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Achieving behavioral intention to renewable energy through perceived costs and benefits and environmental concern

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ABSTRACT

Due to the high pollution caused by the consumption of energy from fossil fuels, governments have implemented policies that allow the transition to renewable sources, but this depends on many factors associated with the costs and attitudes of the population. This study examines the influence of perceived costs, benefits, and environmental concerns on the behavioral intentions toward renewable energy (RE) adoption in Ciudad Juarez, Mexico. A structural equation model is used to validate five hypotheses and information from 511 responses to a survey to explore how perceived costs (PCO) as an independent variable, perceived benefits (PBE), and environmental concerns (ECO) as mediators support intentions to adopt solar energy technologies. Findings reveal that PCO impacts PBE and ECO directly and influences behavioral intentions (BIN) indirectly. This underscores the importance of analyzing PCO in the context of developing countries due to the low per capita income. The study identifies ECO as the most significant factor affecting BIN and PBE as the primary influencer of ECO, suggesting that promoting the benefits of RE could enhance environmental concerns and, consequently, adoption intentions. Sensitivity analysis indicates the necessity of effectively disseminating cost-related information, as costs often overshadow perceived benefits. The findings advocate for clear communication regarding RE costs and benefits and the formulation of supportive policies to facilitate RE adoption in Mexico, highlighting the crucial role of comprehensive awareness strategies in improving public perception and acceptance of RE technologies, providing valuable insights for policymakers, stakeholders, and educators to promote sustainable energy practices.

1. Introduction

Renewable energies have become a fundamental pillar in the fight against climate change and the search for sustainable development. Renewable energies (REs) are those obtained from natural sources that are constantly regenerating, such as the sun, wind, water or biomass (organic matter such as plants and animals) [1]. They are pivotal in the fight against climate change and pursuing sustainable development (Stamatios [2]) and play a crucial role in environmental conservation by reducing greenhouse gas emissions and improving air, soil, and water quality. Economically, REs drive sustainable development, foster job creation, alleviate poverty and reduce consumer financial burdens [3]. They also enhance energy security by decreasing reliance on finite resources and imported energy, mitigating geopolitical tensions and supporting fiscal resilience and political stability [4].

Pursuing renewable energy sources (RES) is a key policy goal for major economies like the U.S., China, and the EU [5]; however, developing nations face significant challenges in advancing RES. These challenges include high upfront costs, long return on investment periods, lack of awareness, and regulatory hurdles, such as fragmented energy policies and monopolistic markets [6]. Additionally, technological barriers, including limited technical expertise and infrastructure,

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further impede progress [7] and economic disparities exacerbate these issues, with high costs and low per capita incomes in developing countries. However, improving communication about the benefits of RES could enhance consumer acceptance and adoption (William P. [8]).

In the context of Mexico, a developing nation, the government has shown support for RES investments through the enactment of several laws aimed at promoting RE and sustainable practices. These include the Law for the Use of Renewable Energies and the Financing of the Energy Transition (LAERFTE), the Energy Transition Law (LTE), the Law for the Promotion and Development of Bioenergy, and the Law for the Sustainable Use of Energy. According to the Ministry of Energy [9], RE's share of the total energy production in Mexico was 29.5% in 2021, which increased to 31.2% by 2023, with projections indicating a rise to 35% by 2024.

Despite these legislative efforts, Mexico faces several challenges in the wider adoption of RES. Gómez-Navarro and Ribó-Pérez [10] identify the prohibitively high cost of capital as a major barrier to fostering entrepreneurship within the RES sector. Additionally, they note the lack of an efficient regulatory agency for REs and a regulatory landscape where the electricity market is under tight control. Mainzer [11] also points out the deterrent effect of lengthy planning and government approval processes for RE projects on potential investors, interpreting this as a sign of limited political commitment, especially in countries with ample non-renewable resources.

In Mexico, research and development in renewable energy sources (RES) is limited, with few institutions involved and much of the discourse occurring in English, creating a barrier for the predominantly Spanish-speaking population. Despite Mexico's favorable geographic and climatic conditions, transitioning from fossil fuels remains challenging; however, international agreements have complicated policy development, balancing economic growth with environmental goals [12]. Although there is growing support for RES projects, this enthusiasm may be more government-driven than widespread among the general populace [13]. High initial costs and an information gap hinder public adoption of RES, with economic concerns often overshadowing the long-term environmental benefits.

