Research

Intention to use reusable shopping bags in an emerging economy: a Bayesian Mindsponge framework analysis

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Abstract

Single-use plastic (SUP) bags at supermarkets have detrimentally exacerbated the plastic waste and dump in landfills. Reusable shopping bags are a feasible solution to alleviate plastic production and consumption, particularly in an emerging economy. The study examined the intention to use reusable shopping bags instead of SUP bags, driven by personal norms and planning behavior. Bayesian Mindsponge framework (BMF) analysis was employed on a dataset of 536 Vietnamese consumers. The study found that instead of obligation, voluntary contribution to reduce plastic bag pollutant is predominant. Findings also indicate that enhancing public awareness and knowledge regarding environmental protection is significantly important. Some demographic characteristics, such as age, education, members in household, and incomes also moderate the relationship between driving factors and intentions. Finally, this study prescribes some policy implications and practical solutions to reduce and gradually restrict SUP in Vietnam.

Keywords Reusable shopping bag · Single-use plastic bag · Norm activation model · Theory of planned behavior · Bayesian mindsponge theory · Vietnam

1 Introduction

In recent decades, Vietnam has frequently dealt with the impacts of climate change and severe environmental crises. One of the most significant ecological destruction is the excessive production and consumption of plastic materials. Vietnam was globally ranked in the top five countries regarding mismanaged plastic waste mass and plastic leakage into the ocean [1]. The plastic industry in Vietnam annually generates a staggering 2.8–3.1 million tons of plastic waste. A significant portion of this waste ends up in landfills, waterways, and oceans, primarily due to inadequate management practices in treating plastic waste [2, 3]. About 90% of plastic waste is dumped into landfills and ends up in incineration, damaging the natural environment. Only roughly 10% is effectively recycled and reused [2, 3]. The consequences of this plastic pollution phenomenon have detrimentally environmental effects, threatening habitats and human beings [4].

Recognizing the urgent need to address plastic pollution, the Vietnamese government has implemented various initiatives to reduce plastic waste. These initiatives include legal frameworks, policies, and financial incentives to promote recycling, reduce single-use plastic (SUP) bags, and foster a culture of environmental responsibility. For

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instance, Directive 33/CT-TTg regarding strengthening plastic waste management, recycling, treatment, and reduction illustrates the government's commitment to tackling plastic pollution and promoting sustainable practices [5]. Furthermore, the Law on Environmental Protection 72/2020/QH14 explicitly states the responsibilities of organizations and individuals in limiting the use, reduction, classification, and disposal of SUP waste and non-degradable plastic packaging [6]. Next, Decree 08/2022/ND-CP outlines a specific roadmap to restrict the production and import of SUP products, non-degradable plastic packaging, and microplastic products [7]. Governors have designed these measures to reduce the environmental footprint of plastic waste and foster a culture of environmental responsibility among citizens and businesses. The Decision 1746/QD-TTg indicates the national action plan for marine plastic litter by 2030 [8]. Accordingly, the Vietnamese government makes great efforts in legal documentation and is committed to reducing and eliminating plastic waste during this decade.

In addition to the Vietnamese legal framework, some businesses and authorities seek solutions to harness the power of science and innovation in recycling plastic waste. A transformation of plastic waste into a valuable resource is one of the feasible solutions via the circular economy, which benefits both the environment and the economy. Nguyen and colleagues have developed a plastic cycle toward circular economy practice and underscored the need to extend the life cycle of plastic products and reduce plastic waste generation, minimizing the environmental impact in urban and riverside areas in Vietnam [9].

A crucial step in addressing plastic waste is the immediate reduction of SUP bags. The World Bank Country Director for Vietnam stated that rapid economic and urbanized development had caused a nationwide plastic pollution crisis, in which SUP items comprise a large portion of plastic pollution in Vietnam [2]. Replacing SUP bags with reusable shopping bags is a critical strategy in this endeavor. Promoting reusable shopping bags at supermarkets or retail stores has become essential in mitigating plastic waste's environmental impacts. However, several barriers and challenges prevent shoppers from changing their awareness, attitudes, and common behaviors from using plastic bags to adopting reusable shopping bags. Understanding these challenges and the factors driving the adoption of reusable bags is important for developing effective strategies to encourage this shift.

Some barriers and challenges prevent shoppers from changing their awareness, attitudes, and common behaviors regarding the use of plastic bags and reusable shopping bags, as follows:

- Shopper's motivation: Consumers' awareness and advocacy on environmental protection play a pivotal role in encouraging the use of reusable shopping bags. Consumers and the community should be aware of the contemporary issues of the environment and change their behavior seriously. Using reusable bags reduces plastic waste and fosters individuals' and communities' responsibility in managing personal waste.
- Government enforcement: Effective policies and regulations are essential in promoting reusable and biodegradable bags. Government initiatives such as banning SUP bags, implementing taxes, and offering incentives can significantly reduce plastic waste.
- Retailers' actions: Retailers can benefit from encouraging reusable bags by reducing the costs of providing SUP bags. This cost-saving measure can also align with corporate social responsibility goals and enhance the brand image of retailers committed to sustainability.

The scholarly corpus of literature has addressed the issues of consumers' attitude and behavior towards the use of SUP bags in Vietnam, yet remaining limited. For example, Liu and his colleague raised the current situation and challenges of the use of SUP in Hanoi and suggested the combination of top-down and bottom-up approaches along the supply chain of products to minimize the SUP dumped at landfills [10]. A descriptive analysis of plastic waste leakage and accumulation in Can Tho City prompts innovative recycling solutions in Mekong Delta region in Vietnam [11]. Additionally, by using Structural Equation Modeling (SEM), [12] studies the willingness to pay to switch to bring shopping bags in Vietnam, while [13] investigates the role of environmental concerns and social motivation toward bringing shopping bags. Furthermore, [14] integrates the theory of planned behavior (TPB) and the norm activation model (NAM) to study the intention and behavior of bringing one's shopping bags. Most previous studies adopt the SEM approach, but to the best of our knowledge, exploring factors impacting the intention to use reusable shopping bags in Vietnam using the innovative Bayesian Mindsponge framework (BMF) method is still scant. This study aims to fill the gap by investigating these associations and interactions of socio-demographic variables using the BMF method, which was proposed by Vuong and colleagues [15, 16].

The BMF analysis combines Bayesian statistics with the Mindsponge mechanism, providing nuanced insights into uncertainty and variation in behavioral intention that traditional models may overlook [15, 16]. First, traditional

econometrics typically rely on frequentist methods, where fixed parameters remain, and confidence interval illustrates uncertainty [17]. Hence, frequency approaches to behavioral research face logical difficulties and need help distinguishing between relevant and irrelevant multiple adjustments, leading to the potential for misinterpretation of statistical significance [17]. However, the BMF approach allows for estimating probability and uncertainty, providing a richer interpretation of the factors influencing behavior [15, 16]. The BMF inherently uses the Bayesian algorithm, which incorporates the prior belief and adjusts with new data in the posterior probability. Second, traditional econometrics assume fixed parameters and ignore the complexity of human behavior, but the BMF overcomes these limitations. Thus, this approach is particularly suitable for examining how individuals internalize new values and adjust their behavior in a dynamic socio-cultural context [18]. Accordingly, this superior nature of the BMF is particularly beneficial when studying the adoption of sustainable practices, where personal norms, attitudes, and social pressures are constantly evolving.

