as a reference for the subsequent evaluation of related information (65). A piece of knowledge can be temporarily kept in the buffer zone of the mind waiting for further assessment (46). In this state, it does not establish influential links with other core values of one's mindset. In brief, perceived consequences of biodiversity loss without the belief of biodiversity loss are merely memorized information without subjective acceptance. As a simple analogy, think of a young student who memorizes a certain piece of knowledge only for the purpose of being able to recite them to the teacher. This information is not necessarily understood nor believed to be true by the student. Moreover, in the context of the present study, it is important to note that Vietnamese culture has a relatively high degree of cultural additivity, which makes it easier for people to keep new values in mind but does not create too much cognitive dissonance even with conflicting values (66, 67).

In people who do not believe in the existence or impacts of biodiversity loss, the more they absorb knowledge about the negative consequences of biodiversity loss in the buffer zone, the more likely cognitive dissonance is increased. When one's existing beliefs (trusted values) are not aligned with new values (which are not believed or poorly believed), being "bombarded" with pro-environmental information will likely backfire. Casually speaking, it is considered "fake news". The effect is quite similar to how perceived greenwashing causes skepticism and negative reactions in consumers (68, 69). Resemblance can also be found in how some people did not believe in COVID-19 and intended to carry out risky behaviors despite having heard of health information and warnings from official sources (70, 71). In such cases, those people are well-aware of the information, but they just do not believe it.

Our results in Model 1 also show that the moderating effect of complete disbelief is stronger than beliefs of insignificance, which is aligned with the presented reasoning. This indicates that the closer one's beliefs fit objective reality (here: biodiversity loss' impacts), the more one's perceptions align with the natural working of the ecosphere. An individual's subjective sphere of influence needs to have a low deviation from its corresponding objective sphere of influence (physical interactions) in order to develop a healthy, eco-friendly mindset – under the ecomindsponge framework (72). This aspect is one of the crucial points for shifting the core values within the collective mindset of human society into a more eco-surplus culture (73). On the other hand, stronger disbelief accompanied by more exposure to the disbelieved information likely reinforces one's perception of reality in the opposite direction. Differently speaking, cognitive dissonance can induce higher subjective sphere deviation. Thus, in the present study's case, such groups of people will have less perceived cost weighting against their preferences for using animal-based products.

However, the results in Model 2 show some inconsistencies with the patterns found in Model 1. The number of owned products made from animal fur/skin represents actual consumption (behavior) compared to personal preference (mental qualities). We found that

the perceived consequences of biodiversity loss do not significantly affect the degree of product consumption. Furthermore, the moderating effect of belief degrees on biodiversity loss' existence and impacts does not follow a pattern. Specifically, among people believing biodiversity loss is real but not a major impact, the higher the perceived consequences of biodiversity loss are, the greater the number of products the person owns. However, the association between biodiversity loss perception and product ownership does not exist among people believing biodiversity loss is not real.

There are several explanations for the inconsistent results of Model 2. Pro-environmental behaviors are multiplex, where influenced factors are unlikely to be examined fully (74). The information processes that produce consumption behaviors are likely to have more layers of cost-benefit-based filtering than consumption attitudes. Consumption behavior in the context of Vietnam, especially toward luxury goods, is influenced by many distinct sociocultural factors (e.g., Confucian values) as well as value perceptions of the young generations (75-77). Furthermore, there may be other "passive" reasons for product ownership, such as inheritance, received gifts, won prizes, etc. Furthermore, mental values in the form of thoughts need to reach certain individual-specific thresholds to become decisions to carry out corresponding behaviors (78). To have a clearer view of this issue, further studies delving into more detail about direct motives and circumstances for product ownership are necessary.

