Ocean economic and cultural benefit perceptions as stakeholders' constraints for supporting preservation policies: A cross-national investigation

Minh-Hoang Nguyen [1,*], Minh-Phuong Thi Duong [2], Quynh-Yen Thi Nguyen [3], Viet-Phuong La [1,4], Phuong-Tri Nguyen [5], Vuong-Quan Hoang [1]

[1] Centre for Interdisciplinary Social Research, Phenikaa University, Yen Nghia Ward, Ha Dong District, Hanoi 100803, Vietnam

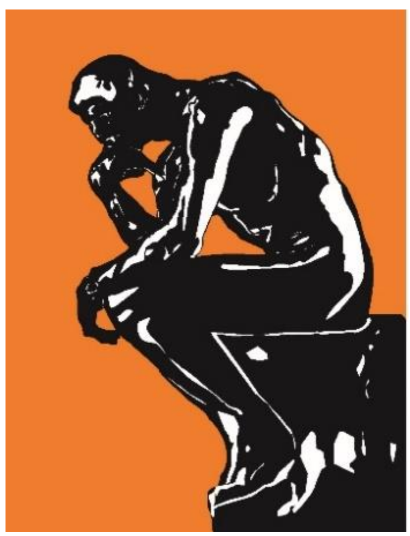
[2] Faculty of Social Sciences and Humanities, Ton Duc Thang University, Ho Chi Minh, Vietnam

[3] Independent researcher, Ho Chi Minh, Vietnam

[4] A.I. for Social Data Lab(AISDL), Vuong & Associates, Hanoi 100000, Vietnam

[5] Securities Research and Training Center, State Security Commission, Ho Chi Minh 700000, Vietnam

* Corresponding: Minh-Hoang Nguyen; Email: hoang.nguyenminh@phenikaa-uni.edu.vn



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Abstract

Effective stakeholder engagement and inclusive governance are essential for effective and equitable ocean management. However, few cross-national studies have been conducted to examine how stakeholders' economic and cultural benefit perceptions influence their support level for policies focused on ocean preservation. The current study aims to fill this gap by employing the Bayesian Mindsponge Framework (BMF) analytics on a dataset of 709 stakeholders from 42 countries, a part of the MaCoBioS project funded by the European Commission H2020. We found that economic and cultural benefit perceptions are generally negatively associated with the policy support level. Regarding economic aspects, stakeholders considering transportation and shipping, renewable energy generation, and oil and gas provision as the most crucial benefits their countries' oceans provide tend to obtain less support for policies focusing on ocean preservation. Meanwhile, for cultural aspects, perceiving recreation and tourism, aesthetic pleasure, mental health and well-being support, and sense of identity provision as the most important benefits provided by the country's ocean are negatively associated with the policy support level. The perceived economic, cultural, and environmental tradeoffs when supporting policies focused on ocean preservation were discussed. Recommendations for improving the effective management of multi-use marine space are also provided to reduce the perceived competing interests among stakeholders.

Keywords: eco-surplus culture; competing interest; marine space multi-use; collaboration

> "[…] hardship brings out power, and later achievements in life suggest that being strict with oneself does not sound that bad."
>
> In "Say Yes to Hardship"; *Meandering Sobriety (2023)*

1. Introduction

The climate crisis is one of the biggest challenges humans face in the 21st century. Due to anthropocentric activities causing the emissions of greenhouse gases, the global surface temperature has increased by 1.1°C from the base temperature of 1850-1900 in 2011-2020 (IPCC, 2023). According to the Intergovernmental Panel on Climate Change, if the human growth trajectory is unchanged, global warming will likely reach 1.5°C between 2030 and 2052 (Masson-Delmotte et al., 2018). Recent evidence suggests that even global warming of 1.5°C and above risks crossing multiple tipping points, which can change part of the climate system and cause abrupt, irreversible, and dangerous impacts on humanity (Armstrong McKay et al., 2022). Some of the adverse consequences of climate change are rising sea levels, more frequent and intense extreme weather events, reduced food security, increased risk of infectious diseases, and reduced physical and mental health, etc. (Pörtner & et al., 2022) Greenhouse gas emission reduction and rapid decarbonization of human activities are two main ways to alleviate the impacts of climate change. Such goals can be accomplished by maintaining and restoring natural ecosystems, as well as minimizing future emissions caused by land use change and environmental deterioration, especially in the marine and coastal ecosystems (Adame et al., 2021; Jacquemont et al., 2022; Macreadie et al., 2021).

Being the largest livable space on Earth, the ocean and its ecosystem services are indispensable for planetary and human well-being. The provided services of marine and coastal ecosystems can be classified into four main categories: provisioning services (e.g., food provision, raw materials, fisheries, etc.), regulating services (e.g., gas and climate regulation, flood and storm protection, etc.), cultural services (e.g., recreation and ecotourism, aesthetic values, cultural heritage values, etc.), and over-arching support services (e.g., resilience and resistance, biologically mediated habitat, nutrient cycling, etc.) (Beaumont et al., 2007; Remoundou et al., 2009). An economic valuation in 2015 by Hoegh-Guldberg (2015) indicates that solely some of these services (i.e., fishing, aquaculture, tourism, education, coastal and oceanic shipping, carbon sequestration, and biotechnology) were already worth more than US$2.5 trillion annually. That was not to mention other fundamental services that are difficult to measure, such as spiritual and cultural services, the production of oxygen, planetary temperature stabilization, and the ocean's role in climate regulation (O'Leary et al., 2022). However, marine and coastal ecosystems have been exploited unsustainably and have not received adequate protection and attention in policymaking decisions, which could result in severe environmental degradation and less effective climate regulation (Barbier, 2017).

Marine protected areas (MPAs) can be deemed one of the most viable and politically acceptable approaches to marine conservation (Wells et al., 2016). Since the 1980s, the expansion of MPAs has occurred rapidly in both number and scope for the primary objective: conservation of nature or biodiversity. Given the dependence of local communities and national economies on the ocean, MPAs have also been used for addressing sustainable development of the local areas, such as management of habitats beneficial for commercial fish, tourism and leisure, ecological resilience, etc. (Wells et al., 2016). Well-managed MPAs can contribute significantly to the conservation of biodiversity, ecosystem health maintenance, climate change mitigation, recovery of marine resources, and human well-being (Graham et al., 2011; Jankowska et al., 2022; Roberts et al., 2017; Strain et al., 2019; Wells et al., 2016). However, the management in MPAs exhibits a predominantly top-down approach that frequently lacks meaningful engagement with the local communities, as the conservation activities have conventionally been implemented under the leadership of governments (Wells et al., 2016).

Given the interconnected socio-ecological nature, effective and equitable ocean management requires stakeholder engagement and inclusive governance (Britton et al., 2021).

Insufficient consideration of local communities' socio-cultural and economic characteristics can lead to significant conflict and resistance (Christie et al., 2017; Richmond & Kotowicz, 2015). In contrast, if the marine stewardship processes engage the communities and reckon with their multifaceted interests, they might actively participate and support the initiatives (Bennett et al., 2022; Johnson et al., 2020). Besides, the level of public support plays a crucial role in determining the legitimacy and credibility of policies, which in turn fosters increased compliance and collaboration among stakeholders (Kelly et al., 2020). McNeill et al. (2018) posited that stakeholder endorsement is crucial in order to secure voluntary compliance and acquire a "social license to operate" for marine conservation initiatives. The active engagement of stakeholders in the initiatives may facilitate information exchange, promote creativity, and enable the discovery of workable solutions to a wide range of difficulties (Ballesteros & Dickey-Collas, 2023).

