What Leonardo DiCaprio has to say about nature-human nexus: The roles of biodiversity loss perception toward skin/fur product consumption

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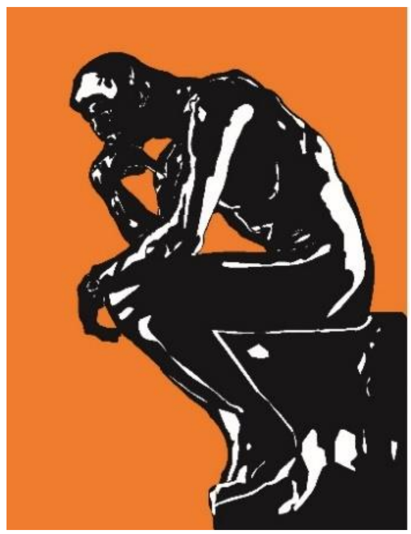

September 8, 2024

[*Original working draft v5* / *Un-peer-reviewed*]

"His love for all things beautiful aside, Kingfisher also wants to ensure his public image is well-received […]"

In "The Most Beautiful Bird"; *The Kingfisher Story Collection* (Vuong, 2022)

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 to construct conceptual models and employ Bayesian analysis aided by Markov Chain Monte Carlo (MCMC) algorithms on a 535 Vietnamese urban residents dataset. The results show that people's preference for using products made from animal skin/fur is negatively associated with the perceived consequences of biodiversity loss when they believe biodiversity loss is 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 were 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

The 2015 American movie "The Revenant," starring Leonardo DiCaprio as fur trapper Hugh Glass, depicts the hardship of early colonists in the New World during the 19th century. The 1820s fur-trading expedition aimed for pelts, especially from beavers, in order to trade with Europeans for essential goods. It can be said that beaver pelts were crucial to the survival of these early American colonists (Dolin, 2010). The movie shows the life-and-death struggles of Glass in the wilderness after being mauled by a grizzly bear. At one point, Glass had to eviscerate a dead horse to take shelter inside its carcass. While the pelts saved the early colonists on a collective level, the skin of the horse saved Glass's life on an individual level. What was the perceived value of nature in the mind of Glass and the collective mind of American society at that time? Fast forwarding to the late 20th century, the People for the Ethical Treatment of Animals (PETA) was founded in the United States and has been fighting against the unsustainable harvesting and use of animal fur/skin. Leonardo DiCaprio himself has spent a large portion of his life promoting better environmental awareness in the public, including biodiversity protection and sustainability. In our complex relationship with nature, what are the thinking pathways regarding using animal-based products related to perceptions of biodiversity?

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. As a familiar example in the animal kingdom, hermit crabs are well-known for their behavior of seeking and using empty mollusk shells.

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 (Hallett et al., 2021). 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 (Gilligan, 2018).

Besides natural survival, humans in complex societies also innovate for social survival purposes (Le, 2022). 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 (Csaba & Skjold, 2018). 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

While the usage of animal-based products is not inherently good or bad, harvesting and consuming in an unsustainable manner can be problematic in the long term (Nguyen & Jones, 2022b). People's perceptions of pro-environmental values are influenced by an eco-surplus culture, which in turn determines their willingness to carry out pro-environmental behaviors (Nguyen & Jones, 2022a). Oppositely, an eco-deficit mindset disregards the value of the natural environment and often leads to unsustainable behaviors.

Although biosphere integrity (which is determined by the rate of biodiversity loss) is one of two core planetary boundaries (Rockström et al., 2009) that are acknowledged as being essential to the Earth system (Steffen et al., 2015), 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 (World Wildlife Fund, 2020). 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 (Aiama et al., 2016; Cowie et al., 2022; Kolbert, 2014; Pievani, 2014).

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 (Aiama et al., 2016). For example, the demand for leather products exerts a substantial demand on the livestock sector (e.g., cow farming) (Aiama et al., 2016). 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 (Opio et al., 2012). Meanwhile, poaching and trading wild animal for fashion products is a major driver of species decline. Although most animals used in fashion are captive-bred (e.g., crocodiles), some species are caught mostly in the wild, such as monitor lizards and pythons (Hughes, 2021; Luiselli et al., 2012). Among 100 million animals reared and killed yearly for the fur trade, 15% are wildsourced. 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 (Hughes, 2021).

Directly harvesting animal skin and fur as raw inputs threatens exotic wild animals' livelihood, reduces biodiversity levels, and creates other environmental impacts through product processing (PETA, 2008). For example, the industrial leather tanning process discharges a large amount of poorly biodegradable toxic wastewater (Hansen et al., 2021; Hutton & Shafahi, 2019). 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 (Gregory et al., 2022). This type of intense animal farming also carries high risks of infectious diseases for animals and humans, such as the SARS-CoV-2 infection outbreaks in mink farms during the COVID-19 pandemic (Oude Munnink et al., 2021).

Overall, the current industrial system of making products from animal skin and fur is unsustainable, including some practices considered not only ethically questionable but also environmentally harmful (PETA, 2008). 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 (Ramchandani & Coste-Maniere, 2017). 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 (Tapper & Reynolds, 1996).