Policy implications

Our study suggests that while it is important to provide environmental knowledge and awareness to the public, doing so without considering the factor of personal belief will be unwise. At best, it may decrease the effectiveness of the environmental campaign. At worst, it may exacerbate the "information wars" against conspiracy theorists (e.g., climate deniers). Products made from genuine fur and leather are commonly regarded as luxury goods. In a society like Vietnam, where the perceptions of social status and appearances are a major part of the subjective cost-benefit judgments involving consumption, environmental knowledge and awareness may not be enough to drive people's attitudes and behaviors. But making people believe in something on a collective scale is difficult even with abundantly available scientific "facts" in this digital era. A high level of policy effectiveness requires a good understanding of the psychological mechanisms underlying people's behaviors. Therefore, instead of focusing on funding low-effective public awareness campaigns on environmental issues, governments should provide more support for fundamental research endeavors in social and environmental psychology, which will later improve the effectiveness of behavior change campaigns.

Limitations

Our study has some limitations. Considering the scope of this study, we cannot investigate deeper into how exactly perceptions and beliefs of biodiversity affect actual behaviors of consuming animal-based products. Since this information process can be highly complex, qualitative research with in-depth interviews is probably a good approach if future studies continue to explore this direction. Our study also only focuses on urban residents, where motives for using fur or leather products are unlikely to be body protection or other survival-based utilities but rather possessing luxury goods. Vietnam, however, has a lot of poor

regions where people may harvest animal skin and fur for basic purposes such as making warm clothes and bags. While this is not within the scope of the present study, future studies can compare these populations to gain more insights into the nature-human relationship in different living conditions.

References

1. Elwood RW (2022) Hermit crabs, shells, and sentience. *Anim Cogn*.
2. Brandt M & Mahsberg D (2002) Bugs with a backpack: the function of nymphal camouflage in the West African assassin bugs Paredocla andAcanthaspis spp. *Animal Behaviour* 63(2):277-284.
3. Hallett EY*, et al.* (2021) A worked bone assemblage from 120,000–90,000 year old deposits at Contrebandiers Cave, Atlantic Coast, Morocco. *iScience* 24(9).
4. Gilligan I (2018) *Climate, Clothing, and Agriculture in Prehistory: Linking Evidence, Causes, and Effects* (Cambridge University Press, Cambridge).
5. Le T-T (2022) Chapter 5: Natural and social survival: the drivers of serendipity. *A New Theory of Serendipity: Nature, Emergence and Mechanism*, ed Vuong Q-H (Sciendo), pp 75-90.
6. Csaba FF & Skjold E (2018) Fur and sustainability: Oxymoron or key to 'deeper' luxury? *Journal of Design, Business & Society* 4(2):131-149.
7. Rockström J*, et al.* (2009) Planetary boundaries: exploring the safe operating space for humanity. *Ecology and Society* 14(2).
8. Steffen W*, et al.* (2015) Planetary boundaries: Guiding human development on a changing planet. *Science* 347(6223).
9. World Wildlife Fund (2020) Living Planet Report 2020 - Bending the curve of biodiversity loss. eds Almond REA, Grooten M, & Petersen T (Gland, Switzerland).
10. Kolbert E (2014) *The sixth extinction: an unnatural history* (Henry Holt and Company, New York, NY) First edition Ed p 319.
11. Pievani T (2014) The sixth mass extinction: Anthropocene and the human impact on biodiversity. *Rend. Fis. Acc. Lincei* 25(1):85-93.
12. Cowie RH, Bouchet P, & Fontaine B (2022) The Sixth Mass Extinction: fact, fiction or speculation? *Biological Reviews* 97(2):640-663.
13. Aiama D, Carbone G, Cator D, & Challender DWS (2016) Biodiversity risks and opportunities in the apparel sector. (IUCN, Gland).
14. Opio C, Gerber P, & Steinfeld H (2012) Livestock and the environment: addressing the consequences of livestock sector growth. *Advances in Animal Biosciences* 2(3):601-607.
15. Luiselli L, Bonnet X, Rocco M, & Amori G (2012) Conservation Implications of Rapid Shifts in the Trade of Wild African and Asian Pythons. *Biotropica* 44(4):569-573.
16. Hughes AC (2021) Wildlife trade. *Current Biology* 31(19):R1218-R1224.
17. PETA (2008) Wool, Fur, and Leather: Hazardous to the Environment. in *PETA*.
18. Hansen É, de Aquim PM, & Gutterres M (2021) Environmental assessment of water, chemicals and effluents in leather post-tanning process: A review. *Environmental Impact Assessment Review* 89:106597.
19. Hutton M & Shafahi M (2019) Water Pollution Caused by Leather Industry: A Review. *ASME 2019 13th International Conference on Energy Sustainability collocated with the*