This study investigates the key questions: What factors influence Vietnamese consumers' intention to use reusable shopping bags, and how do these intentions interact with demographic characteristics such as age, education level, family size, and personal income? By integrating the TPB, NAM, and BMF analysis, this study offers a comprehensive view of the driving factors of environmentally friendly behavior. This integrated approach provides valuable insights into how Vietnamese consumers' attitudes, norms, and perceived behavioral control influence their adoption of reusable shopping bags. The findings are expected to inform policymakers, businesses, and environmental agencies in designing effective interventions to promote sustainable consumption habits, ultimately contributing to reducing plastic waste and building a more sustainable future for Vietnam.

The study is structured into five main sections, starting with an overview of the significance and objectives of the study, followed by an introduction to the theoretical and methodological background. The following sections present the study's results, discuss the findings and their practical implications, and conclude with critical insights and recommendations for future research.

2 Methodology

2.1 Theoretical background

A study on a social and psychological topic relying on a specific underlying theory should be favorable, but interpreting findings and results sometimes reflects a limited understanding of this topic. Therefore, incorporating more than a single theoretical framework to explain the complex behavior is important and necessary. This study encompasses three essential theories: The Theory of Planned Behavior (TPB), the Norm Activation Model (NAM), and the Bayesian Mindsponge framework (BMF). The TPB is a psychological framework used to predict and understand individual behavior, while the NAM explains how personal norms influence pro-social and altruistic behavior, particularly pro-environmental behavior. Research relying on the TPB and NAM using the SEM approach could be found in [14], but scarce research uses the BMF. The BMF combines the Mindsponge theory, describing how people absorb, process, and filter information based on personal, social, and cultural influences, and the Bayesian analysis, releasing the assumption of fixed parameters in explaining the dynamic behavior [15–18]. This study elicits a favorable nature from the TPB, NAM, and BMF, as follows.

2.1.1 Theory of planned behavior (TPB)

Theory of Planned Behavior (TPB) is a widely used research model for understanding customer behaviors in recent decades [19, 20]. TPB illustrates that behavioral intentions are driven by attitudes toward the behavior, subjective norms, and perceived behavior control [19, 20]. Then, the favorable intention produces the behavior. The significant impact of these predictors may vary. For example, La Barbera and Ajzen studied that perceived behavioral control calibrates the effects of subjective norms and attitudes on intentions. Higher perceived behavioral control strengthens the relationship between attitudes and behavioral intention but weakens the relationship between subjective norms and behavioral intention [21]. While some studies confirm the significance of subjective norms and attitudes in predicting intentions, the role of perceived behavioral control is less consistent, with some research finding no significant effect [22]. These findings highlight the complexity of factors influencing behavioral intention and the need for context-specific cases in TPB application. There is also the influence of the TPB across various fields, including consumer behavior [19], entrepreneurship [22], and environmental study [23]. This study investigates the pro-environmental intention driven by the TPB factors and the most influential theory in intentional behavior, namely the Norm Activation Model (NAM).

2.1.2 Norm activation model (NAM)

A commonly used model explaining the behavioral outcomes relevant to altruistic behavior is the Norm Activation Model (NAM), proposed by Schwartz in 1977 [24]. The NAM has been widely applied in predicting prosocial and pro-environmental behaviors and intentions [25, 26]. The central element of this model is personal norm, defined "as feelings of moral obligation not as intentions" [24]. Two main determinants of personal norms are the awareness of the consequences of individuals' behavior and the feeling of responsibility to perform well [24, 25]. Some studies [25, 27] validate the NAM, demonstrating its effectiveness as a mediator in predicting prosocial behaviors in the social and environmental setting. Personal norms mediate the effects of problem awareness and general values on pro-environmental behavior [27]. Onwezen and his colleagues extend the NAM model in which personal norm mediates the relationship between anticipated pride and guilt within the integrated NAM-TPB model [26]. Harland and colleagues underscored the importance of incorporating additional situational and personality dimensions as mediated predictors of pro-environmental behavior, potentially enhancing the explanatory power of personal norms in the model [28]. Finally, these state-of-the-art studies regarding the NAM raise the diversified factors boosting prosocial and pro-environmental actions.

2.1.3 Bayesian Mindsponge framework (BMF) analysis

The Bayesian Mindsponge framework (BMF) analysis has gained considerable attention among scholars and practitioners as a novel and innovative method for social and psychological research [15, 16, 29]. This method combines the mindsponge mechanism and Bayesian analysis. On the one hand, mindsponge theory describes a mechanism of information processing where the sponge absorbs and rejects new ideas or perspectives into the core value of the mind. On the other hand, Bayesian statistics use the Markov chain Monte Carlo (MCMC) algorithm to estimate posterior results instead of using p-value as frequentist statistics [17]. The mindsponge theory also explains how individuals recognize new cultural values in their core values and understand how people adapt and observe external cultural settings [17]. Regarding reusable shopping bags, attitudes are shaped by moral norms, lifestyle, and environmental knowledge, which influence their intentions to use reusable bags. Nguyen and his colleague express the Mindsponge culture, characterized by entrepreneurship and result-oriented thinking, and can be employed to promote sustainable behaviors (e.g., using reusable shopping bags) [18]. The Mindsponge culture can encourage individuals to imbibe an eco-surplus mindset, which is critical in tackling environmental issues. Therefore, embracing the mindsponge theory can entail sustainable development through adaptive thinking and creative performance [16, 29].

2.1.4 Comparative analysis of reusable shopping bags in Vietnam

Research on Vietnam's use of reusable shopping bags shows several key findings. Makarchev and his colleagues posit that plastic bag consumption among Vietnamese consumers remains prevalent, and many consumers are resistant to following plastic bag bans [30]. These authors name two socio-demographic and seven socio-psychological predictors significantly associated with plastic bag use [30]. Nguyen used the integrative model of TPB and NAM studying 536 Vietnamese consumers including that personal norms and attitudes have a more substantial impact on intentions [14]. Similarly, Tran and colleagues adopted the TPB model and Contingent Valuation Model to estimate the willingness to pay for switching to bring shopping bags in Vietnam [12]. The results indicated that attitude, social norms, perceived behavior, and eco-literature have no significant effects on willingness to pay, but eco-literature does. It suggests that consumers with having knowledge of the environment opt for bringing their bags instead of paying for plastic bags use [12].

The World Bank reports that plastic bags are the most common plastic waste, comprising 26% of total top 10 items disposed in riverbank and ocean [3]. SUP items were found at riverbanks (72%) and coastal sites (52%) of total plastic waste [3]. Approximately 80 tons of plastic waste and nylon bags are discarded daily in Hanoi and Ho Chi Minh City [10]. A case study in Hanoi City shows that SUP bags are the most frequently used to shop in Vietnam and these bags are reused as kitchen bin liners with a high rate of 68.85%. However, most of them end up in landfills [10]. Policies on plastic bag reduction by imposing tax and garbage separation at source are favorable, but challenging in expediting these policies [10]. Liu and colleagues recommended the targeted multi-dimensional reforms and a mix of bottom-up and top-down approaches along the entire supply chain to overcome the current situation in Vietnam [10].

The study of Truong and colleagues is consistent with Liu's study that consumers, being highly aware of environmental effects in Hanoi, tend to bring shopping bags. The retailers' promotional programs encourage young consumers to bring their bags. Social motivation moderates the association between environmental concerns and pro-environmental

behaviors [13]. To sum up, recent studies on Vietnamese consumer behavior highlight an increasing interest in sustainable consumption at supermarkets or retail stores. Shoppers in big cities (i.e., Hanoi) have high environmental concerns and are likely to bring their bags to shop. But some factors such as personal attitude and norm, social pressure, and motivations need to be explored more in this study. Hence, we pose hypothesis that personal norm, personal attitude, subjective norm, and perceived behavioral control are positively associated with intention to use reusable shopping bags with the moderation of socio-demographic variables.