1.2. Psychosocial 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 (Ajzen, 1991; Madden et al., 1992).

For example, applying TRA to consumer behavior toward apparel made from alligator leather – a controversial luxury product, Summers et al. (2006) 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 et al. (2016) 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 (Jung & Oh, 2019). In a similar model of reasoning, it is shown that social pressure is likely the most dominant factor in forming consumers' purchase intention in an ethical fashion. At the same time, trust and knowledge also play important roles (Y. Liu et al., 2020). Such sociopsychological influence may not be straightforward. 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 (Shin & Jin, 2021).

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 et al., 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 (Challender et al., 2015; Zhang & Yin, 2014). 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 (Buijs et al., 2008; Nisiforou & Charalambides, 2012; Şekercioğlu, 2012; Tonin & Lucaroni, 2017). Thus, examining how perceptions of biodiversity influence people's purchase behavior toward animal-based products can be a helpful approach.

On the front of policymaking and social campaigns, certain obstacles hinder effective communication efforts. Research shows that while pro-environmental education for animal-product consumption is important, political, cultural, and individual preferences strongly influence understanding subjective perceptions to avoid value conflicts (Lindgren, 2020; Petroman et al., 2015). Interventions regarding animal-product consumption in the form of food often focus on the aspect of information, particularly knowledge of environmental impacts (Petroman et al., 2015). However, communication about the perceived sustainability and naturalness of animal-based products to the public can be distorted through manipulative marketing schemes by those who sell such products (Borkfelt et al., 2015). Besides, policies promoting sustainable consumption of animal-based products are often undermined by old social norms and local cultural values in some developing countries (Nguyen & Jones, 2022b).

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 the mindsponge theory (Vuong, 2023; Vuong & Napier, 2015) 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.

1.3.1. Overview of the mindsponge theory and the information filtering process

The mindsponge mechanism was originally proposed to examine how the mind filters information in the context of acculturation, taking in values deemed beneficial and ejecting those deemed negative or no longer needed, analogous to a sponge filtering water (Vuong & Napier, 2015). Mindsponge was later developed into a more general and dynamic theory of information processing in the human mind (Vuong, 2023; Vuong & Nguyen, 2024a, 2024b).

The mindsponge mechanism suggests that for information to appear in the human mind and affect subsequent thinking and behaviors, it must pass through the mind's subjective cost-benefit judgments (Vuong, Nguyen, et al., 2022a). Specifically, information is ejected from the mind if perceived as costly and absorbed into the mind if perceived as beneficial (Vuong et al., 2023). Mindset changes are caused by incorporating new information evaluated as beneficial and rejecting information conflicting with the current core values or old information evaluated as irrelevant. To acclimate to a constantly shifting living environment, a person's core set of values is perpetually modified. The information filtering system in the mind is enabled by and follows the biological principles of neuroplasticity (Costandi, 2016; Eagleman, 2015). This allows for flexible and dynamic adaptation based on cognitive functions.

A mindsponge filtering process can be summarized as follows: 1) information from the external environment or retrieved from memory is temporarily stored as working memory during the evaluation process; 2) the decision for acceptance or rejection of this information is based on the subjective cost-benefit judgments on its attached values in relation to the current mindset; 3) if the information is accepted, it is integrated into the mindset and can influence the evaluation of future related information. The mindsponge theory also expands more into the nature-human interactions under the ecomindsponge concept (Nguyen et al., 2023). This provides a closer view of the information filtering process from the perspective of subjective sphere optimization, meaning to fit one's subjective influences to their objective counterparts. In other words, the mind tries to adapt and aligns its values to reality, although deviation can happen during the process, and the approach in terms of intention can also affect the intensity and speed of filtering.

1.3.2. Research question formulation

Based on the principles of information processing, 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, 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 (Vuong, Nguyen, et al., 2022a). 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 where 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) (Ministry of Natural Resources and Environment, 2014). 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 (Andersson et al., 2021). Thirdly, the association between urban residents' perception and 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 (Nguyen, 2021). 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 (Brittain et al., 2020). 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 (2021) 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) (Kim et al., 2019).

Most 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. Model construction, analysis method, and statistical validation

The current study employed the Bayesian Mindsponge Framework (BMF) analytics, which incorporates mindsponge-based thinking and the statistical power of Bayesian inference (Nguyen et al., 2022). 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 (Gill, 2014), allowing us to focus solely on estimating models containing the issues of interest (Nguyen et al., 2022). Moreover, thanks to the development of computational power, Bayesian inference is 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 (Cowles, 2013; Dunson, 2001; Wagenmakers et al., 2018). 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 (Camerer et al., 2018; Open Science Collaboration, 2015). Ronald Fisher developed the p-value to aid the judgment of whether we should doubt the null hypotheses. Still, 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 et al. (2015), scientists should avoid making binary judgments 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 (Diaconis & Ylvisaker, 1985). Besides, we performed the "prior-tweaking" technique to test the robustness of the posterior results when priors are adjusted (Vuong et al., 2021). The informative prior employed in this study is the normal distribution with a mean of 0 and deviation of 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 present study, two models for statistical analyses were constructed using five variables following the research question conceptualization stated in the Introduction section.