ASME 2019 Heat Transfer Summer Conference, (American Society of Mechanical Engineers, Bellevue, Washington, USA), p V001T010A002.

20. Gregory BRB*, et al.* (2022) Are fur farms a potential source of persistent organic pollutants or mercury to nearby freshwater ecosystems? *Science of The Total Environment* 833:155100.
21. Oude Munnink BB*, et al.* (2021) Transmission of SARS-CoV-2 on mink farms between humans and mink and back to humans. *Science* 371(6525):172-177.
22. Ramchandani M & Coste-Maniere I (2017) To Fur or not to Fur: Sustainable Production and Consumption Within Animal-Based Luxury and Fashion Products. *Textiles and Clothing Sustainability: Sustainable Fashion and Consumption,* Textile Science and Clothing Technology, ed Muthu SS (Springer, Singapore), pp 41-60.
23. Tapper S & Reynolds J (1996) The wild fur trade: historical and ecological perspectives. *The Exploitation of Mammal Populations*, eds Taylor VJ & Dunstone N (Springer Netherlands, Dordrecht), pp 28-44.
24. Madden TJ, Ellen PS, & Ajzen I (1992) A Comparison of the Theory of Planned Behavior and the Theory of Reasoned Action. *Pers Soc Psychol Bull* 18(1):3-9.
25. Ajzen I (1991) The theory of planned behavior. *Organizational Behavior and Human Decision Processes* 50(2):179-211.
26. Summers TA, Belleau BD, & Xu Y (2006) Predicting purchase intention of a controversial luxury apparel product. *Journal of Fashion Marketing and Management: An International Journal* 10(4):405-419.
27. Paul J, Modi A, & Patel J (2016) Predicting green product consumption using theory of planned behavior and reasoned action. *Journal of Retailing and Consumer Services* 29:123-134.
28. Jung HJ & Oh KW (2019) Exploring the Sustainability Concepts Regarding Leather Apparel in China and South Korea. *Sustainability* 11(19):5389.
29. Liu Y*, et al.* (2020) The importance of knowledge and trust for ethical fashion consumption. *Asia Pacific Journal of Marketing and Logistics* 33(5):1175-1194.
30. Shin DC & Jin BE (2021) Do fur coats symbolize status or stigma? Examining the effect of perceived stigma on female consumers' purchase intentions toward fur coats. *Fashion and Textiles* 8(1):10.
31. Challender DW, Harrop SR, & MacMillan DC (2015) Understanding markets to conserve trade-threatened species in CITES. *Biological Conservation* 187:249-259.
32. Zhang L & Yin F (2014) Wildlife consumption and conservation awareness in China: a long way to go. *Biodiversity and Conservation* 23(9):2371-2381.
33. Buijs AE, Fischer A, Rink D, & Young JC (2008) Looking beyond superficial knowledge gaps: Understanding public representations of biodiversity. *The International Journal of Biodiversity Science & Management* 4(2):65-80.
34. Nisiforou O & Charalambides AG (2012) Assessing undergraduate university students' level of knowledge, attitudes and behaviour towards biodiversity: a case study in Cyprus. *International Journal of Science Education* 34(7):1027-1051.
35. Şekercioğlu ÇH (2012) Promoting community-based bird monitoring in the tropics: Conservation, research, environmental education, capacity-building, and local incomes. *Biological Conservation* 151(1):69-73.