For effective stakeholder engagement and inclusive governance, it is essential to understand factors contributing to the willingness to support policies focused on preserving marine and coastal ecosystems. Several studies have been performed in this line of research and suggest that the stakeholders' support for conservation initiatives (including policies) depends on the degree of socio-cultural and economic cost-benefit analysis associated with conservation activities (e.g., MPAs) and the ocean ecosystems. For example, opposition to MPA implementation usually occurs in areas where local residents' food security relies on fishing activities (Westlund et al., 2017). A study in Thailand also found that the support for conservation and MPAs was hindered by the local people's perceived negative impacts of MPAs on fisheries and agricultural livelihoods, negligible merits for tourism livelihoods, and inequitable resource distribution (Bennett & Dearden, 2014). However, if the resident has access to alternative income sources outside of fishing, engages in MPA scoping meetings, concerns about overfishing, and settles in tourism-related areas, they are more likely to support MPAs or the future establishment of MPAs (Casola et al., 2022). Wakita et al. (2014) discovered that cultural benefits (e.g., religious usage, recreation provision, health provision, etc.) are positively associated with behavioral intentions for marine conservation. Recently, Nguyen, Duong, et al. (2023) also found stakeholders' perceived impacts of marine and coastal ecosystems on human well-being, climate and weather, and climate change reduction might positively influence their support for marine protection policies. Multiple studies have been conducted, but studies on the effects of cultural ecosystem services on stakeholders' support for conservation policies remain limited (Rodrigues et al., 2017).

Marine and coastal ecosystems are associated with dynamic and diverse societal contexts with a wide range of uses and users, which often function under complicated governance structures characterized by ambiguous property rights and the possibility of competing interests (O'Leary et al., 2022). Although stakeholders from different countries can share the benefits of the same ocean system, their preferences and value systems can vary significantly according to the social, cultural, political, and economic contexts. Studying the perceptions of cross-national stakeholders can offer insights into the similar patterns of socio-ecological interactions across countries, which is beneficial for achieving international consensus on conservation communication, collaboration, and stewardship.

Based on the above necessities, the current study has the following main objective:

- Examine and compare how cross-national stakeholders' perceived economic and cultural benefits of their countries' oceans affect their support level for policies focused on marine and coastal preservation for addressing climate change, nature conservation, and sustainable development.

The Mindsponge Theory was employed to provide a theoretical explanation for the constructed models examining the issues (Vuong, 2023b). The theory is an information-processing approach to studying the human mind. It has been widely applied to investigate and explain multiple socio-psychological relationships and phenomena (Asamoah et al., 2023; Jin et al., 2023; Kantabutra & Ketprapakorn, 2021; Khuc, Dang, et al., 2023; Khuc, Tran, et al., 2023; Kumar et al., 2022; Nguyen, Le, et al., 2023; Ruining et al., 2023; Ruining & Xiao, 2022; Santirocchi et al., 2023; Shu et al., 2023; Tanemura et al., 2022; Vuong et al., 2023; Vuong, Le, et al., 2022). Meanwhile, the Bayesian Mindsponge Framework (BMF) analytics, combining the strengths of Mindsponge Theory and Bayesian analysis, was utilized to test the constructed models on a dataset of 709 stakeholders in 42 countries (Fonseca et al., 2023; Nguyen et al., 2022; Vuong, Nguyen, et al., 2022).

The next section details the Mindsponge Theory, BMF analytics, the statistical model, and the analyzed dataset. Then, the estimated results using Bayesian analysis are shown in Section 3. Section 4 discusses the study's main findings with relevant literature and indicates their practical and theoretical implications.

2. Methodology

2.1. Theoretical foundation

The current study employed the Mindsponge Theory, an information-processing theory of the mind, to rationalize the model construction and explain the estimated results (Vuong, 2023b). In a study on acculturation and the global mindset, Quan-Hoang Vuong and Nancy Napier proposed the notion of the "mindsponge mechanism" as a means of explaining the intricate process through which the mind assimilates or disregards novel cultural values, contingent upon various factors (Vuong & Napier, 2015). They metaphorized the mind as a sponge to elucidate the cognitive process "that squeezes out inappropriate values and absorbs new ones that fit or complement the context" (Vuong & Napier, 2015). Later, the mindsponge mechanism was developed into Mindsponge Theory with components elaborated using the information-processing scheme borrowed from metaphysics and incorporating the latest evidence in brain and life sciences (Davies & Gregersen, 2014; Vuong, 2023b). The Mindsponge Theory has been extensively utilized in a diverse range of socio-psychological studies (Asamoah et al., 2023; Jin et al., 2023; Kantabutra & Ketprapakorn, 2021; Khuc, Dang, et al., 2023; Khuc, Tran, et al., 2023; Kumar et al., 2022; Nguyen, Le, et al., 2023; Ruining et al., 2023; Ruining & Xiao, 2022; Santirocchi et al., 2023; Shu et al., 2023; Tanemura et al., 2022; Vuong et al., 2023; Vuong, Le, et al., 2022).

According to the Mindsponge Theory, the mind can be conceptualized as a cognitive entity that functions as both a collector and processor of information, specifically an information collection-cum-processor. It possesses the ability to acquire and process various forms of information while engaging in interactions within its surrounding environment, referred to as the "infosphere." The information-processing system of the mind is comprised of the following features, as outlined by Vuong (2023b):

- The process is characterized by dynamic self-balancing, resembling the patterns observed in biosphere systems.
- The process entails a thorough cost-benefit assessment to optimize perceived benefits and minimize perceived costs for the system.
- It has objectives and priorities in alignment with the system's specific demands.
- It necessitates energy consumption, adhering to the principle of energy conservation.
- The primary role of the mind is to ensure its existence by any means possible, including survival, growth, and reproduction.

Within the mind, the mindset refers to a collection of deeply ingrained information, such as core values or beliefs, that are stored in memory and significantly influence later cognitive processes and behavioral responses. The core values within the mindset serve as a standard to assess the cost and benefit of absorbed information throughout the multi-filtering process. This evaluation ultimately determines whether the new information is accepted or rejected from the mind. In the event that the perceived benefits outweigh the perceived costs, the information will be granted access to the mindset, and conversely. Upon entering the mindset, the new information will be internalized as core values and thereafter serve as cognitive references for the mind's future information processing (Vuong, Nguyen, et al., 2022).

From the information-processing perspective, a person’s support level towards preservation-centered policies can be deemed an output of the mind’s information processing. For an individual to have a higher support level, more information related to policy focusing on marine and coastal preservation must be absorbed and internalized through the multi-filtering process. In other words, its perceived benefits need to be greater than perceived costs. Marine and coastal preservation is expected and evidenced to be a viable solution for addressing climate change, nature conservation, and sustainable development (Graham et al., 2011; Jankowska et al., 2022; Roberts et al., 2017; Strain et al., 2019; Wells et al., 2016). However, implementing policy centered on marine and coastal preservation requires tradeoffs. Such tradeoffs can be myriads, depending on the policy design, implementation, and contextual characteristics. For instance, when implementing Marine Protected Areas (MPAs) in ecologically important regions, it is widely acknowledged that there may be short-term adverse economic impacts (33, 34). Nevertheless, if people can substitute the services provided by the ocean with alternatives from other sources, their tradeoff might be lower, possibly resulting in higher support for marine conservation. In the study of Casola et al. (2022), residents who have access to alternate means of income beyond fishing and express concerns about overfishing are more inclined to support the development of MPAs or future initiatives aimed at creating MPAs.

Given that cultural and economic benefits provided by the ocean are crucial for maintaining the existence of stakeholders, we hypothesized that how those benefits associate with stakeholders' support for policy centering on marine and coastal preservation depends on the importance of those benefits. Here, we specify cultural and economic benefits as they are two main types of benefits provided by the ocean that can be measured through survey research.

2.2. Model construction

2.2.1. Variable selection and rationale

In this study, we used the dataset generated by Fonseca et al. (2023) as a part of the MaCoBioS project, funded by the European Commission H2020. The data was collected through an online survey on the Qualtrics internet platform between November 16, 2021, and February 16, 2022. The question was translated into four different languages, including English, French, Spanish, and Italian. The survey interface was tailored to the device used accordingly. A total of 709 responses were recorded in the final dataset and stored in Mendeley Data as "Survey_Fonsecaetal_07122022.xlsx".