$$SkinFurLike \sim normal(\mu, \sigma) \tag{1.1}$$

$$\mu_i = \beta_0 + \beta_{BioLossCost} * BioLossCost_i + \beta_{BioLossCost*UnrealBD} * BioLossCost_i * UnrealBD_i + \beta_{BioLossCost*InsignificantBD} * BioLossCost_i * InsignificantBD_i \tag{1.2}$$

$$\beta \sim normal(M, S) \tag{1.3}$$

$$SkinFurNum \sim normal(\mu, \sigma) \tag{2.1}$$

$$\mu_i = \beta_0 + \beta_{BioLossCost} * BioLossCost_i + \beta_{BioLossCost*UnrealBD} * BioLossCost_i * UnrealBD_i + \beta_{BioLossCost*InsignificantBD} * BioLossCost_i * InsignificantBD_i \tag{2.2}$$

$$\beta \sim normal(M, S) \tag{2.3}$$

For the outcome variables *SkinFurLike* and *SkinFurNum*, the probability around μ is in the form of a normal distribution with standard deviation σ. Each model has an intercept β_0 and coefficients $\beta_{BioLossCost}$, $\beta_{BioLossCost*UnrealBD}$, and $\beta_{BioLossCost*InsignificantBD}$. For the coefficients, the probability around M is also in the form of a normal distribution, with a standard deviation S.

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. In contrast, 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 (Vuong et al., 2020; Vuong, Nguyen, et al., 2022b). 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 promoting 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 (Vuong, 2018, 2020): *[redacted for peer review purposes]*.

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 into one dimension (or variable).	Numerical	1. Strongly disagree 2. Disagree 3. Agree 4. Strongly agree
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 for 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. We will use the estimated results using uninformative priors to limit subjective influences for interpretation. The estimated results using 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 Appendix, Figures A1 and A2, respectively).

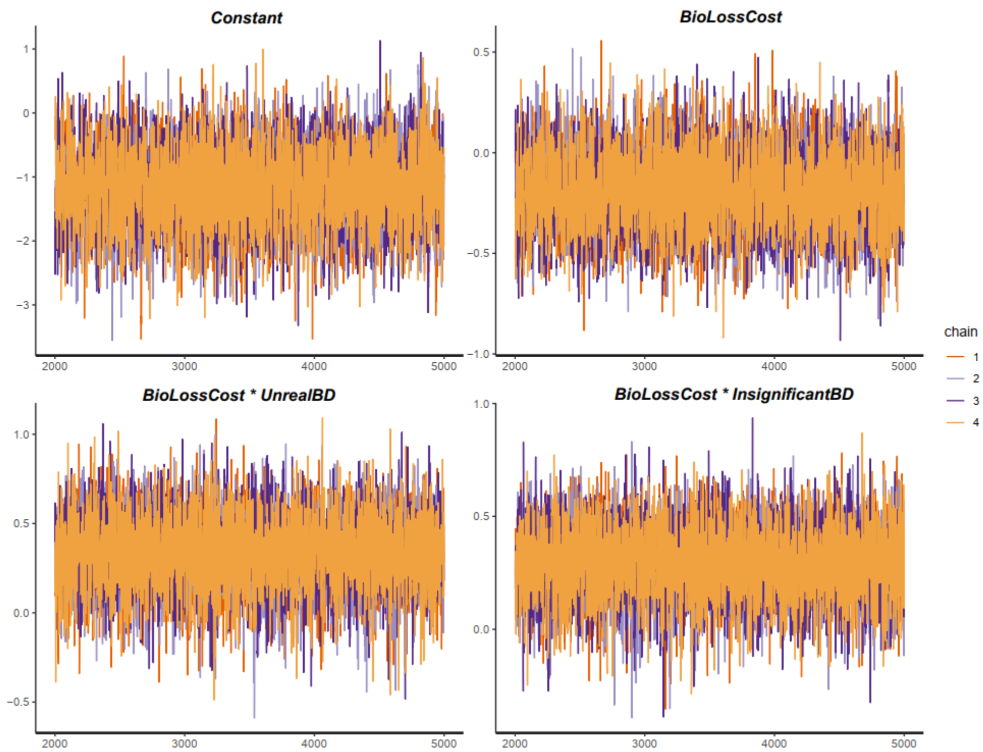

Figure 1: Model 1's trace plots

The estimated posterior results using uninformative priors show that *BioLossCost* has a negative impact on *SkinFurLike* ($M_{BioLossCost}$= -0.19 and $S_{BioLossCost}$= 0.20), while *BioLossCost*UnrealBD* and *BioLossCost*InsignificantBD* have positive impacts on *SkinFurLike* ($M_{BioLossCost*UnrealBD}$= 0.33 and $S_{BioLossCost*UnrealBD}$= 0.21; $M_{BioLossCost*InsignificantBD}$ = 0.29 and $S_{BioLossCost*InsignificantBD}$ = 0.16). Figure 2 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.