2.2 Research framework

2.2.1 Variable selection

The dataset used in this study was from Nguyen's survey, which collected 536 respondents on their behavior towards bringing their shopping bags instead of using plastic bags [31]. Nguyen conducted the data collection, which was peer-reviewed and published in a paper in Data in Brief, in November 2020 in Vietnam (https://doi.org/10.1016/j.dib.2021.107226). In general, Vietnam is an emerging economy in Southeast Asia with a population of less than 100 million people. Vietnam is ranked as one of the top ten countries across the world in the production and consumption of plastic products [1]. Nguyen gathered data on-site at the top 10 supermarkets in Hanoi and Ho Chi Minh City and online approach randomly through 50 enterprises with diversified business sectors in November 2020. On the one hand, the author directly distributed to consumers at the supermarkets with instructions (acceptance rate of 89.9%); on the other, the author sent questionnaires to individuals in some organizations through email with an acceptance rate of 54.2%. The survey collection generated a dataset of 536 Vietnamese consumers. The demographic characteristics include information about gender, age, educational qualification, job, marital status, number of family members, and income. For the customer behaviors, Nguyen collected data on intention to use, attitude, subject norms, perceived behavioral control, awareness of consequences, ascription of responsibility, and personal norms.

We selected four main continuous variables and categorical demographic information from the dataset for this study (Table 1). The dependent variable of intention is composed of three items, which express the intention to use their shopping bags instead of plastic bags at supermarkets. Four independent variables include personal norm, attitude, subject norms, perceived behavioral control (three items for each variable). Nguyen's paper presents a detailed description of all items [31]. The demographic characteristics include age, educational level, family size, and income. First, we hypothesize that older individuals are generally more aware of environmental protection, guided by their personal and social norms. In contrast, younger people may prioritize convenience, often opting for SUP bags. Second, higher levels of education are expected to correlate with greater environmental consciousness. Third, higher-income families are more inclined to conserve resources, often choosing reusable bags. Lastly, larger families may similarly adopt resource-saving behavior for pragmatic reasons.

2.2.2 Method rationale and conceptual model

Unlike frequentist statistics, Bayesian analysis has gained considerable attention among scholars in analyzing data in recent years. Bayesian analysis with the Hamiltonian Markov Chain Monte Carlo (MCMC) simulation iteratively generates a large number of samples, providing more efficiency for the posterior estimation of any parameters. While traditional methods fixed parameters using statistical inference, Bayesian inference produces the posterior probability with the prior probability and likelihood function to the observed dataset. The Bayesian analysis with the MCMC technique highly fits mindsponge-based reasoning and model construction, resulting in the Bayesian Mindsponge Framework.

This study used the open-source software package for Bayesian network modeling and analysis, namely **Bayesvl** R language, proposed by [15, 16]. Bayesvl is a user-friendly regression model, explicitly visualized and eye-catching graphic model, and remarkably free accessible-source software [15, 16]. Bayesvl package is appropriate for examining socio, psychological, and behavioral issues [15].

$$\text{Posterior probability} \propto \text{Prior probability} \otimes \text{Likelihood function.}$$

The conceptual model in this study combines the NAM and TPB theory (see Fig. 1). Grounding on the NAM theory, we take the variable of personal norm to test its association with the intention to use reusable shopping bags. On the

Table 1 Description of variables

Variable	Description	Data type	Coding	Details
Intention	Intention to use own shopping bags instead of plastic bags at supermarkets	Continuous	Strongly disagree: 1 Disagree: 2 Neutral: 3 Agree: 4 Strongly agree: 5	Mean = 3.82 SD = 0.823
Personal norm	Moral obligation to perform or refrain from using single-use plastic bags at supermarkets	Continuous	Strongly disagree: 1 Disagree: 2 Neutral: 3 Agree: 4 Strongly agree: 5	Mean = 4.11 SD = 0.873
Attitude	Consumer's overall evaluation or thoughts about using reusable shopping bags	Continuous	Strongly disagree: 1 Disagree: 2 Neutral: 3 Agree: 4 Strongly agree: 5	Mean = 4.16 SD = 0.874
Subject norms	Perceptions of social pressure or influence on the behavior of using reusable shopping bags	Continuous	Strongly disagree: 1 Disagree: 2 Neutral: 3 Agree: 4 Strongly agree: 5	Mean = 3.52 SD = 0.933
Perceived behavioral control	The beliefs about the consumer's ability to use the reusable shopping bags	Continuous	Strongly disagree: 1 Disagree: 2 Neutral: 3 Agree: 4 Strongly agree: 5	Mean = 3.77 SD = 0.905
Education	Educational levels	Categorical	Others: 1 High school graduation: 2 College/University graduation: 3 Master/PhD graduation: 4	36 (6.72%) 114 (21.27%) 339 (63.25%) 47 (8.77%)
Age	Age ranging from youth to old person	Categorical	Under 20: 1 From 20 to 29: 2 From 30 to 39: 3 From 40 to 49: 4 From 50 to 59: 5 Over 60: 6	56 (10.45%1) 208 (38.81%) 145 (27.05%) 48 (8.96%) 64 (11.94% 15 (2.8%)
FamMembers	Numbers of family members in a household	Categorical	Only 1: 1 From 2 to 4: 2 Upper 4	41 (7.56%) 367 (68.47%) 128 (23.88%)

Table 1 (continued)

Variable	Description	Data type	Coding	Details
Income	Personal income per month (million VND)	Categorical	Under 6: 1 From 6 to 10: 2 From 10 to 20: 3 From 20 to 30: 4 From 30 to 40: 5 Upper 40: 6	77 (14.37%) 139 (25.93%) 184 (34.33%) 65 (12.13%) 41 (7.56%) 30 (5.6%)

other hand, three variables from the TPB theory (attitude, subjective norm, and perceived behavioral control (PBC)) are independent variables for our research model. Hence, we hypothesize that the four independent variables are positively associated with the intention to use one's own shopping bags. However, among these relations, we also test the moderated role of demographic variables including age, educational level, family members, and income. We hypothesize that the participants' demographic information either intensifies or attenuates these associations in our study. This hypothesis indicates non-linear relationships between independent variables and the intention to use reusable bags. The following mathematical model describes these hypotheses:

$$\text{Intention} \sim \alpha + \text{Personal Normal} + \text{Attitude} + \text{Subjective Norm} + \text{PBC}$$
$$+ \text{Personal Norm} * \text{Demographics} + \text{Attitude} * \text{Demographics} + \text{SubjectiveNorm} * \text{Demographics} + \text{PBC} * \text{Demographics}.$$

Based on the conceptual framework in Fig. 1, we use the Bayesvl package and generate the interactions between independent variables and demographic information, impacting the intention to use own shopping bags in Fig. 2.

2.3 Analysis and validation

As soon as we established the Mindsponge-based model construction, we employed the Bayesian analysis in the next stage of BMF analytics. We used the Pareto-smoothed importance sampling leave-one-out (PSIS-LOO) diagnosis to check the model's goodness of fit. The conditional value or k-values for fitting the model is shown in Table 2. The effective sample size (n_eff) and the Gelman-Rubin shrink factor (Rhat) in the trace plots show reliable and qualified results when the Markov chain converges. The value of n_eff being larger than 1000 indicates the convergence of the Markov chain. Additionally, the Rhat value should not exceed 1.1. We used the Bayesvl package and ggplot2 in R packages to analyze Bayesian results and visualization.

3 Research findings and results

Before interpreting the simulated posterior model, we elaborated on the model's goodness-of-fit (GoF) using the PSIS-LOO diagnosis test. The test's estimated k-values are shown in Fig. 3, indicating that most of the k-values are under 0.1, while a limited amount of k-values more than 0.1 (but all k-estimates are below 0.5). This PSIS-LOO test suggests that the constructed model fits the data well.