Extensive research conducted across various nations has consistently highlighted the impact of perceived benefits on environmental concerns and the intention to engage with RESs; notable examples include studies by Oh et al. [14] in South Korea, Lam and Law [15] in Hong Kong and William Philip Wall et al. [8] in Thailand. Despite this, exploring how the perception of costs influences user engagement with RES in developing countries remains sparse. This gap is particularly pronounced in Mexico, contrasting findings from Streimikiene et al. [16] in Lithuania, underscoring such cost perceptions' significance. The absence of literature analyzing these dynamics within the Mexican context underscores a critical research opportunity; thus, this study introduces a structural equation modeling approach underpinned by homeowner data to bridge this knowledge gap. This model elucidates the interplay between four key constructs: the perception of costs (PCO) as an exogenous variable, with perceived benefits (PBE) and environmental concerns (ECO) us outcome. This conceptual framework was empirically tested through five hypotheses, validated by the analysis of 511 questionnaire responses, offering a novel insight into the determinants of RES engagement in a developing country setting.

The outcomes of this research will enable a detailed quantification of the links between specific variables and behaviors, facilitating the formulation of targeted strategies to enhance the receptivity and purchasing trends toward REs within Mexican society. A distinctive feature of this investigation is the incorporation of a sensitivity analysis, designed to pinpoint potential risks associated with lower levels of certain variables.

Following this introductory segment, the paper is structured as follows: the second section articulates the cost-benefit dynamics; the third section delineates the methodology employed in this study; the fourth section presents the findings and engages in a comprehensive discussion; and the concluding fifth section encapsulates the study's conclusions, offers recommendations, highlights the research limitations, and outlines avenues for future inquiry.

2. Cost-benefit dynamics in renewable energy

In the context of Mexico, a developing country, it is theorized that the interplay between Perceived Costs (PCO) and Perceived Benefits (PBE) significantly informs Environmental Concerns (ECO). These concerns, in turn, play a crucial role in shaping the Behavioral Intentions (BIN) of individuals toward embracing renewable energy (RE) technologies. This conceptual framework is visually represented through Fig. 1, which outlines the hypothesized relationships among these pivotal variables, providing a structured model for understanding the dynamics at play in the decision-making process related to RE adoption.

2.1. *The dynamics between PCO and PBE*

In RE adoption, the interplay between PCO and PBE has been identified as a critical determinant. For instance, research conducted in Malaysia by Zahari and Esa [17], underscored the significance of high RE costs. While the benefits of adopting RE are widely recognized, their direct influence on purchasing decisions is not always statistically significant (William P. [8]), suggesting that the impact of PCO might be more pronounced. This notion is supported by findings from South Korea, where Oh et al. [14] observed that perceived trust and positive emotions towards RE significantly modulate this relationship. In Spain, Marrero et al. [18] further reinforced this argument, indicating that REs engender trust as inexhaustible energy sources, offering consistent supply and enhancing energy security while simultaneously reducing carbon emissions and utility bills.

Moreover, there is a common misconception that RE technologies are complex and difficult to use, largely attributed to insufficient information dissemination and unfamiliarity with their operational mechanisms. For example, a study in Portugal by Pinto et al. [19] found that public perception of REs is predominantly favorable, attributed to their role in reducing air pollution and CO_2 emissions. Thus, despite the perceived high costs associated with REs, users can recognize the benefits related to reductions in utility bills, environmental impact, and improved supply security. Based on these insights, we formulate the following hypothesis for the Mexican context:

H_1. The PCO of generating REs directly and positively influences the PBE among users in Mexico (PCO→REs).

2.2. *The influence of PCO on ECO*

The nexus between environmental concern and user intentions is nuanced, often mediated by perceived utility, usability, and the financial implications for rural inhabitants in Taiwan, as Li and Lin [20] have elucidated. Moreover, environmental consciousness has a discernible impact on consumer behavior, leading to the preference for eco-friendly products and services in Saudi Arabia despite the persistent evaluation of price points before purchase decisions [21]. Concurrently, research from the United States and China illustrates that consumers of environmentally friendly merchandise, such as hybrid vehicles, seek to manifest their environmental awareness through their choices and are inclined to invest a premium on these goods [22].