36. Tonin S & Lucaroni G (2017) Understanding social knowledge, attitudes and perceptions towards marine biodiversity: The case of tegnùe in Italy. *Ocean & Coastal Management* 140:68-78.
37. Vuong Q-H (2022) *Mindsponge Theory* (AISDL).
38. Vuong Q-H & Napier NK (2015) Acculturation and global mindsponge: an emerging market perspective. *International Journal of Intercultural Relations* 49:354-367.
39. Vuong Q-H, Le T-T, & Nguyen M-H (2022) Mindsponge mechanism: an information processing conceptual framework. *The mindsponge and BMF analytics for innovative thinking in social sciences and humanities*, eds Vuong Q-H, Nguyen M-H, & La V-P (De Gruyter), pp 21-46.
40. Vuong Q-H, Nguyen M-H, & La V-P (2022) *The mindsponge and BMF analytics for innovative thinking in social sciences and humanities* (De Gruyter).
41. Ministry of Natural Resources and Environment (2014) Vietnam fifth national report to the United Nations Convention on Biologival Diversity. (Vietnamese governments, Hanoi).
42. Andersson AA*, et al.* (2021) CITES and beyond: Illuminating 20 years of global, legal wildlife trade. *Global Ecology & Conservation* 26:e01455.
43. Nguyen M-H (2021) Multifaceted interactions between urban humans and biodiversity-related concepts: A developing-country dataset. *Data Intelligence* 3(4):578–605.
44. Brittain S*, et al.* (2020) Ethical considerations when conservation research involves people. *Conservation Biology* 34(4):925-933.
45. Kim Y, Dykema J, Stevenson J, Black P, & Moberg DP (2019) Straightlining: overview of measurement, comparison of indicators, and effects in mail–web mixed-mode surveys. *Social Science Computer Review* 37(2):214-233.
46. Nguyen M-H, La V-P, Le T-T, & Vuong Q-H (2022) Introduction to Bayesian Mindsponge Framework analytics: an innovative method for social and psychological research. *MethodsX* 9:101808.
47. Nguyen M-H, La V-P, Le T-T, & Vuong Q-H (2022) Bayesian Mindsponge Framework analytics: a novel methodological approach for social sciences and humanities. *The mindsponge and BMF analytics for innovative thinking in social sciences and humanities*, eds Vuong Q-H, Nguyen M-H, & La V-P (De Gruyter), pp 87-116.
48. Gill J (2014) *Bayesian methods: A social and behavioral sciences approach* (CRC press).
49. Wagenmakers E-J*, et al.* (2018) Bayesian inference for psychology. Part I: Theoretical advantages and practical ramifications. *Psychonomic bulletin review* 25(1):35-57.
50. Dunson DB (2001) Commentary: practical advantages of Bayesian analysis of epidemiologic data. *American journal of Epidemiology* 153(12):1222-1226.
51. Cowles MK (2013) *Applied Bayesian statistics: with R and OpenBUGS examples* (Springer Science & Business Media, New York).
52. Open Science Collaboration (2015) Estimating the reproducibility of psychological science. *Science* 349(6251).
53. Camerer CF*, et al.* (2018) Evaluating the replicability of social science experiments in Nature and Science between 2010 and 2015. *Nature Human Behaviour* 2(9):637-644.
54. Halsey LG, Curran-Everett D, Vowler SL, & Drummond GB (2015) The fickle P value generates irreproducible results. *Nature methods* 12(3):179-185.