Fonseca et al. (2023) designed the survey to study stakeholders' perceptions of marine and coastal ecosystems, climate change, and ecosystem management. The questionnaire questions cover a wide range of issues, including climate change attitudes, socio-demographic information, and the importance of and threats to coasts, oceans, and animals. The majority of questions necessitated an answer, although demographic questions had the alternative of selecting "prefer not to answer." Survey participation was voluntary, so respondents were given the option to leave and resume the survey at a later time. The data were subjected to anonymization procedures to safeguard the privacy of respondents, thereby preventing the recording of their IP addresses, location data, or contact information. Respondents were also provided with the option of submitting additional remarks and their contact details. However, these contact details have been excluded from the dataset to safeguard the confidentiality of the participants.

Fonseca et al. (2023) determined to employ purposive snowball sampling as a recruitment method because it supports reaching communities that are typically difficult to reach, like ocean ecosystem stakeholders. The survey was explicitly promoted on the social media platforms of MaCoBioS, namely Twitter and Instagram. In addition, the survey collectors made efforts to reach out to 105 stakeholder groups encompassing conservation, tourism/recreation, and fishing/seafood sectors across various countries, including the UK, Norway, Ireland, France, Italy, Spain, Bonaire, Martinique, and Barbados. These stakeholder groups were contacted to distribute the survey among their members and encourage referrals. Given that the objective of the project was to carry out a cross-national survey on the perspectives of coastal and marine stakeholders regarding climate change, anthropogenic impacts, and the significance and governance of marine and coastal ecosystems, it was impractical to employ alternative sampling methods, such as stratified or random sampling, due to due to the tremendous incurred costs (Vuong, 2018). Thus, it is essential to note that the sample should not be seen as indicative of the broader population. The survey was specifically tailored to target those who are 18 years of age or older. Before the main survey collection, a pilot was conducted with 20 participants.

We employed 11 variables generated from the original dataset to construct the model: one outcome variable and ten predictor variables. The outcome variable is *SupportforPolicyFocus*, reflecting the stakeholders' support level for policies focusing on enhancing and preserving marine and coastal ecosystems to address climate change, nature conservation, and sustainable development. Meanwhile, variables representing stakeholders' perceived economic and cultural benefits were generated from variable *Q6* in the original dataset. Variable *Q6* was created from the question inquiring about what stakeholders considered the three most important benefits that their countries gained from the marine and coastal ecosystems. A pool of 14 options was provided for stakeholders to select from, including 'food,' 'recreation and tourism,' 'places to support mental health and well-being,' 'transport and shipping,' 'natural coastal protection,' 'renewable energy,' 'raw material for construction,' 'places to support diverse marine plants and animals,' 'climate control,' 'aesthetic pleasure,' 'places that provide a sense of identity,' 'oil and gas,' 'water quality,' 'places that support history and cultural heritage.' Based on the respondents' answers, we created ten new binary variables reflecting whether the respondents considered a specific type of economic or cultural gain from the marine and coastal ecosystems beneficial.

Table 1: Variable description

Variable	Description	Type of variable	Value
SupportforPolicyFocus	The degree to which the stakeholder thinks enhancing and preserving marine and coastal	Numerical	1: Strongly disagree

	ecosystems should be a key focus of policies that address climate change, nature conservation, and sustainable development		2: Disagree 3: Neither agree nor disagree 4: Agree 5: Strongly agree
Economic_Food	Whether the respondent considers food as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Economic_Transport	Whether the respondent considers transport and shipping as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Economic_RenewableEnergy	Whether the respondent considers renewable energies as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Economic_RawMaterial	Whether the respondent considers raw materials for construction as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Economic_OilandGas	Whether the respondent considers oil and gas as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes

Culture_Recreation	Whether the respondent considers recreation and tourism as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Culture_MentalHealth_Wellbeing	Whether the respondent considers places to support mental health and well-being as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Culture_Aesthetics	Whether the respondent considers aesthetic pleasure as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Culture_SenseofIdentity	Whether the respondent considers places that provide a sense of identity as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes
Culture_HistoryandHeritage	Whether the respondent considers places that support history and cultural heritage as one of the most important benefits gained from his/her country's ocean	Binary	0: No 1: Yes

2.2.2. Statistical model

To examine how the perceived economic benefits of the country's ocean systems influence stakeholders' support level towards preservation-centered policies, Model 1 was formulated with *SupportforOcean* as the outcome variable and the perceived economic values as predictor variables. Model 1 was constructed as follows:

$$SupportforOcean \sim normal(\mu, \sigma) \quad (1.1)$$

$$\mu_i = \beta_0 + \beta_1 * Economic\_OilandGas_i + \beta_2 * Economic\_Transport_i + \beta_3 * Economic\_RenewableEnergy_i + \beta_4 * Economic\_RawMaterial_i + \beta_5 * Economic\_Food_i + \beta_6 * Culture\_SenseofIdentity_i + \beta_7 * Culture\_Aesthetics_i + \beta_8 * Culture\_HistoryandHeritage_i + \beta_9 * Culture\_Recreation_i + \beta_{10} * Culture\_MentalHealth\_Wellbeing_i \quad (1.2)$$

$$\beta \sim normal(M, S) \quad (1.3)$$

The shape of the normal distribution, whose width is determined by the standard deviation σ and mean μ determines the highest probability of occurring of the coefficient's value. μ_i indicates the respondent i's support level towards preservation-centered policies. Model 1 contains β_1 – β_{10} as the coefficients, β_0 as the intercept, and the standard deviation σ indicates the "noise." The coefficients are distributed as a normal distribution around the mean, denoted M, and with the standard deviation, denoted S.

The logical model of Model 1 can be visualized in Figure.