In the context of Germany, Egli et al. [23] have observed that the financial outlay associated with RE can be prohibitively expensive, impacting environmental considerations among consumers. This financial barrier often necessitates the pursuit of costly financing alternatives or reliance on governmental subsidies to facilitate acquisition. This scenario underscores a dichotomy where individuals recognize RE's environmental and economic advantages in the long term but are constrained by immediate financial limitations. Similarly, Halstead et al.

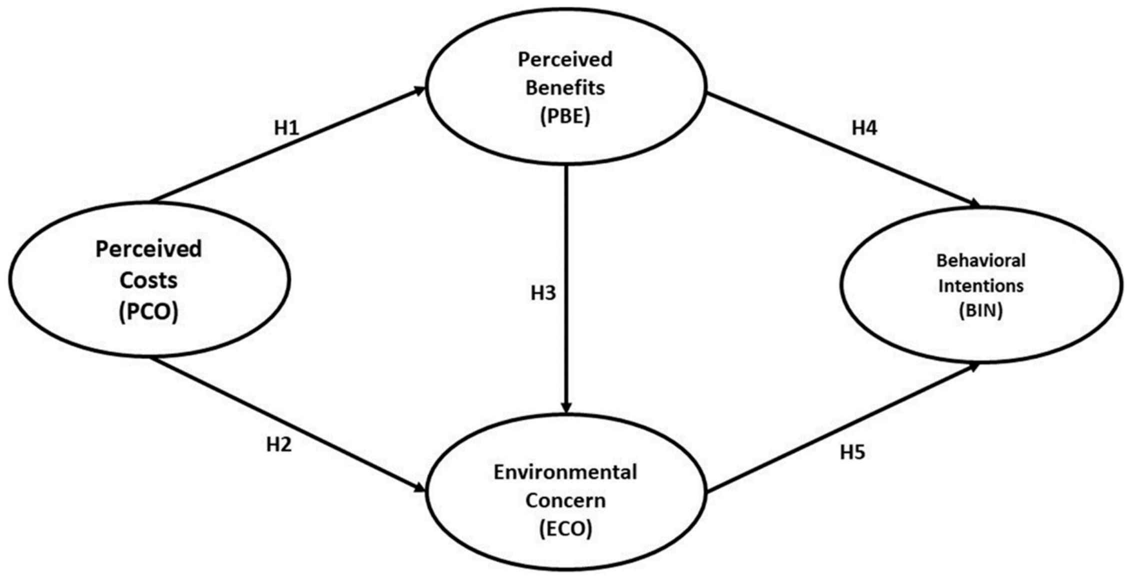

Fig. 1. Model of RE adoption dynamics in Mexico, highlighting the roles of PCO, PBE, ECO, and BIN.

[24] have highlighted that the financing cost for RE initiatives significantly hampers the transition towards renewable sources within Europe, exacerbated by the need for a unified policy framework for RE at a regional level.

In contrast, Kumar et al. [25] in India advocate for governmental and regulatory entities to champion decentralized RE systems' environmental merits and reliability to potential adopters, who are often deterred by the initial high costs rather than the long-term environmental benefits. Nonetheless, in Greece, consumers have demonstrated a willingness to bear higher costs for RE when the environmental gains are made explicit (Stamatios [26]). Based on these considerations, the following hypothesis is posited for the Mexican scenario:

> H_2. The PCO associated with REs directly and positively influences ECO among Mexican users (PCO→REs).

2.3. Relationship between PBE and ECO

In South Korea, increasing awareness of environmental crises has spurred a growing willingness among individuals to engage in eco-friendly actions, including the acceptance of higher costs for green energy [27]. This trend illustrates that individuals acknowledging the environmental advantages of RE exhibit a greater commitment to supporting institutional and government-led environmental initiatives, recognizing the potential for reduced pollution of soil, water, and air as a direct manifestation of their ECO. A similar sentiment is echoed in Japan, where the adoption of RE is seen as beneficial not only for the environment but also for the regional economy. The gradual increase in RE consumption is attributed to a long-term vision where concerned users perceive both environmental and economic benefits, such as lower utility bills and reduced emission levels, as key motivations for their investment in RE [28].