We used the R package with version 4.2.1, considered as "vigorous calisthenics" for Markov chains with 5000 iterations and 2000 times for the warmup period. The simulation took nearly two minutes to complete the estimation. The simulated results indicating the diagnosis of the Markov chain convergence are illustrated in Table 3. All the coefficient' n_eff values are larger than 1000 and Rhat values are equal to 1, suggesting that the Markov chain model has converged well.
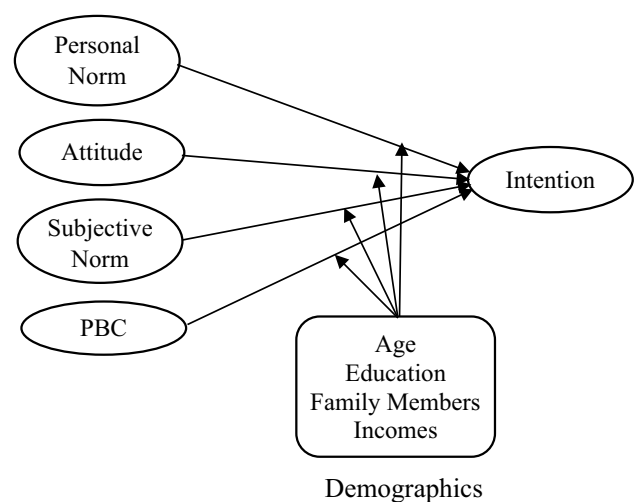

Fig. 1 Conceptual research model

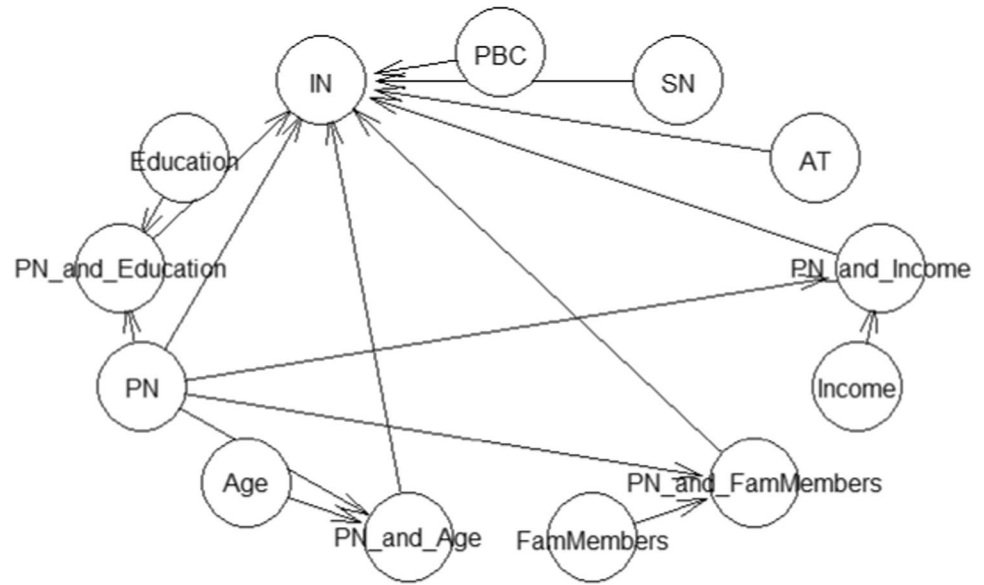**Fig. 2** TPB-NAM-based research framework with Bayesvl package

Table 2 PSIS-LOO goodness-of-fit

k-values	Condition
Below 0.5	Good
0.5–0.7	OK
0.7–1.0	Bad
More than 1	Very bad

Fig. 3 PSIS-LOO diagnostic plot
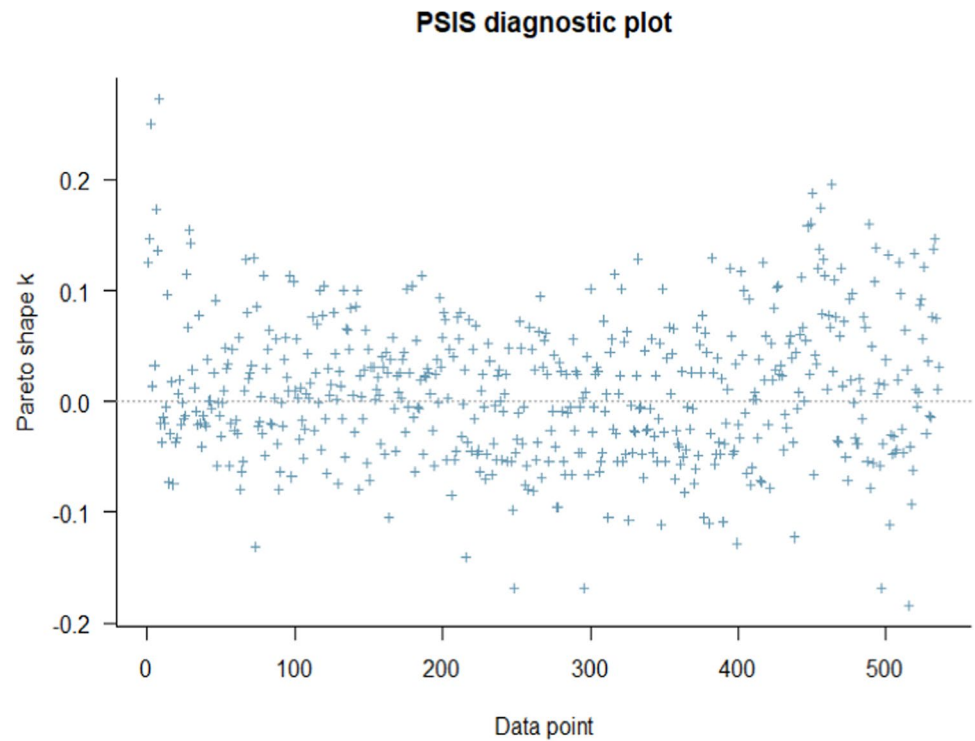
Table 3 Simulated posterior results