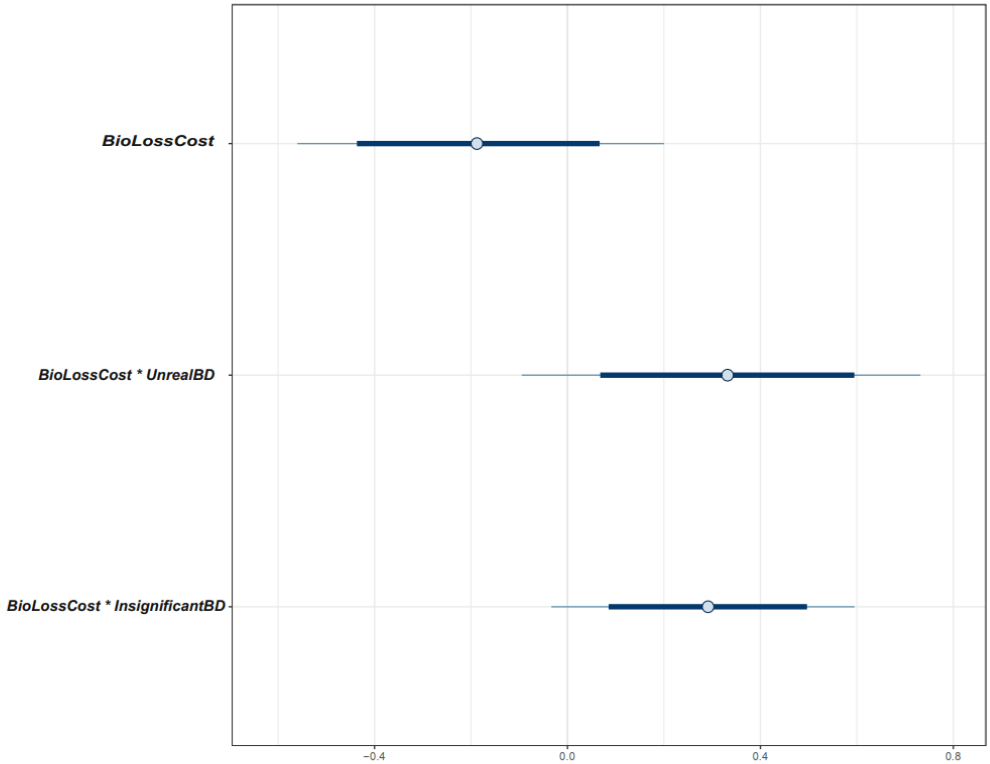

Figure 2: Posterior distributions of Model 1's parameters

When simulated using informative priors reflecting our disbelief 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 that the effects' patterns of *BioLossCost*, *BioLossCost*UnrealBD*, and *BioLossCost*InsignificantBD* are robust or not sensitive to prior adjustment.

We calculated the probability of being interested in consuming animal skin/fur products to interpret the estimated results. Because the outcome variable of Model 1 (*SkinFurLike*) is binary, 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:

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

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:

$$\pi_{Yes} = \frac{e^{(-1.18-0.19\times BioLossCost+0.33\times BioLossCost\times UnrealBD+0.29\times BioLossCost\times InsignificantBD)}}{1+e^{(-1.18-0.19\times BioLossCost+0.33\times BioLossCost\times UnrealBD+0.29\times BioLossCost\times InsignificantBD)}}$$

$$= \frac{e^{(-1.18-0.19\times 4+0.33\times 4*1+0.29\times 4\times 0)}}{1+e^{(-1.18-0.19\times 4+0.33\times 4\times 1+0.29\times 4\times 0)}} = 0.35 = 35\%$$

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 3. In the scenarios where people believe biodiversity loss is not real or it is real but insignificant, the more they perceive the consequences of biodiversity loss, the higher the 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). The effects of perceived biodiversity loss on the preference for consuming products made from animal skin/fur are divergent between people who deem biodiversity loss a major issue and those who do not.

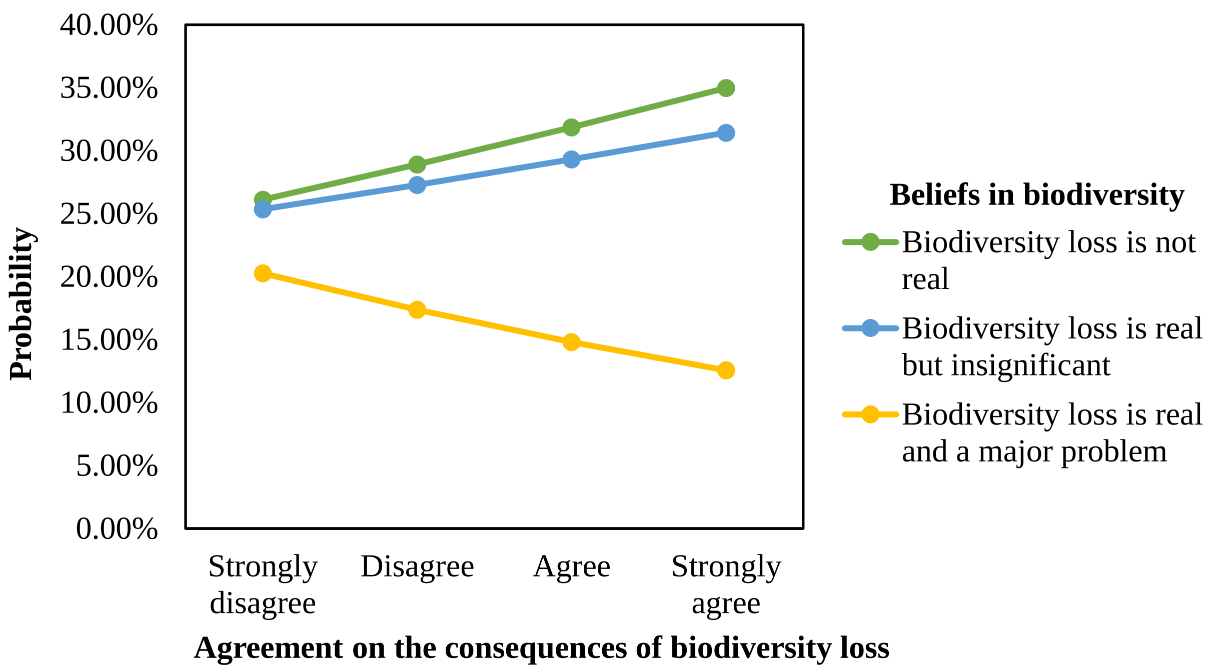

Figure 3: Estimated probabilities of being interested in products made from animal fur and leather-based on different biodiversity loss belief and perception scenarios

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 equal 1. The trace plots (see Figure 4), Gelman plots (see Appendix, Figure A3), and autocorrelation plots (see Appendix, Figure A4) also confirm the convergence of the model simulation, suggesting that posterior results can be interpreted.