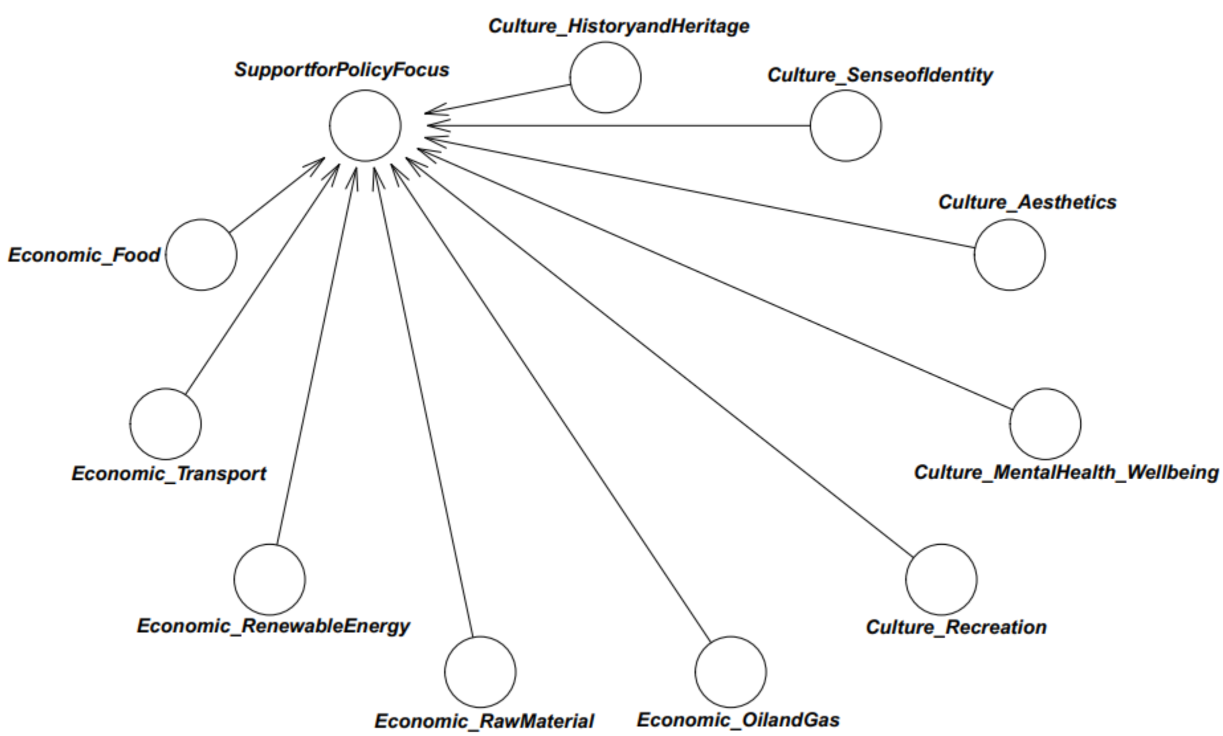

Figure 1: Logical connection of Model 1

2.3. Analysis and validation

The current study utilized the Bayesian Mindsponge Framework (BMF) as the methodological approach (Nguyen et al., 2022; Vuong, Nguyen, et al., 2022). BMF is the analytical framework that integrates the strengths of the mindsponge theory with Bayesian inference in order to examine various psychological and behavioral concepts or phenomena. The utilization of the Mindsponge Theory within the framework enables the construction of theoretical models that concisely and effectively capture the intricate and dynamic nature of the human mind (Nguyen et al., 2022). Simultaneously, Bayesian inference, renowned for its remarkable flexibility, facilitates the fitting of these models for statistical analysis (Dunson, 2001; McElreath, 2018). The two components exhibit a high degree of compatibility and mutually enhance one another during the course of conducting a study. In summary, the match between mindsponge and Bayesian inference encompasses the following key aspects: (1) both approaches, at a philosophical and theoretical level, embrace subjectivity, making them suitable for social and psychological research; (2) they offer researchers considerable flexibility in constructing and fitting models; and (3) both the theory and inference are capable of updating information in a dynamic manner (Nguyen et al., 2022).

Due to the intricate nature of the human psychological process, we determined to construct parsimonious models to enhance the ability to make accurate predictions. The Bayesian inference method is advantageous in estimating parsimonious models because of its probabilistic treatment of all properties, even the unknown parameters and uncertainties (Gill, 2014). In contrast to confidence intervals, which are commonly computed by making assumptions of large sample approximations, Bayesian interval estimates derived from Markov Chain Monte Carlo (MCMC) techniques are suitable for small sample sizes (Depaoli & Van de Schoot, 2017; Dunson, 2001).

Bayes' theorem states that the posterior distribution is proportional to the aggregate of the prior distribution and the likelihood function. As the sample size increases, the likelihood function gains greater weight in the overall calculation. Thus, prior distributions serve as an effective mechanism for incorporating information from previous studies, theoretical assumptions, and personal expectations (or intuition) and mitigating the influence of confounding factors. However, the feature of prior distribution is also a controversial aspect of Bayesian inference, as some researchers argue the subjective decision of prior distribution will undermine the credibility of the obtained results, perhaps leading to conclusions that are influenced not by the data itself but rather by the pre-existing beliefs held by an investigator who may exhibit excessive enthusiasm or skepticism (Dunson, 2001).

Models can be constructed with uninformative priors or a flat prior distribution to reduce the least prior information for model estimation, lowering the risk of subjective biases (Diaconis & Ylvisaker, 1985). The uninformative prior distributions of all parameters were set as normal distributions with the mean value at 0 and standard deviation at 10. In the current study, we also performed a prior-tweaking technique to test the sensitivity of the posterior distributions if prior beliefs are changed (Vuong, Nguyen, et al., 2022). The informative priors were set as normal distributions with the mean value at 0 and standard deviation at 0.5, reflecting our belief in the unambiguous effects of stakeholders' perceived economic and cultural benefits of the ocean ecosystems on their support level towards preservation-centered policies. The prior distribution incorporation will also help alleviate weak data identification problems, reducing the risk of multicollinearity induced by the high correlation levels among predictor variables (Adepoju & Ojo, 2018; Jaya et al., 2019; Leamer, 1973).

It is essential to acknowledge that the scientific community is now dealing with a reproducibility crisis. Numerous research conducted in various disciplines, particularly psychology (Open Science Collaboration, 2015) and social sciences in general (Camerer et al., 2018), have encountered challenges in replicating their findings. The wide sample-to-sample variability in the p-value is argued to be the main reason for the crisis (Halsey et al., 2015). Hence, the decision to utilize Bayesian analysis was motivated by the need to circumvent the utilization of *p*-values since Bayesian analysis offers the advantage of interpreting outcomes through the use of credible intervals (Wagenmakers et al., 2018).

To validate the simulated posterior outcomes, a three-pronged validation technique is employed. The goodness-of-fit of each simulated model was assessed using Pareto-smoothed importance sampling leave-one-out cross-validation (PSIS-LOO) diagnostic plots (Vehtari et al., 2017). The model's suitability with the data can be determined by observing whether all *k* values depicted on the plot are below 0.5. Subsequently, we proceeded with the convergence assessment by employing diagnostic statistics and visual representations. The diagnostic statistics encompass two key measures: the effective sample size (*n_eff*) and the Gelman-Rubin shrink factor (*Rhat*) (Brooks & Gelman, 1998; McElreath, 2018). The diagnostic plots consist of the trace plot, Gelman-Rubin-Brook plot, and autocorrelation plot. Ultimately, the prior-tweaking procedure was executed. The Results section provides a comprehensive presentation of diagnostic statistics and charts, accompanied by thorough explanations and interpretations.

We employed the bayesvl R package to perform Bayesian analysis in the present study (La & Vuong, 2019; Vuong, Nguyen, et al., 2022). The dataset, data description, and code snippets pertaining to the Bayesian analysis were deposited on The Open Science Framework to facilitate convenient and transparent replication or validation of the study's results (Vuong, 2018):

3. Results

The model fitting was executed using R version 4.2.0 ("Vigorous Calisthenics"). Four Markov chains were employed, each including 5000 iterations, with 2000 iterations designated for the warming stage. The simulation using uninformative priors took 2 minutes 39 seconds.

The estimated results incorporating uninformative and informative priors are presented in Table 2.

First, we examine the model's goodness of fit with the data by assessing the generated PSIS-LOO plot. The plot shown in Figure 2 implies that all *k*-values are below the 0.5 threshold, suggesting that Model 1 fits the data well.