Parameters	Mean	SD	n_eff	Rhat
Constant	1.23	0.24	7213	1
Personal norm	− 0.06	0.06	6736	1
Education	0.10	0.01	8947	1
Age	0.04	0.01	13,360	1
Family members	0.01	0.01	9868	1
Income	-0.01	0.01	14,282	1
Attitude	0.17	0.03	10,616	1
Subjective norm	0.05	0.03	12,069	1
Perceived behavioral control	0.10	0.03	11,188	1
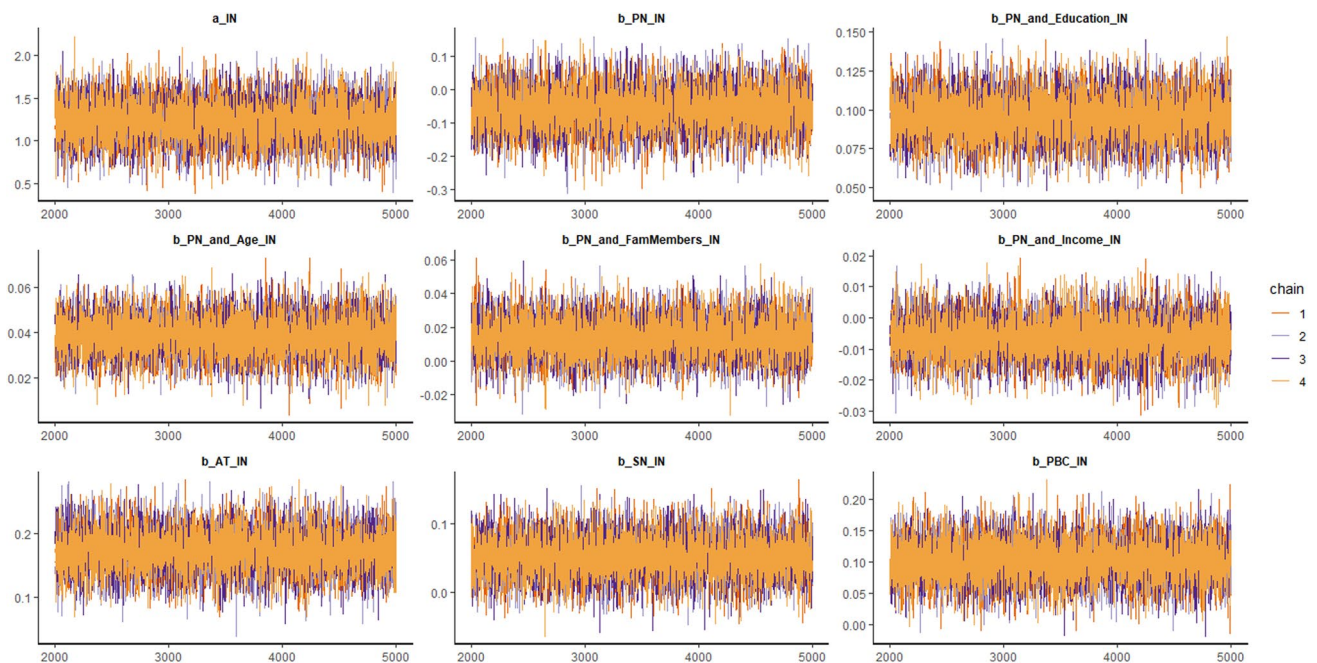
Fig. 4 Trace plots of MCMC draw coefficients in the model

We also use the trace plots of Markov chain to illustrate the Markovchain central limit theorem in Fig. 4. The coefficients' Markov chains oscillate around an equilibrium, which suggests a good signal of convergence.

Similarly, the model's convergence signals can be examined in the Gelman-Rubin-Brook plots (Fig. 5) and autocorrelation plots (Fig. 6). The shrink factors in the Gelman-Rubin-Brook are volatile within the 0–1000 iterations but rapidly reduce to one prior to the 2000th iterations (Fig. 5). The autocorrelation levels achieve nearly zero after a specific number of lag (i.e., 5) in the autocorrelation plots (Fig. 6). Figure 7 illustrates technical validation for the posterior distribution of each variable in the Bayesian regression model.

From the analysis, we found that the personal norm has a negative impact on the intention to use (= − 0.06). However, we discovered the positive association between intention with attitude (= 0.17), subjective norm (= 0.05), and personal behavioral control (= 0.10) (Fig. 8). The association is positively moderated by age, education, and family members, but negatively moderated by income. The posterior distributions in the density plots are distributed on one specific side of the origin (Fig. 9). These associations are also seen reliable.

Fig. 10 illustrates the interaction between independent variables and dependent variables in the moderation role of age, education, family member, and income. The x-axis represents the independent variables, while y-axis indicates the level of intention to use reusable shopping bags. The moderated variables are classified into three groups (+ 1 standard deviation, neutral, and -1 standard deviation). In terms of age, personal norm, attitude and subjective norm
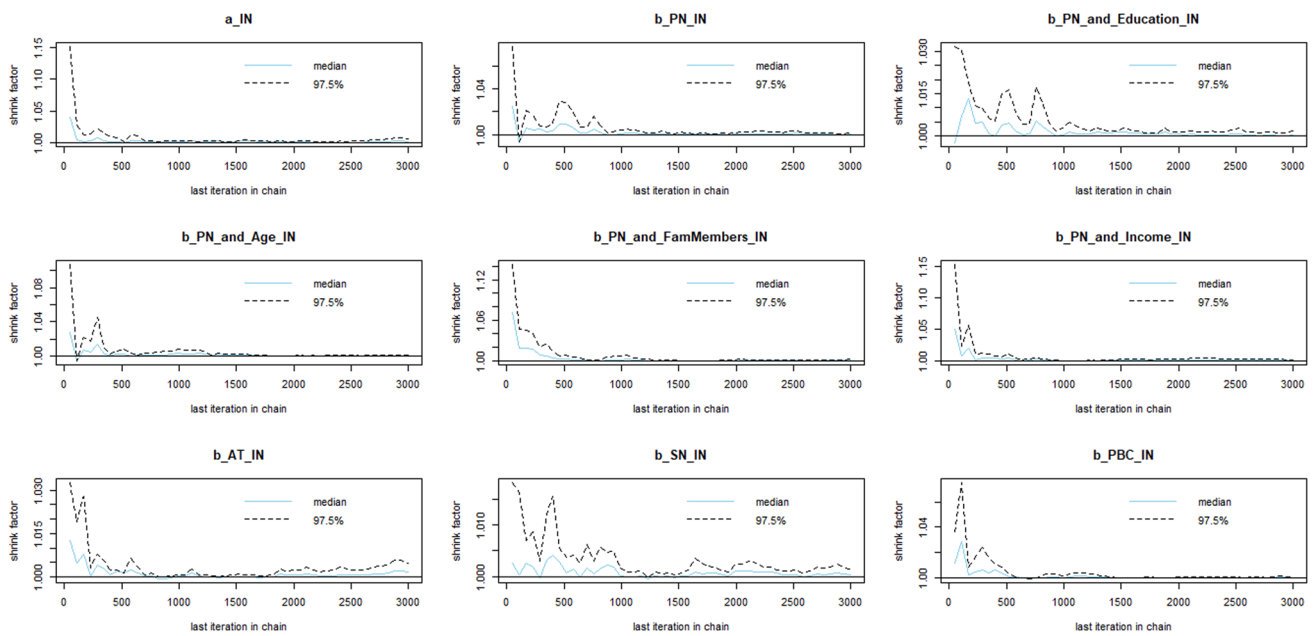
Fig. 5 Gelman-Rubin-Brook plots of the constructed model
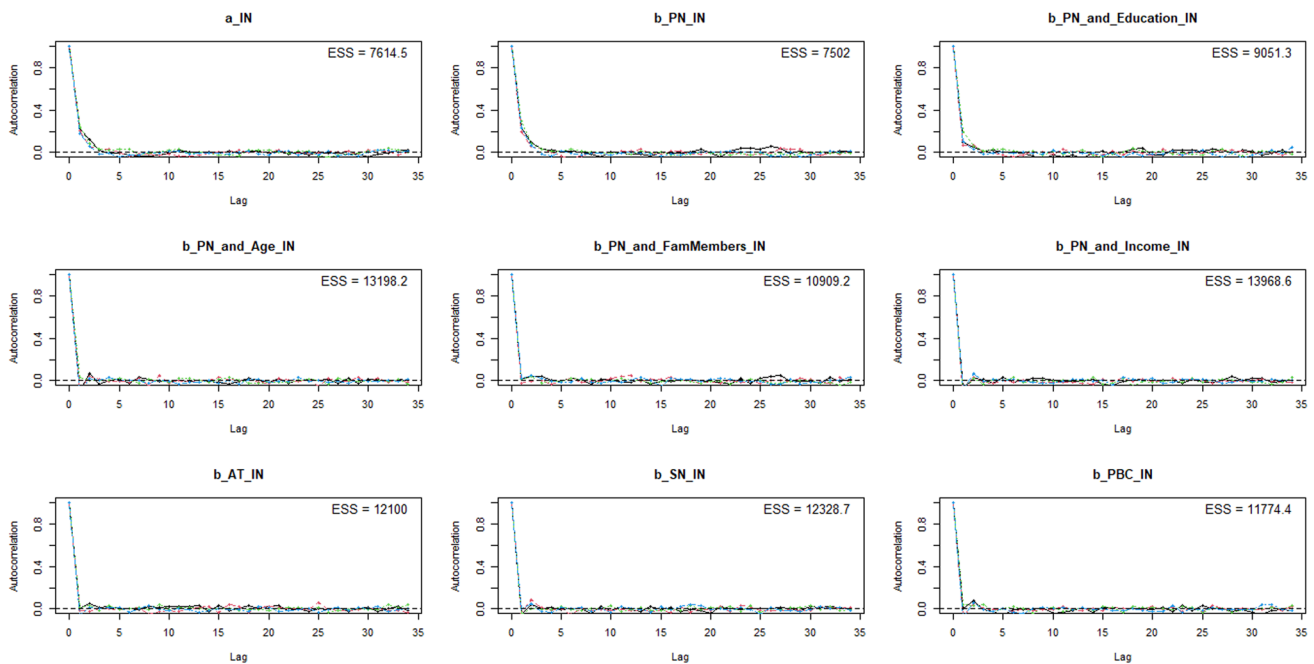