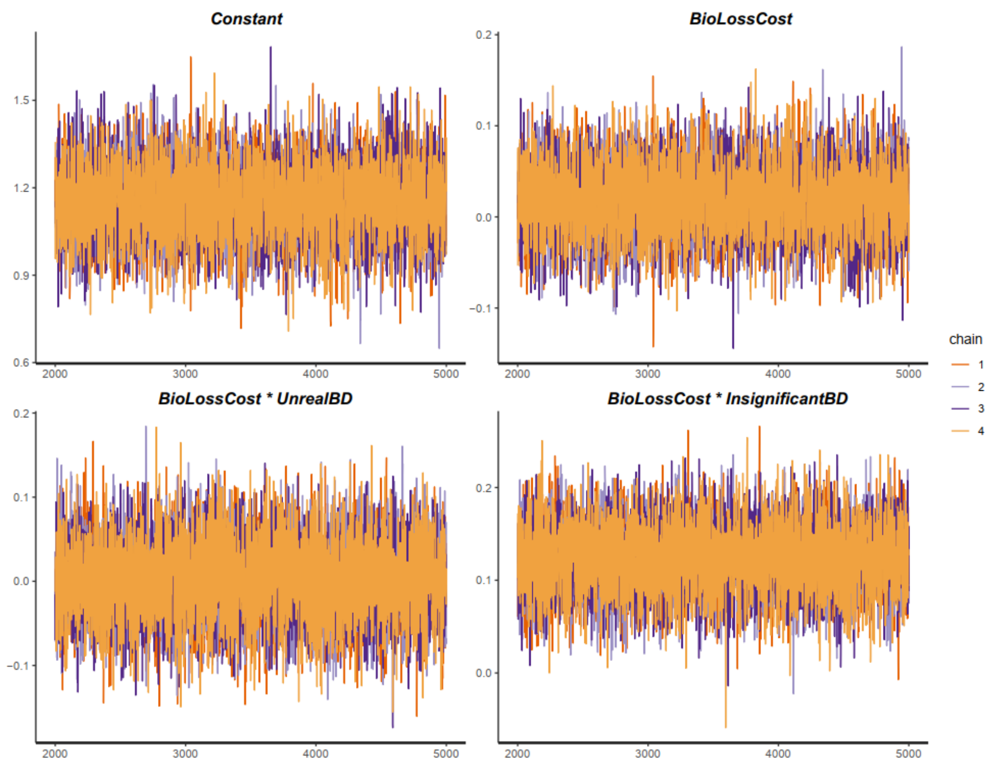

Figure 4: Model 2's trace plots

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

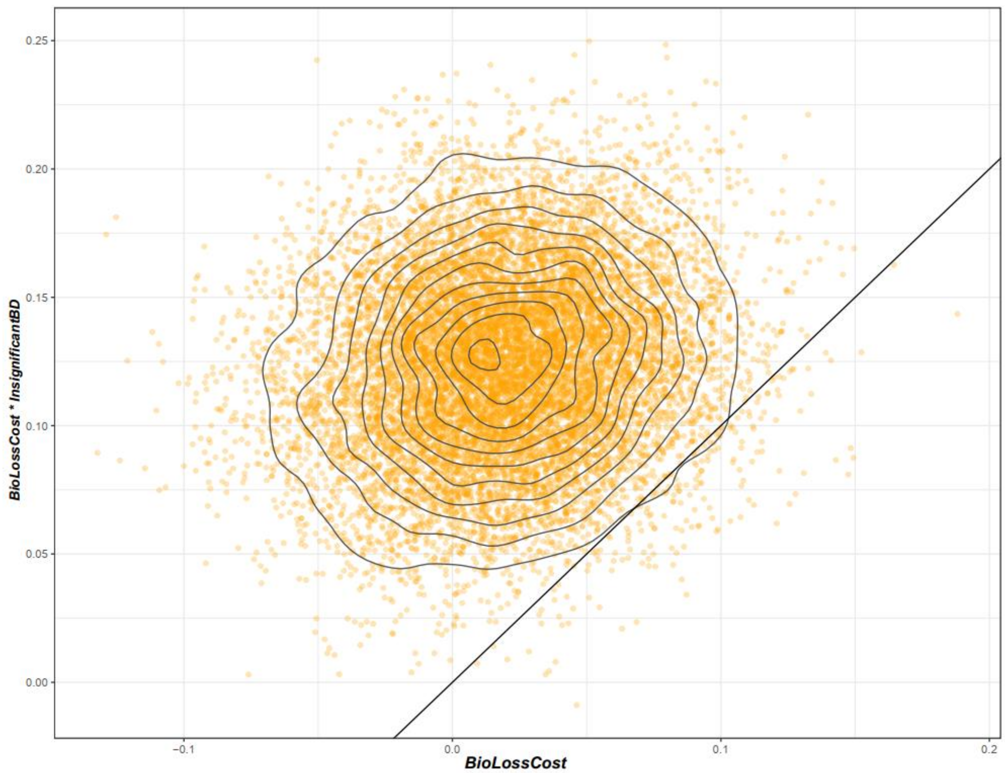

Figure 5: Model 2's two-dimensional density plot of *BioLossCost* and *BioLossCost*InsignificantBD*