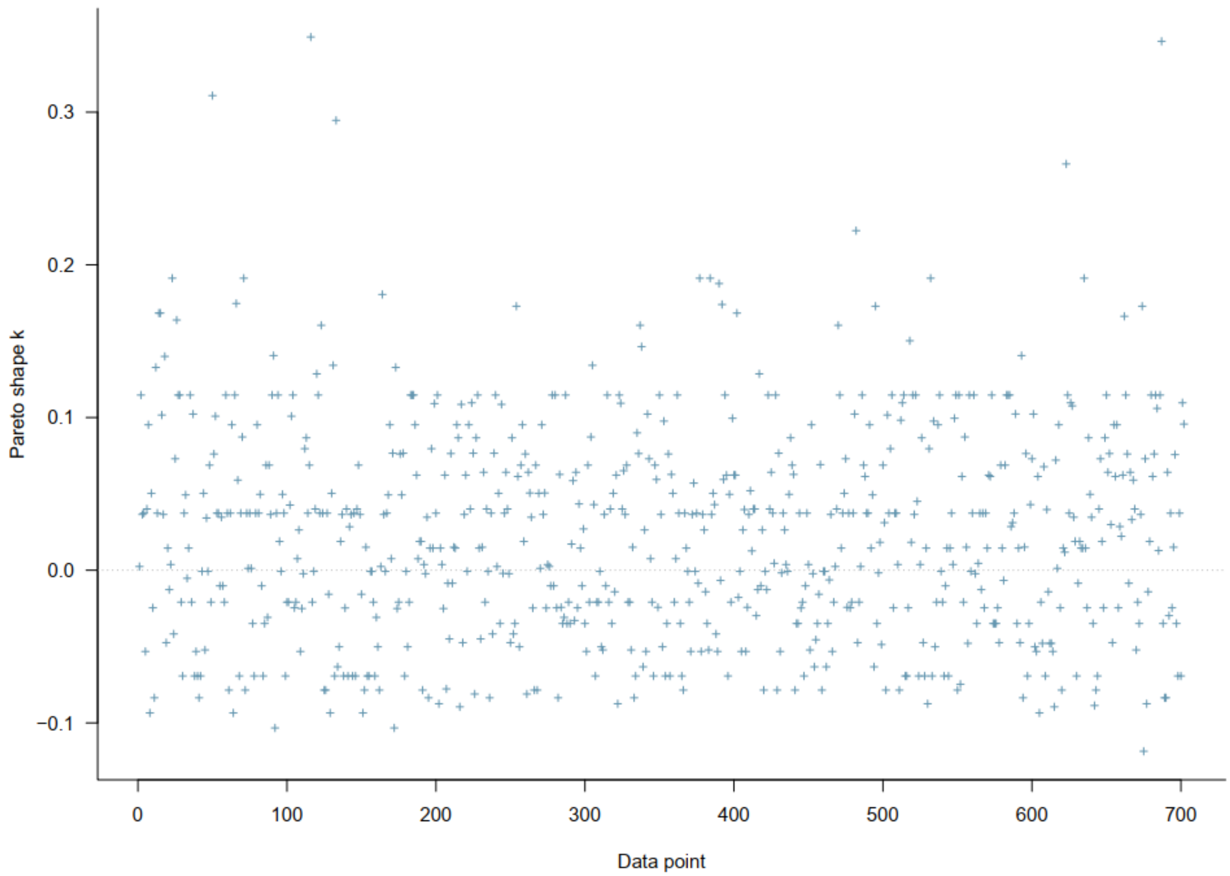

Figure 2: Model 1's PSIS-LOO test

Table 2: Model 1's estimated results

Parameters	Uninformative priors				Informative priors			
	Mean	SD	n_eff	Rhat	Mean	SD	n_eff	Rhat
Constant	4.70	0.06	9315	1	4.70	0.06	9996	1
Economic_Food	0.03	0.05	14321	1	0.04	0.05	15682	1
Economic_Transport	-0.17	0.06	19628	1	-0.17	0.06	18132	1
Economic_RenewableEnergy	-0.14	0.07	16841	1	-0.13	0.07	16852	1
Economic_RawMaterial	0.17	0.24	21385	1	0.13	0.21	21752	1
Economic_OilandGas	-0.12	0.12	21782	1	-0.12	0.11	19392	1
Culture_Recreation	-0.16	0.05	16715	1	-0.16	0.05	18893	1
Culture_MentalHealth_Wellbeing	-0.06	0.06	14932	1	-0.06	0.06	13931	1
Culture_Aesthetics	-0.20	0.09	16058	1	-0.20	0.08	19336	1

Culture_SenseofIdentity	-0.09	0.08	17842	1	-0.09	0.08	20951	1
Culture_HistoryandHeritage	-0.03	0.08	18222	1	-0.03	0.08	17552	1

Next, we proceed to diagnose the convergence of the Markov chain. All of the coefficients' effective sample sizes (*n_eff*) exceed 1000, and the Gelman-Rubin (*Rhat*) values are equal to 1, indicating that the model's Markov chains have achieved satisfactory convergence (see Table 2).

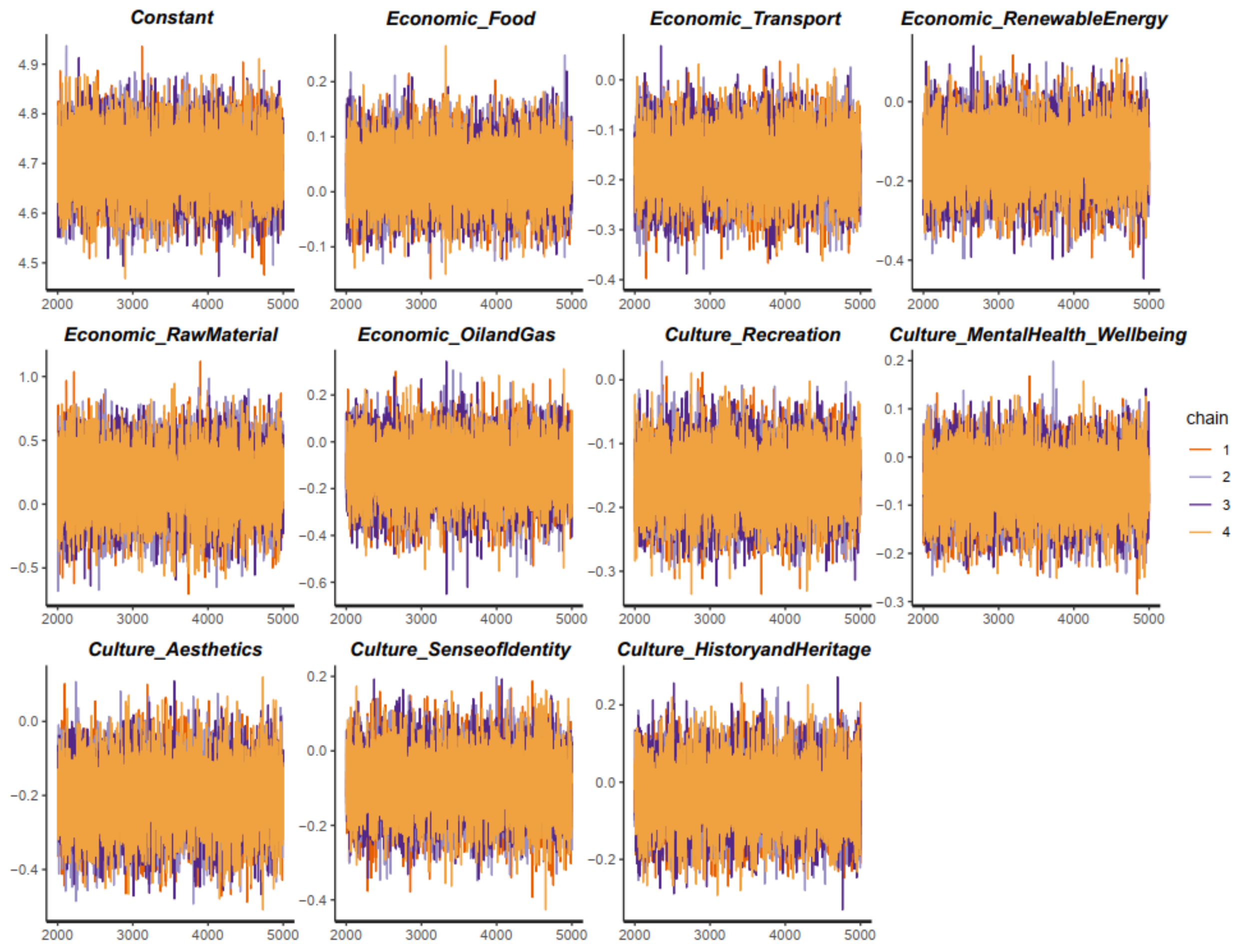

Figure 3: Model 1's trace plots

Additionally, we employed the trace, Gelman–Rubin–Brooks, and autocorrelation plots to validate the convergence of the Markov (or the Markov chain central limit theorem). The convergence of coefficient' Markov chains can be reflected through the healthy mixing around a central equilibrium shown in Figure 3.