Fig. 6 Autocorrelation functions plots of coefficients

seem to be not moderated by age, but personal behavioral control is positively moderated by age. It means that the elderly tend to control their personal behavior with the intention to use reusable bags rather than young people do. The young generation with the rapid lifestyle do practice their life in quick-temper by using SUP bags.

Given the education qualification, it is clear that the higher level of the educational group has a likelihood to use reusable bags, but the lower level of the education group also intensively increases their intention far more than the educated group, in terms of personal norm. This finding implies the necessity of educating and training the group with lower educational level potentially increasing their intention and behavior. For the family members, the household with few members (1 or 2) under the pressure of subjective norms tend to increase the intention to use reusable shopping
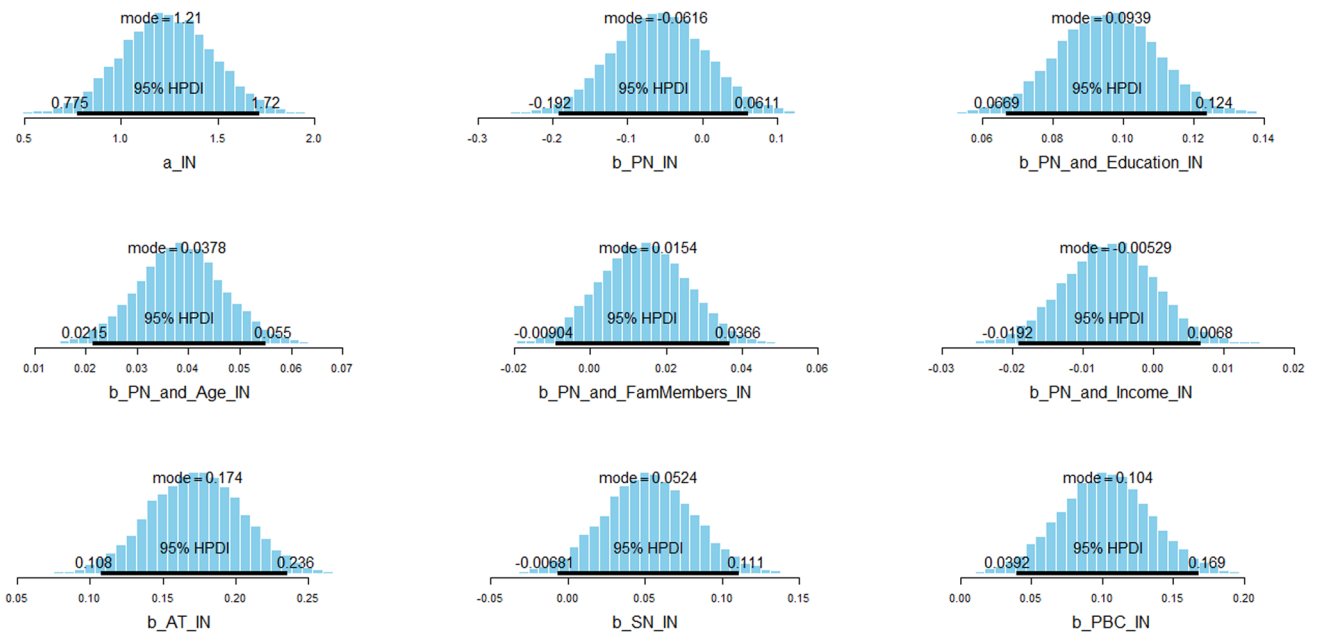
Fig. 7 Posterior distributions of the constructed model
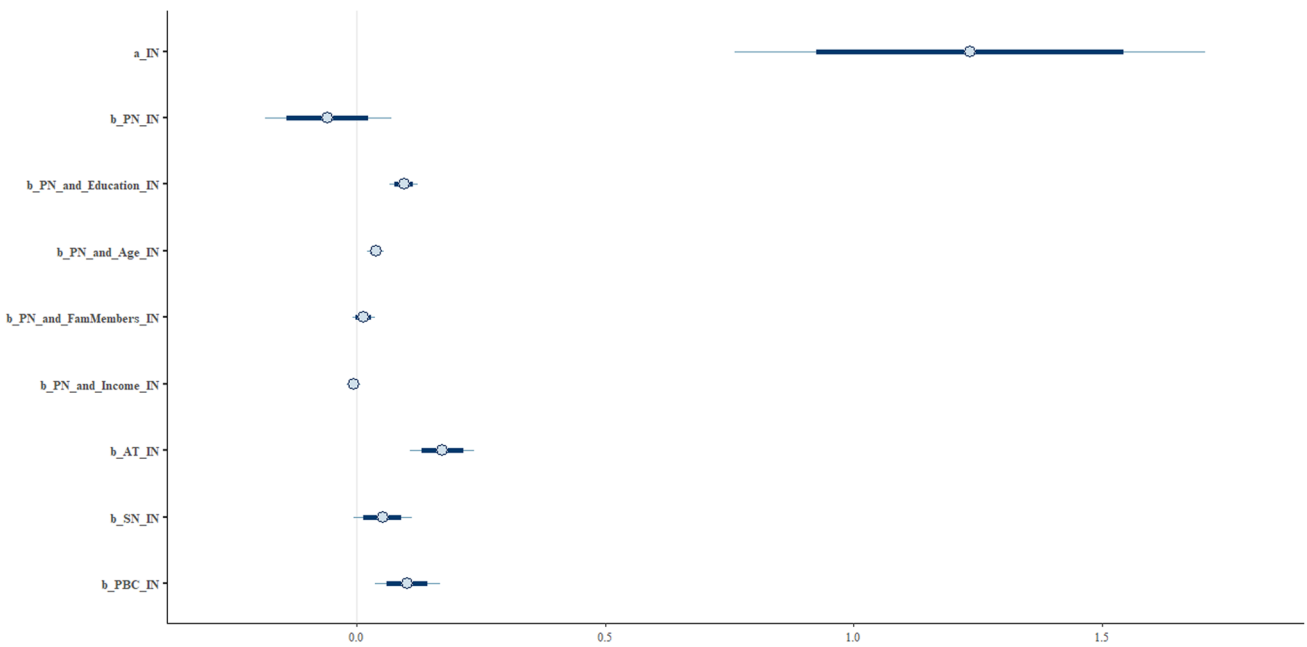
Fig. 8 Interval plots of coefficients