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 5. 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 6). 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 of 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

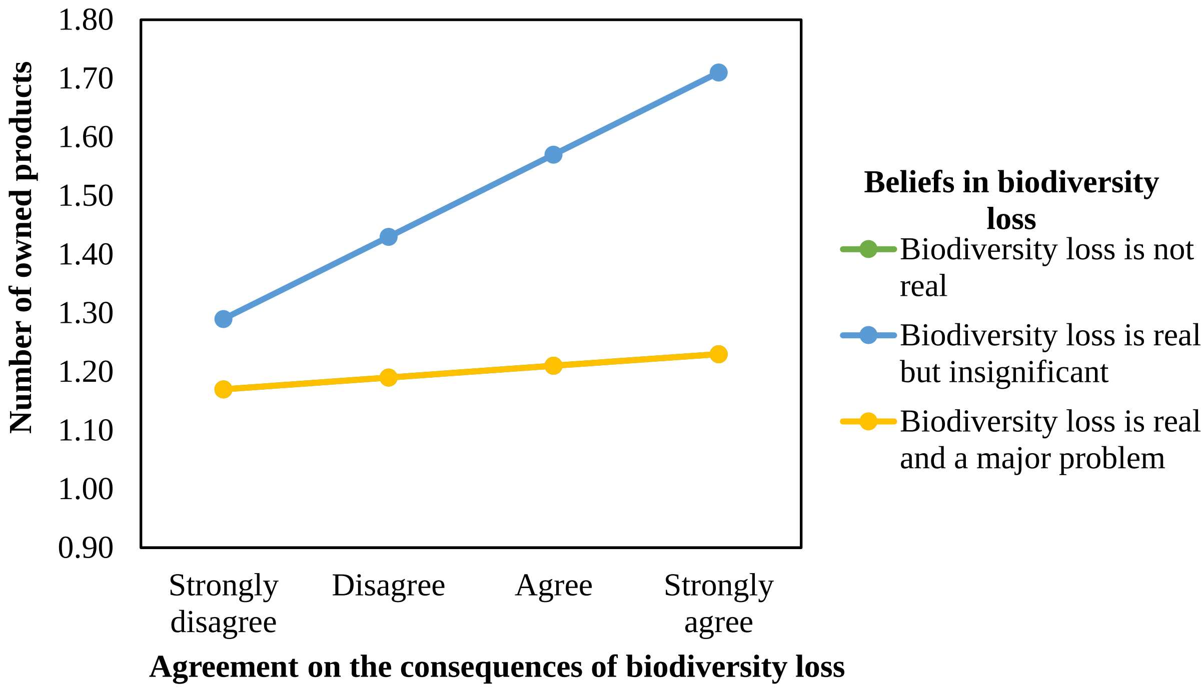

Figure 6: The estimated number of owned products based on different biodiversity loss belief and perception scenarios

4. Discussion

The current study is the first to examine the associations between biodiversity loss perception, 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 aligns with other studies on the relationship between knowledge about the natural environment and pro-environmental attitudes (Geiger et al., 2019; Ienna et al., 2022; Janmaimool & Khajohnmanee, 2019; P. Liu et al., 2020; Rajapaksa et al., 2018). 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 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 to be properly used as a reference for the subsequent evaluation of related information (Vuong, Le, La, & Nguyen, 2022). A piece of knowledge can be temporarily kept in the buffer zone of the mind waiting for further assessment (Nguyen et al., 2022). 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 (Nguyen & Jones, 2022b; Vuong et al., 2018).

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 similar to how perceived greenwashing causes skepticism and negative reactions in consumers (Rahman et al., 2015; Szabo & Webster, 2021). 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 (Ullah et al., 2021; Vuong, Le, La, Nguyen, et al., 2022). In such cases, those people are well aware of the information but 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 must have a low deviation from its corresponding objective sphere of influence (physical interactions) to develop a healthy, eco-friendly mindset – under the ecomindsponge framework (Nguyen et al., 2023). 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 (Vuong, 2021). 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 (Kollmuss & Agyeman, 2002). The information processes that produce consumption behaviors will likely have more cost-benefit-based filtering layers than consumption attitudes. Consumption behavior in the context of Vietnam, especially toward luxury goods, is influenced by many distinct socio-cultural factors (e.g., Confucian values) as well as value perceptions of the young generations (Ha & Tam, 2015; Jain, 2022; Le & Quy, 2020). Furthermore, other "passive" reasons for product ownership may exist, 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 (Nguyen et al., 2021). To have a clearer view of this issue, further studies delving into more detail about direct motives and circumstances for product ownership are necessary.

Implications for policies and science

Our study suggests that while providing environmental knowledge and awareness to the public is important, 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. As presented in this article, a better understanding of the psychological pathways in terms of information processes can help increase the effectiveness of incorporating positive values into pro-environmental behaviors in marketing campaigns aiming at promoting mindful consumption (Gupta et al., 2023; Lim, 2016). 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.