Figure 4 displays all Gelman-Rubin-Brooks plots with their shrink factors. Those plots indicate a swift decrease to a value of 1 during the warmup period, or before the 2000th iteration. In Figure 5, it can be seen that the autocorrelation levels of all coefficients decline rapidly to zero after reaching a specific number of lags. Both outcomes suggest a favorable convergence of Markov chains. Hence, the obtained simulated outcomes are suitable for analysis and interpretation.

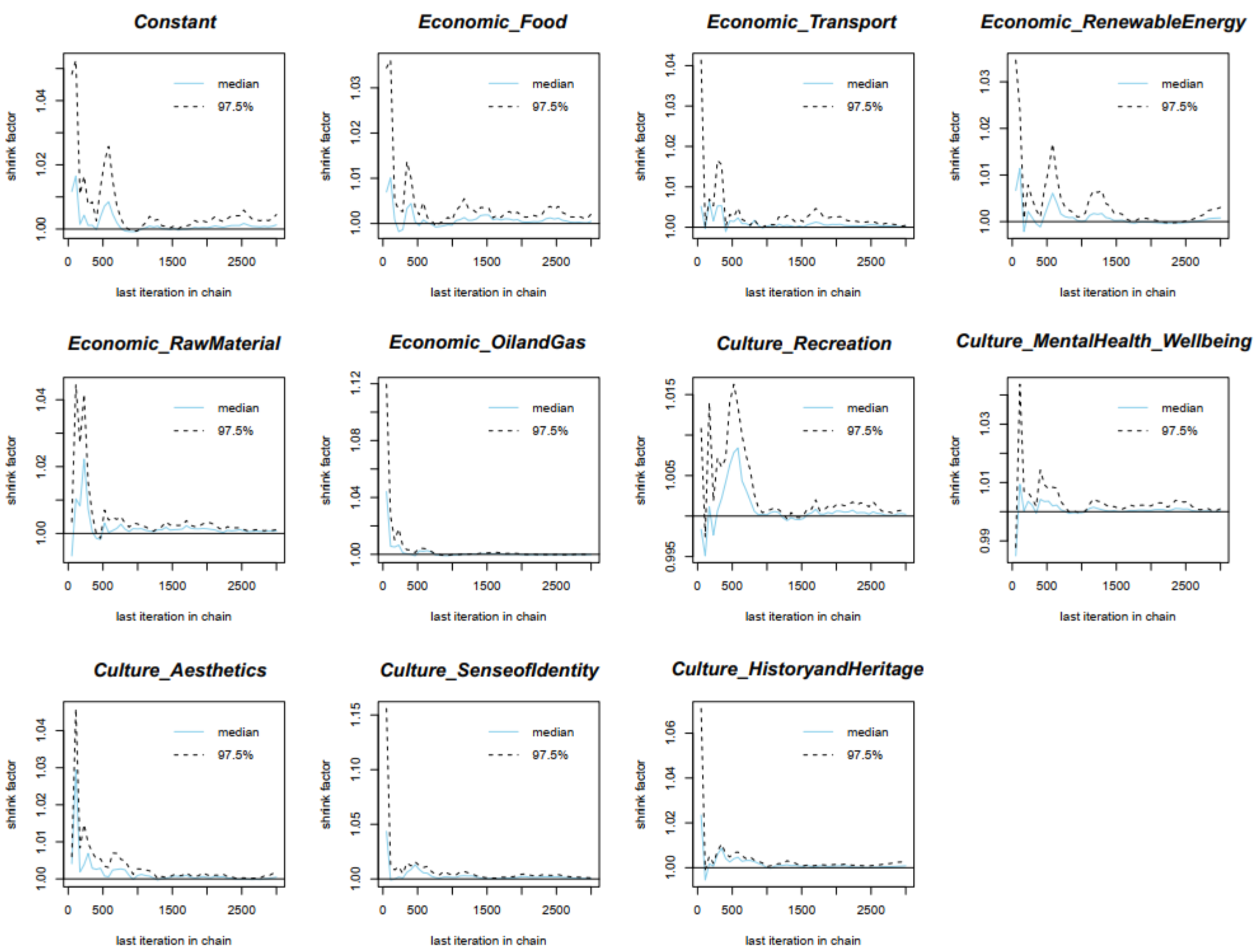

Figure 4: Model 1’s Gelman-Rubin-Brooks plots

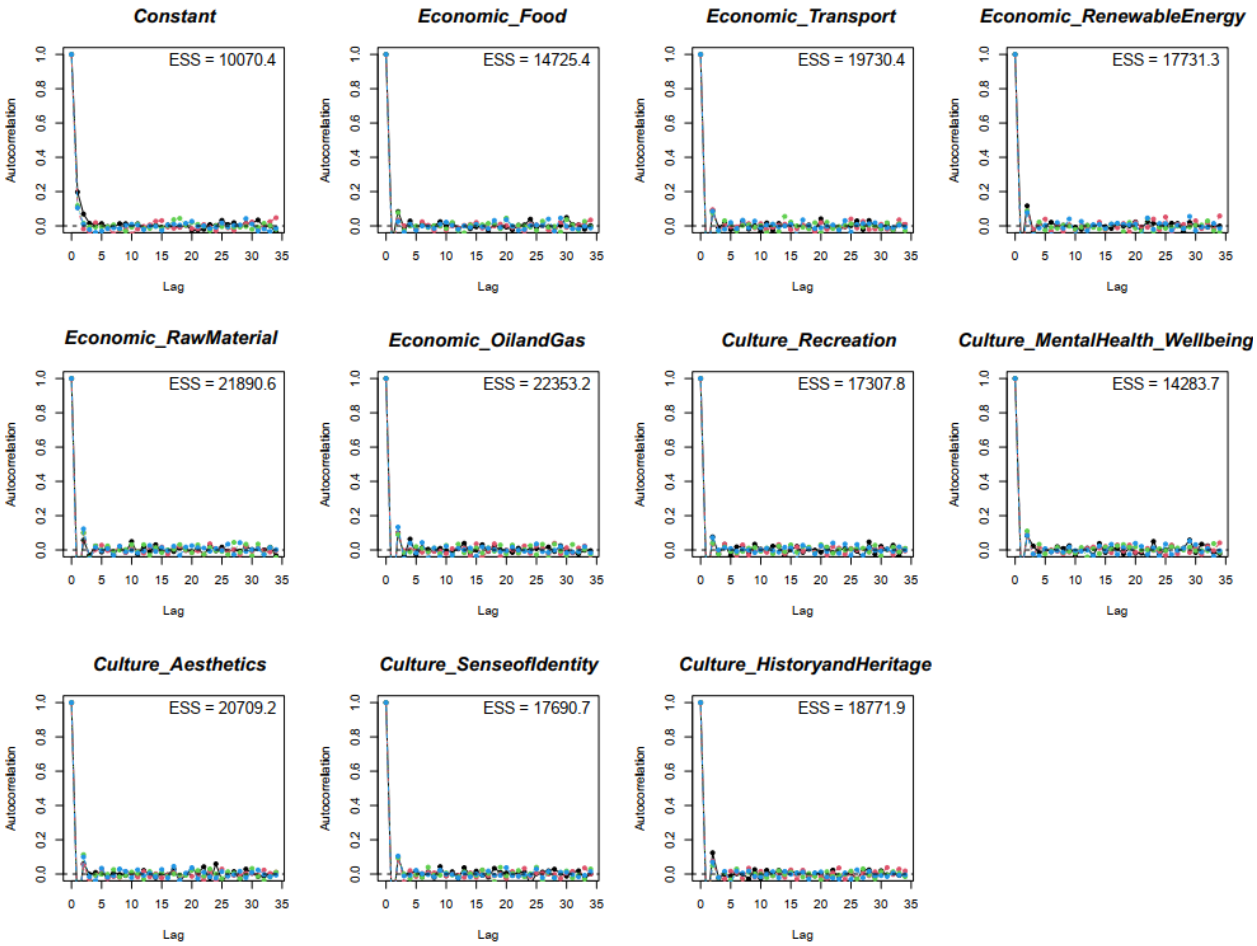

Figure 5: Model 1's autocorrelation plots

The estimated results of Model 1 help assess the effects of stakeholders' perceived economic benefits of ocean ecosystems on their support level towards preservation-centered policies. Based on the results presented in Table 2, in terms of the economic aspect, stakeholders perceiving transport, renewable energy, and oil and gas as the most important benefits deriving from the ocean are less likely to support ocean preservation-focused policies ($M_{Economic\_Transport}$ = -0.17 and $S_{Economic\_Transport}$ = 0.06; $M_{Economic\_RenewableEnergy}$ = -0.14 and $S_{Economic\_RenewableEnergy}$ = 0.07; $M_{Economic\_Transport}$ = -0.12 and $S_{Economic\_Transport}$ = 0.12). In terms of the cultural aspect, stakeholders perceiving health and well-being, aesthetics, recreation, and sense of identity as the most important benefits deriving from the ocean are less likely to support ocean preservation-focused policies ($M_{Culture\_MentalHealth\_Wellbeing}$ = -0.06 and $S_{Culture\_MentalHealth\_Wellbeing}$ = 0.06; $M_{Culture\_Aesthetics}$ = -0.20 and $S_{Culture\_Aesthetics}$ = 0.09; $M_{Culture\_Recreation}$ = -0.16 and $S_{Culture\_Recreation}$ = 0.05; $M_{Culture\_SenseofIdentity}$ = -0.9 and $S_{Culture\_SenseofIdentity}$ = 0.08). Other perceived benefits, like food and raw material provision, as well as history and heritage, tend to have ambiguous effects on stakeholders' support level, as the absolute value of these coefficients' standard deviations is higher than their mean value. The estimated results using informative priors that reflect our disbelief in the effects of the predictor variables also do not show much difference from the estimated results using uninformative priors. Therefore, the estimated results can be deemed robust.