bags rather than other groups. This result indicated that the group with one or two members in the household has a tendency to use reusable shopping bags than the group with three or four members in the household. Finally, under the pressure of subjective norms, groups with high income also use reusable shopping bags. The more income they attain; the more likelihood they use the reusable shopping bags.
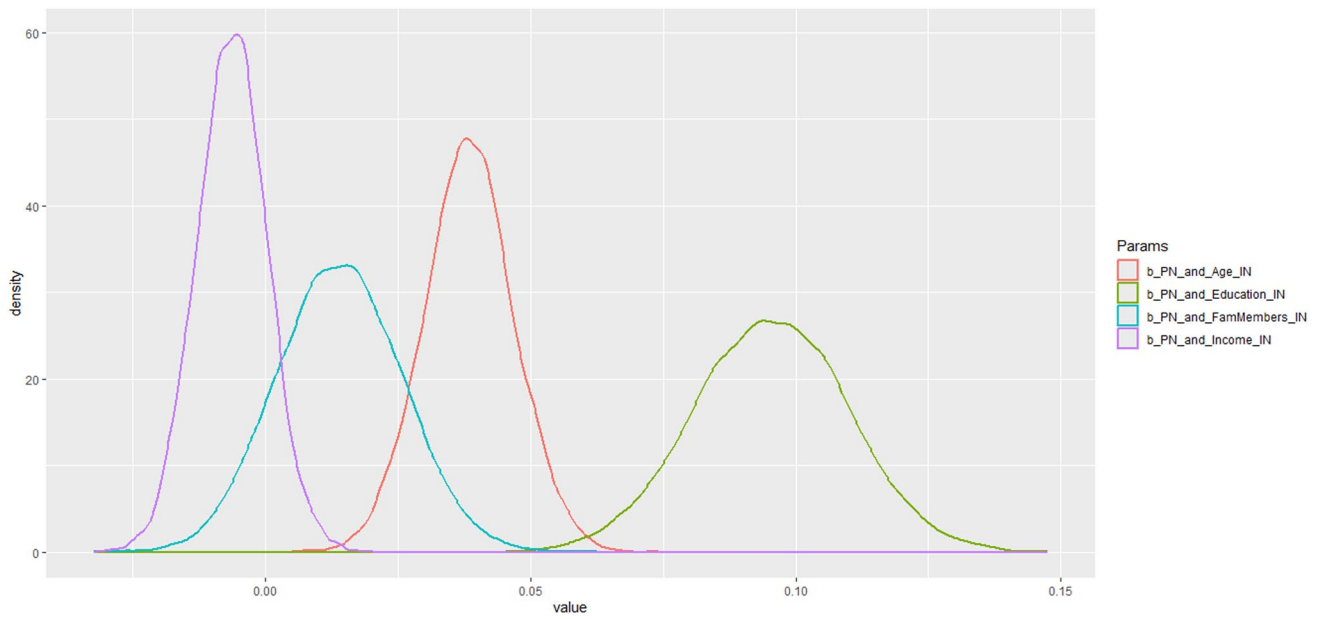
Fig. 9 Density plot 2
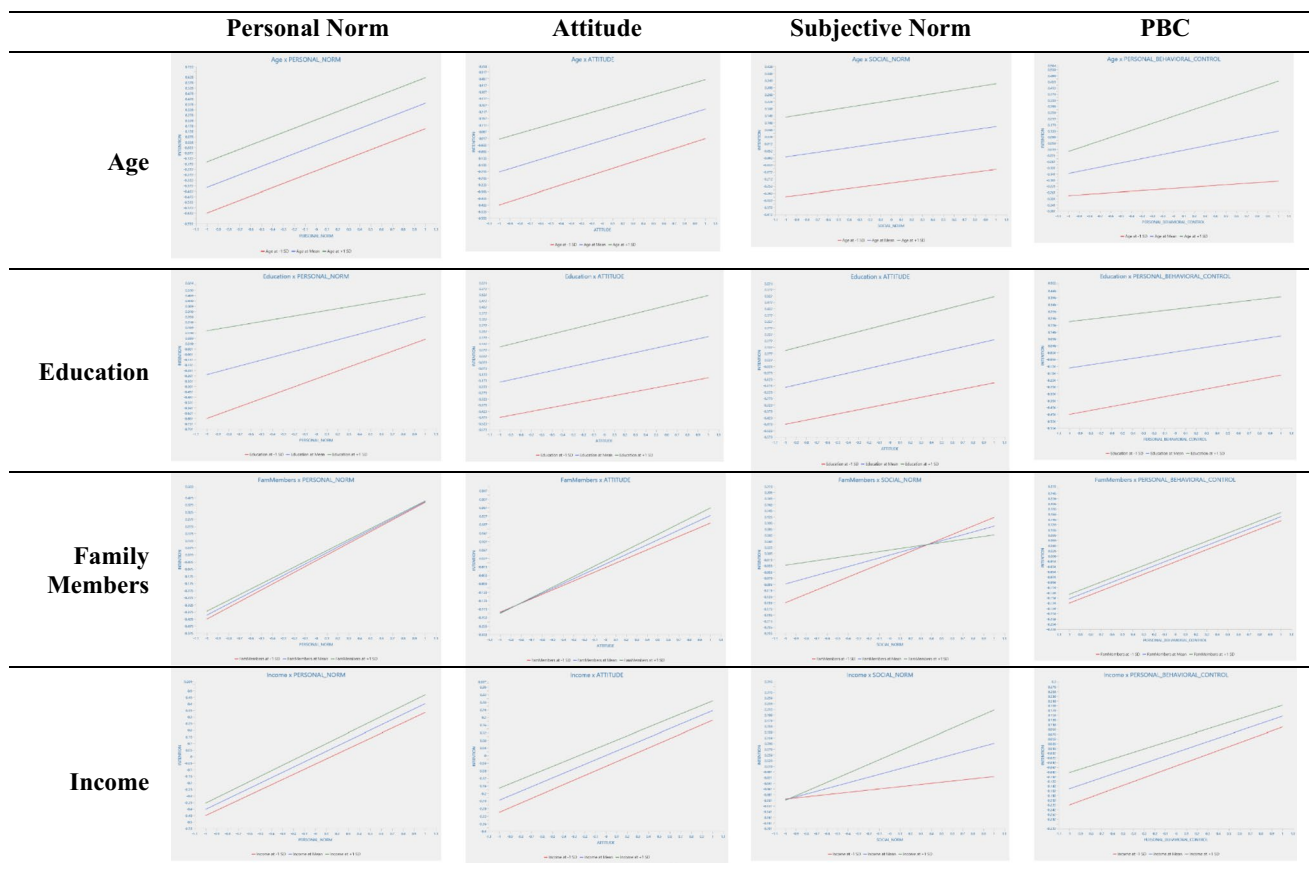
Fig. 10 Interactions among variables and characteristics

4 Discussions

The current study employed the Bayesian Mindsponge framework analysis on the dataset of 536 Vietnamese consumers to examine the non-linear relationship between factors impacting the use of reusable shopping bags in supermarkets. The estimated results suggested that the consumers' attitude toward green consumption is the most influential factor impacting the intention to use. However, the personal norm is negatively associated with intention. As defined in the NAM, personal norm is "as feelings of moral obligation not as intentions" [24]. It can be explained that consumers practice green consumption by using reusable shopping bags in the voluntary way instead of obligating them to do so. It makes sense that people tend to be against what they are forced to do. Therefore, we obtain the negative effect of personal norm on intention to use reusable bags.