With the current progress of our societies, the value of animal skin and fur to human life and death is no longer obvious, like when humans had to strive to survive in the wilderness. Socio-cultural and economic elements now shape their values. But are those values really worth the "dying" of the natural world? This question might be not only ours but also of those whose lifetime accomplishment is attached to nature, like Leonardo DiCaprio (e.g., Leonardo DiCaprio Foundation since 1998). Therefore, more support for fundamental research endeavors in social and environmental psychology should be provided, as they will shed light on the beliefs and value systems of the human-nature nexus underlying our societies and lead to evidence-based humanity where scientific values meet humanistic values.

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 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. However, Vietnam has many 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.

Appendix

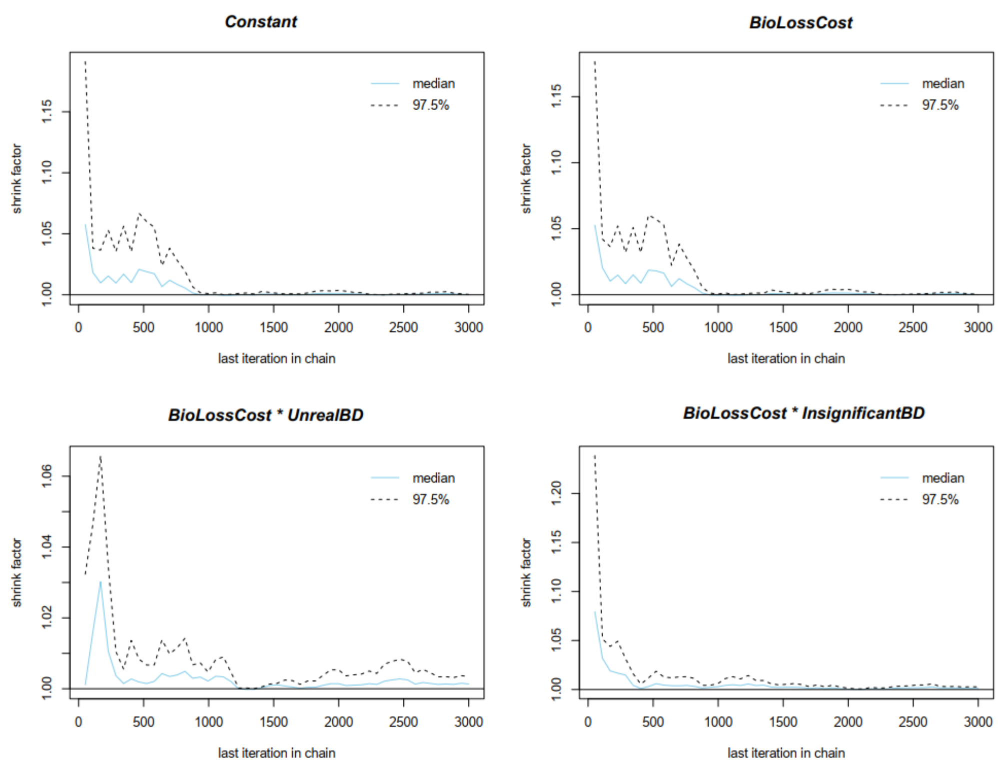

Figure A1: Model 1's Gelman plots

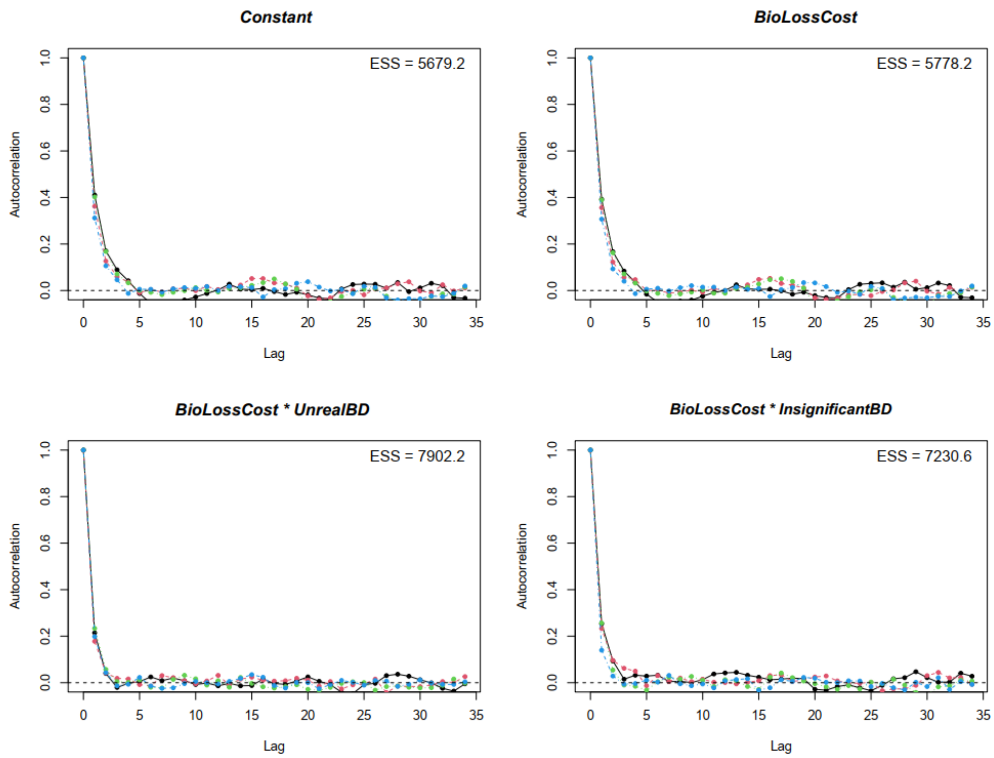

Figure A2: Model 1's autocorrelation plots

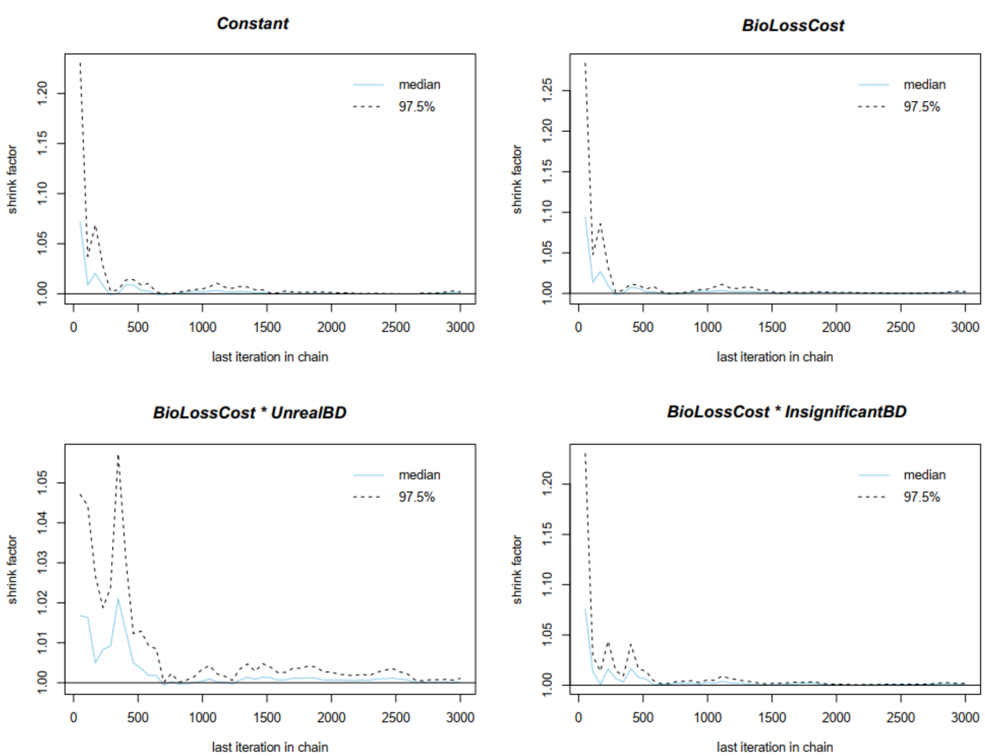

Figure A3: Model 2's Gelman plots

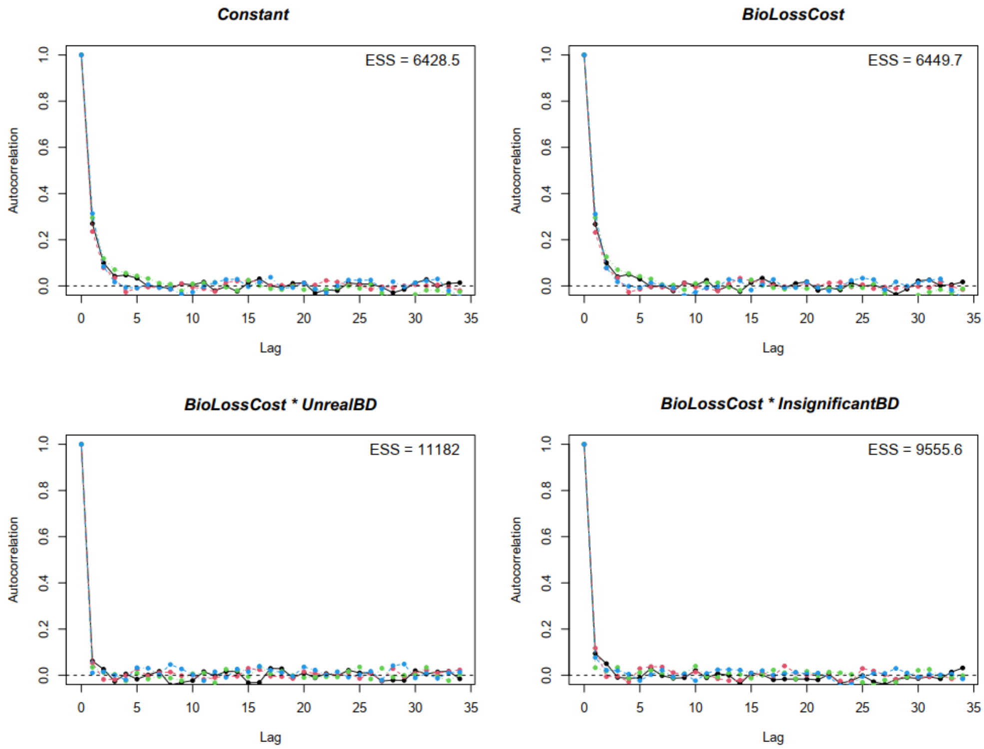

Figure A4: Model 2's autocorrelation plots

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