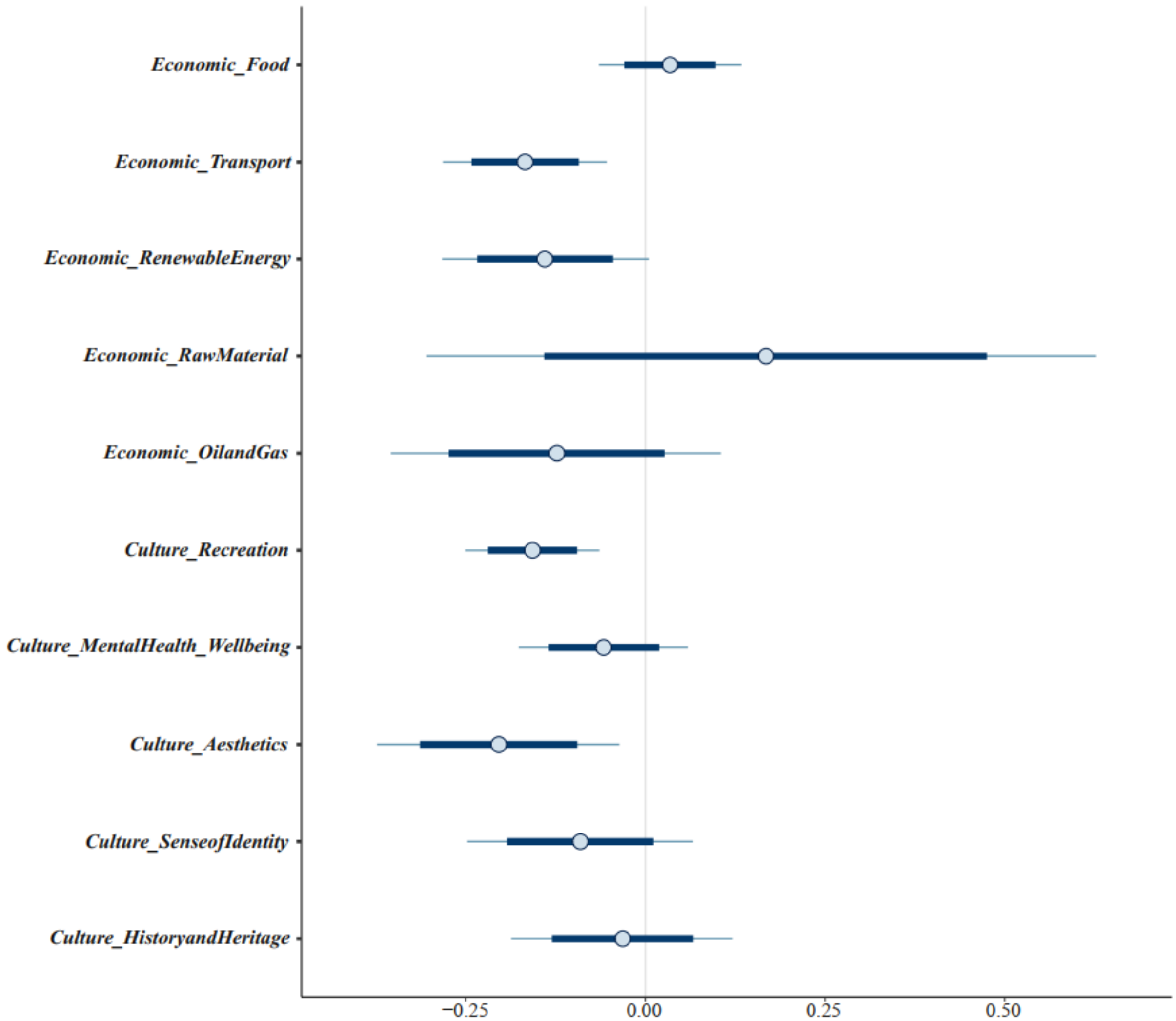

Figure 6: Model 1's posterior distributions

Figure 6 displays the posterior distributions of Model 1 in the form of an interval plot. The thin blue lines represent the probability mass beyond the highest credible zone, whereas the thick blue lines indicate the probability mass contained within the 89% Highest Posterior Density Intervals (HPDI). Visually, the HPDIs of *Economic_Transport*, *Economic_RenewableEnergy*, *Culture_Recreation*, and *Culture_Aesthetics* are located almost entirely on one side of the *x*-axis (either negative or positive), implying the high reliability of the effects. Although small parts of *Economic_OilandGas*, *Culture_MentalHealth_Wellbeing*, and *Culture_SenseofIdentity* coefficients' HPDIs are still situated on the positive side, that portion is not significant, so the effects of *Economic_OilandGas*, *Culture_MentalHealth_Wellbeing*, and *Culture_SenseofIdentity* can be deemed moderately reliable. The remaining coefficients' distributions, like *Economic_Food*, *Economic_RawMaterial*, and *Culture_HistoryandHeritage*, demonstrate ambiguous tendencies.

4. Discussion

Using the Bayesian Mindsponge Framework (BMF) analytics on the dataset of 709 stakeholders in 42 countries, the current study found negative associations between stakeholders' perceived economic-cultural benefits and their support level for policies centered on ocean preservation. For the economic aspects, the results suggest that stakeholders considering transportation and shipping, renewable energy generation, and oil and gas provision as crucial benefits provided by their countries' oceans tend to obtain less support for policies focusing on ocean preservation. Meanwhile, for cultural aspects, perceiving recreation and tourism, aesthetic pleasure, mental health and well-being support, and sense of identity provision as crucial benefits are negatively associated with the policy support level.