The second and third impacts are perceived behavioral control and subjective norms. These results suggested that enhancing the consumers' attitude toward the green economy became important. The authorities should frequently hold workshops and educational programmes to gain the awareness and attitude to sustainable production and consumption. For production, authorities should strengthen the extended producer responsibility (EPR) policy in Vietnam. On the consumption, teaching and training people in sustainable consumption are importantly necessary. Specially, the educational and training programmes should aim to young generations as the moderated result of age suggested in this study, because our finding indicates that the youngers are less likely to use reusable bags. The older shoppers are good at controlling their perceived behavior as compared to the young generations.

It is also obvious that well-educated people pay serious attention to green consumption rather than others. Hence, the national policy at the long-term period should enhance higher education and continue to set education as a national priority. Increasing the rate of undergraduate and graduate learners in Vietnam. In fact, among Southeast Asia, the ratio of students enrolled in higher education institutions is quite low [32]. Hence, strengthening the higher education and addendum of environmental science and climate change in curriculum becomes urgent and significant these days [33]. Overall, increasing awareness and pro-environment behaviors through education at schools and universities is one of the feasible solutions to protect environment, being consistent with [12].

Households with one or two members were strongly influenced by others, while households with three or four members were less influenced by others. In other words, single person or young couples are strongly influenced by others or society in their behaviors. This finding is consistent with the social culture in Vietnam, where the sense of community is highly appraised. They tend to adapt their behavior aligning with social perspectives.

For the income variable, people with high incomes are inclined to be economical and energy-saving behavioral consumption rather than the people with low income. Generally, people with high income are positively associated with higher education. Hence, these people usually practice the pro-social and pro-environmental behavior. Our finding states that affluent people are likelihood to save and highly frequent to use reusable bags. In other words, the more the income per capita increases, the more sustainable people perform.

5 Concluding remarks

This study investigated the driven factors of personal norm, attitude, subjective norm, perceived behavioral control influencing intention to use reusable shopping bags in supermarkets in an emerging country like Vietnam. The associations also were tested the moderation role of age, educational qualification, numbers of family members at households, and personal income. We used the BMF analytics with the dataset of 536 participants in Ha Noi and Ho Chi Minh City of Vietnam [31]. We discovered that personal norms have a negative effect on intention, suggesting that the motivation to bring own shopping bags stems from customers' own awareness, but not the obligation from social perspectives. Among driving factors, attitude has the strongest impact on intention. Therefore, initiatives in training and workshops to enhance the public awareness is significantly necessary. For example, many malls and supermarkets in Hanoi, Ho Chi Minh City, and Da Nang promoted the No Plastic Bag Campaign with the motto "Less Plastic Bags, More Life" in 2024, and accordingly, Hanoi people say no to SUP bags [34].

However, for the long term strategy, policies on restrictions and gradual bans of the plastic bags in supermarkets and retail stores are of importance on terminating the plastic bags by 2030 in Vietnam [2]. From the authorities, a plastic tax or fee should be a considerable action. For the business operations, retailers should consider the

price-reducing tactics when consumers use their own shopping bags. Retailers can either provide shoppers with non-plastic packages (i.e., banana leaves, biodegradable eco-bags, or paper package) or sell the reusable shopping bags at supermarkets to minimize the use of SUP bags [34]. For manufacturing and production, manufacturers have responsibility to protect the environment through Extended Production Responsibility and encourage the use of biodegradable packaging. A feasible solution to reduce plastic pollution not only sticks to consumers, but also all stakeholders should be involved to tackle this wicked problem.

The current research has certain limitations. First, this survey was conducted by direct and online forms in 2020 at the top 10 supermarkets in Hanoi and Ho Chi Minh City [31]. Hence, we call for upgrading the dataset surveyed at the nationwide scope for better generalization and understanding of Vietnamese customers' behaviors. Second, besides the TPB and the NAM, we suggest embracing some of the latest underlying theories in studying pro-environmental behavior (i.e., the theory of interpersonal behavior, and value-belief-norm theory). While this study focuses on behavioral intention, further studies should broaden the understanding of customer behaviors. Finally, additional empirical evidence from international scholars is required to shed light on the mechanism of intention and behavior to use reusable shopping bags across the globe.

Declarations

Appendix

Code

```
functions{
    int numLevels(int[] m) {
      int sorted[num_elements(m)];
      int count = 1;
      sorted = sort_asc(m);
      for (i in 2:num_elements(sorted)) {
        if (sorted[i] != sorted[i-1])
          count = count + 1;
      }
      return(count);
    }
}
data{
    // Define variables in data
    int<lower=1> Nobs;   // Number of observations (an integer)
    real IN[Nobs];   // outcome variable
    int NEducation;
    int<lower=1,upper=NEducation> Education[Nobs];
    real PN[Nobs];
    int NAge;
    int<lower=1,upper=NAge> Age[Nobs];
    int NFamMembers;
    int<lower=1,upper=NFamMembers> FamMembers[Nobs];
    int NIncome;
    int<lower=1,upper=NIncome> Income[Nobs];
    real AT[Nobs];
    real SN[Nobs];
    real PBC[Nobs];
}
transformed data{
    // Define transformed data
    vector[Nobs] PN_and_Education;
    vector[Nobs] PN_and_Age;
    vector[Nobs] PN_and_FamMembers;
    vector[Nobs] PN_and_Income;
    for (i in 1:Nobs) {
        PN_and_Income[i] = Income[i]*PN[i];
    }

    for (i in 1:Nobs) {
        PN_and_FamMembers[i] = FamMembers[i]*PN[i];
    }

    for (i in 1:Nobs) {
        PN_and_Age[i] = PN[i]*Age[i];
    }

    for (i in 1:Nobs) {
        PN_and_Education[i] = PN[i]*Education[i];
    }

}
parameters{
    // Define parameters to estimate
    real<lower=0> sigma_IN;
    real a_IN;
    real b_PN_IN;
    real b_PN_and_Education_IN;
    real b_PN_and_Age_IN;
    real b_PN_and_FamMembers_IN;
    real b_PN_and_Income_IN;
    real b_AT_IN;
    real b_SN_IN;
    real b_PBC_IN;
}
```

```
transformed parameters{
    // Transform parameters
    real mu_IN[Nobs];
    for (i in 1:Nobs) {
        mu_IN[i] = a_IN + b_PN_IN * PN[i] + b_PN_and_Education_IN * PN_and_Education[i] +
b_PN_and_Age_IN * PN_and_Age[i] + b_PN_and_FamMembers_IN * PN_and_FamMembers[i] +
b_PN_and_Income_IN * PN_and_Income[i] + b_AT_IN * AT[i] + b_SN_IN * SN[i] + b_PBC_IN * PBC[i];
    }
}
model{
    // Priors
    a_IN ~ normal(0,100);
    b_PN_IN ~ normal( 0, 10 );
    b_PN_and_Education_IN ~ normal( 0, 10 );
    b_PN_and_Age_IN ~ normal( 0, 10 );
    b_PN_and_FamMembers_IN ~ normal( 0, 10 );
    b_PN_and_Income_IN ~ normal( 0, 10 );
    b_AT_IN ~ normal( 0, 10 );
    b_SN_IN ~ normal( 0, 10 );
    b_PBC_IN ~ normal( 0, 10 );

    // Likelihoods
    IN ~ normal(mu_IN, sigma_IN);
}
generated quantities {
    // simulate data from the posterior
    real yrep_IN[Nobs];
    // log-likelihood posterior
    vector[Nobs] log_lik_IN;
    for (i in 1:num_elements(yrep_IN)) {
      yrep_IN[i] = normal_rng(mu_IN[i], sigma_IN);
    }
    for (i in 1:Nobs) {
      log_lik_IN[i] = normal_lpdf(IN[i] | mu_IN[i], sigma_IN);
    }
}
```

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