55. Diaconis P & Ylvisaker D (1985) Quantifying prior opinion. *Bayesian Statistics*, eds Bernardo JM, DeGroot MH, Lindley DV, & Smith AFM (North Holland Press, Amsterdam), Vol 2, pp 133-156.
56. Vuong Q-H*, et al.* (2021) On the environment-destructive probabilistic trends: a perceptual and behavioral study on video game players. *Technology in Society* 65:101530.
57. Vuong Q-H, Nguyen M-H, & La V-P (2022) Updated protocol for performing BMF analytics using bayesvl. *The mindsponge and BMF analytics for innovative thinking in social sciences and humanities*, eds Vuong Q-H, Nguyen M-H, & La V-P (De Gruyter, Warsaw), pp 301-370.
58. Vuong Q-H*, et al.* (2020) Bayesian analysis for social data: A step-by-step protocol and interpretation. *MethodsX* 7:100924.
59. Vuong Q-H (2020) Reform retractions to make them more transparent. *Nature* 582:149.
60. Rajapaksa D, Islam M, & Managi S (2018) Pro-Environmental Behavior: The Role of Public Perception in Infrastructure and the Social Factors for Sustainable Development. *Sustainability* 10(4):937.
61. Geiger SM, Geiger M, & Wilhelm O (2019) Environment-Specific vs. General Knowledge and Their Role in Pro-environmental Behavior. *Frontiers in Psychology* 10.
62. Janmaimool P & Khajohnmanee S (2019) Roles of Environmental System Knowledge in Promoting University Students' Environmental Attitudes and Pro-Environmental Behaviors. *Sustainability* 11(16):4270.
63. Liu P, Teng M, & Han C (2020) How does environmental knowledge translate into pro-environmental behaviors?: The mediating role of environmental attitudes and behavioral intentions. *Science of the Total Environment* 728:138126.
64. Ienna M*, et al.* (2022) The Relative Role of Knowledge and Empathy in Predicting Pro-Environmental Attitudes and Behavior. *Sustainability* 14(8):4622.
65. Vuong Q-H, Le T-T, La V-P, & Nguyen M-H (2022) The psychological mechanism of Internet information processing for post-treatment evaluation. *Heliyon* 8(5):E09351.
66. Vuong Q-H*, et al.* (2018) Cultural additivity: behavioural insights from the interaction of Confucianism, Buddhism and Taoism in folktales. *Palgrave Communications* 4:143.
67. Nguyen M-H & Jones TE (2021) Predictors of support for a biodiversity loss countermeasure and bushmeat consumption among Vietnamese urban residents. *Conservation Science and Practice*:In Press.
68. Szabo S & Webster J (2021) Perceived Greenwashing: The Effects of Green Marketing on Environmental and Product Perceptions. *J Bus Ethics* 171(4):719-739.
69. Rahman I, Park J, & Chi CG-q (2015) Consequences of "greenwashing": Consumers' reactions to hotels' green initiatives. *International Journal of Contemporary Hospitality Management* 27(6):1054-1081.
70. Ullah I, Khan KS, Tahir MJ, Ahmed A, & Harapan H (2021) Myths and conspiracy theories on vaccines and COVID-19: Potential effect on global vaccine refusals. *Vacunas* 22(2):93-97.
71. Vuong Q-H*, et al.* (2022) Covid-19 vaccines production and societal immunization under the serendipity-mindsponge-3D knowledge management theory and conceptual framework. *Humanit Soc Sci Commun* 9:22.

72. Nguyen M-H & Le T-T (2022) Ecomindsponge theory: positioning humans in the ecosphere. *SM3D Portal*:84.
73. Vuong Q-H (2021) The semiconducting principle of monetary and environmental values exchange. *Economics and Business Letters* 10(3):284-290.
74. Kollmuss A & Agyeman J (2002) Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental Education Research* 8(3):239-260.
75. Jain S (2022) Factors influencing online luxury purchase intentions: the moderating role of bandwagon luxury consumption behavior. *South Asian Journal of Business Studies* ahead-of-print(ahead-of-print).
76. Le NTC & Quy VT (2020) Personal Values of Luxury Services Consumption: A Confucian Culture Perspective. *Journal of International Consumer Marketing* 32(4):300-312.
77. Ha N & Tam H (2015) Attitudes and Purchase Intention Towards Counterfeiting Luxurious Fashion Products in Vietnam. *International Journal of Economics and Finance* 7(11):p207.
78. Nguyen M-H*, et al.* (2021) Alice in Suicideland: Exploring the Suicidal Ideation Mechanism through the Sense of Connectedness and Help-Seeking Behaviors. *IJERPH* 18(7):3681.