From the Mindsponge Theory's subjective cost-benefit assessment, to optimize their benefits, individuals must navigate complex tradeoffs between the benefits they derive from the ocean, such as maritime transportation, oil and gas extraction, employment opportunities in tourism, ocean aesthetics enjoyment, mental health and well-being support, sense of identity, and the policies designed to preserve marine ecosystems (Cheung & Sumaila, 2008). Preservation inherently involves a long-term effort to ensure the health and resilience of marine ecosystems for sustainable usage of marine resources and future generations. However, individuals' immediate benefits from the ocean offer short-term advantages (Hodgson et al., 2020), which can sometimes contradict the broader, more abstract goal of long-term ocean preservation.

Maritime transportation plays an indispensable role in global economic development as it is responsible for shipping billions of dollars worth of goods each day, accounting for >90% (by weight) of global trade (Walker, 2016; Walker et al., 2019). Its role is so important that the EU White Paper 2011 envisions a 50% transition from road to rail and maritime transportation by 2050 (Walker et al., 2019). Meanwhile, despite global endeavors to reduce the dependence on fossil fuels for energy production, oil and gas continue to constitute a significant portion of the overall energy supply. Even in the European Union, oil and petroleum products (34.5 %) and natural gas (23.7%) still held the largest and second-largest share in the structure of gross available energy in 2021 (Eurostat, 2023). Therefore, the perceived tradeoffs for environmental preservation among stakeholders in countries that receive tremendous benefits from maritime transportation and oil and gas extraction might be high, hindering their absorption and internalization of environmental preservation ideas into the mind.

The research highlights negative associations between the perceived cultural benefits of marine and coastal areas (i.e., recreation, aesthetics, and cultural identity) and the level of support for preservation-centered policies. When individuals perceive that conservation policies may disrupt or limit valuable benefits derived from the ocean, such as recreational activities, ocean aesthetics, and a sense of identity, there tends to be a stronger resistance to such policies. For some local communities, fishing is identified as "an integral part of social and family relationships – their identity and cultural values" (Dyrset et al., 2022). Changing their fishing lifestyle for preservation initiatives might impose a significant tradeoff on them. Several populations' cultural practices even conflict with global preservation initiatives, like the Faroese tradition, known as *grindadráp*, Iceland's whale hunting, and Japan's Taiji's dolphin hunt. Still, they decline to give up the activities due to their culture and tradition (Boffey, 2023; Daly, 2021; France-Presse, 2023). People interested in scuba diving, leisure boating, and recreational fishing might also experience the tradeoffs derived from preservation initiatives due to social conflicts arising from the allocation of resources (Gómez et al., 2021). This reason might also explain the negative association between perceived mental health and well-being as a major benefit of the ocean and preservation-focused policy support, as cultural ecosystem services are evident to improve human well-being through improving and maintaining their active connections to a place, identity, and values (Leong et al., 2019; Lloret et al., 2021; Pita et al., 2021; Pita et al., 2022; Young et al., 2016; Zunino et al., 2020).

Our result also hints at stakeholders' perceived tradeoff between marine conservation and other efforts for sustainable development, like renewable energy. Although implementing marine renewable energies can help capitalize on kinetic energy from waves, tidal currents, wind, or thermal and salinity gradients, beneficial for the development of blue economy, it might cause several threats to the surrounding environment where they are installed and operate (Dai et al., 2015; Goffetti et al., 2018). For example, renewable energy devices and infrastructures can possibly change the hydrodynamics, such as creating a slow "recirculation" process (Pelc & Fujita, 2002), limiting the transport of gases, nutrients, and food to sedentary organisms (Shields et al., 2011); their installment and operation can threaten life underwater and above water (Pelc & Fujita, 2002; Sun et al., 2012); their noise (specifically, offshore wind farm) might negatively affect the behaviors species particularly sensitive to noise (Goffetti et al., 2018). To reduce these negative impacts, installing and operating marine renewable energies have to align with the objectives of area-based marine conservation, which might create perceived tradeoffs among stakeholders considering renewable energies as an important benefit of their countries' oceans. Future studies are needed to validate the perceived tradeoff or conflict between green growth alternatives (i.e., renewable energies) and marine conservation and explore socio-economic and environmental factors that can mediate or moderate this relationship.

Based on these findings, the perceived tradeoffs of the support for conservation-centered policies tend to exist with economic-cultural and other environmental benefits (i.e., renewable energies). It leads us to the question: can humans make use of marine ecosystems for economic-cultural and other environmental benefits while prioritizing coastal protection, support biodiversity, and climate control?

The multi-use of marine space can be a solution for managing the impacts of economic-cultural and environmental activities on the marine and coastal ecosystems and ensuring access to resources for traditional and prospective users. Other researchers have suggested that economic-cultural and environmental activities do not always compete but can complement each other if appropriately designed and implemented. For example, highly or fully protected marine areas can help promote biomass, numerical density, species richness, and size of organisms within the protected zones (Cooney et al., 2019), which not only meets conservation objectives but also generates spill-over effects and benefit local fisheries adjacent to the protected areas' boundaries (Halpern et al., 2009). Meanwhile, offshore wind farms can serve as artificial reef structures for benthic invertebrates and shelter for fish, aiding conservation efforts (Ashley et al., 2014; Coolen et al., 2020). They can also be utilized together with aquaculture to supply seafood (Jansen et al., 2016).

Nevertheless, initiating and maintaining the multi-use of marine space is not easy. Here, we suggest two conditions that should be met for actualizing and improving the effectiveness of multi-use sea space.

First, collaboration among policymakers, specialists, and stakeholders is imperative for marine spatial planning, regulation, implementation, monitoring, and evaluation of multi-use. For instance, when constructing offshore wind farms, the business should work with ornithologists, oceanologists, and climatologists to alleviate the farms' negative impacts and bolter their positive effects on the surrounding ecosystems (Dai et al., 2015). When the local communities' culture contradicts conservation objectives, exchanging knowledge and values between local residents, modern scientists, and conservationists may motivate conservation management (McPherson et al., 2016). Adopting an open culture is essential for effective collaboration as it can help resolve potentially conflicting interests, epistemologies, and methodologies, thus lowering friction and reducing the cost of interdisciplinary collaboration (Nguyen & Vuong, 2021).

Second, stakeholders' acceptance to cooperate and accept the policy, program, or solution that is deemed optimal for prioritizing the environmental preservation criteria while maintaining other economic and cultural benefits is crucial. We emphasize environmental preservation goals over economic or cultural benefits here because a resilient marine ecosystem is a fundamental condition for other aspects to progress. Otherwise, when climate change passes the tipping points, or the extinction rate keeps increasing, they will have severe consequences for ecosystem function and service provisioning and, eventually, decline or even disrupt economic and cultural systems. Therefore, we urge the development of an eco-surplus culture among marine ecosystem stakeholders (Nguyen & Jones, 2022; Vuong, 2021). With eco-surplus mindsets, stakeholders will value the environmental benefits more, perceive less tradeoff induced by other economic-cultural benefits, and be likely to behave in a way that contributes to marine conservation, particularly in support of conservation-focused policies. Even when multi-use of marine space is implemented, people with eco-surplus mindsets might also be less likely to violate the laws protecting the oceans, which can significantly reduce the costs of regulation and monitoring. Communities of Practice can be a promising alternative to encourage the eco-surplus culture through social learning (Steins et al., 2021).

This research offers valuable insights but has significant limitations (Vuong, 2020). It hints at the tradeoffs between marine conservation with cultural and economic interests and even other environmental priorities but cannot thoroughly explore their complexity, potentially oversimplifying real-world dynamics. Consequently, future research should involve real-world scenarios and be approached carefully, considering marine ecosystems' complex and constantly changing nature. Moreover, most of the samples were obtained from high-income countries in Europe, so the results might not reflect the perceptions of stakeholders from countries with lower income levels and different socio-cultural backgrounds.

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