In India, the testimonies of active RE users play a significant role in shaping potential users' environmental concerns, thereby influencing their decisions towards becoming active participants in the RE landscape. Prasath et al. [29] highlight how the shared experiences of benefits from RE usage foster a heightened sense of environmental responsibility among potential adopters. Conversely, Zhu et al. [30] in China found that potential RE users tend to engage in thorough research, leading to increased environmental awareness and a readiness to incur higher costs, referred to as an investment in 'cognitive capital'.

Contrastingly, in Turkey, Madenci et al. [31] suggest that environmental concerns among users are often driven not by the direct perceived benefits of RE, but rather by the adverse implications of inaction. In this scenario, individuals opt for RE not solely for the potential savings on energy bills or the reduction of pollutants but due to a broader concern for the environmental impact of not transitioning to renewable sources. This understanding underscores a willingness to accept higher costs and adjust consumption habits in favor of environmental sustainability. Therefore, the following hypothesis is advanced for consideration in the Mexican context:

> H_3. The PBE of REs significantly influences the ECO of users in Mexico (PBE→REs).

2.4. The influence of PBE on BIN

In Thailand, a range of factors, including perceived energy independence, ECO, awareness about RE, and beliefs in its benefits, have been identified as key determinants shaping consumers' intentions to purchase (William P. [8]). Similarly, in Pakistan, Nazir and Tian [32] observed that intentions towards utilizing REs are influenced by consumers' perceptions of behavioral control, usability of RE technologies, their comparative advantages, associated costs, and ECO. Furthermore, Lin et al. [33] in Taiwan have shown that ECO impacts individuals' subjective norms or personal standards, influencing their willingness to engage in sustainability-oriented endeavors. Nevertheless, for these perceived benefits to translate into concrete purchase intentions, confidence in the reliability and effectiveness of RE technologies must be bolstered. Immature or unproven technologies are perceived as risky, potentially deterring investment and diminishing support for policy initiatives aimed at energy transition, as demonstrated in South Korea by Oh et al. [14].

Extensive research grounded in the Theory of Planned Behavior has linked PBE to BIN, revealing that sociopsychological factors, such as environmental attitudes and perceived behavioral control, about REs significantly influence purchase intentions in Vietnam [34]. Moreover, Irfan, Zhao, et al. [35] in Pakistan emphasize that spreading awareness about the benefits of REs through various channels is essential for enhancing BINs, given that such intentions and the associated ECO stem from informed knowledge.

A notable perceived advantage of RE adoption in Europe is the region's limited reserves of non-renewable resources like oil and gas. Consequently, the high costs of energy imports, energy dependence, and sectorial reliance on imported energy markedly sway BINs [36]. Public opinion polls in Ireland reflect favorable attitudes towards REs, crediting their perceived benefits. However, the sluggish proliferation of RE technologies in many jurisdictions is hampered by the extensive bureaucratic processes that deter societal motivation. Based on these insights, the following hypothesis is proposed:

H_4. The PBE of REs directly and positively impacts the BIN of users in Mexico (PBE→REs).

2.5. The connection of ECO and BIN

Research from Thailand highlights that ECO significantly enhances the intent among consumers to invest in RE technologies (William P. [8]). In China, it has been demonstrated that attitudes, moral norms, and perceived behavioral control are pivotal in molding consumers' intentions toward RE purchases, showcasing the critical role ECO plays in shaping behaviors toward RE adoption [37]. This behavioral inclination is deeply rooted in prior environmental awareness, as evidenced by studies showing that environmental attitudes, perceived behavioral control, and subjective norms are influential in the decision to adopt eco-friendly products like water heaters and alternative fuel vehicles in China, thus highlighting the significant impact of ECO on intentions to adopt RE products [38].

In Turkey, the mediation role of users' environmental norms between global environmental perceptions and energy-saving behaviors further underscores the importance of ECO in fostering pro-environmental actions and intentions [39,40]. Beyond individual consumer behavior, the effect of ECO on collective BIN towards RE technologies has been observed. In Pakistan, findings by Shakeel and Rahman [41] illustrate that subjective norms, perceived behavioral control, and positive attitudes towards RE technologies significantly influence group intentions towards their usage. Khalid et al. [42] further affirm that environmental concerns influence the production and adoption rates of RE technologies and position them as a dependable alternative to fossil fuels, underpinning environmental preservation efforts. Given the evidence from various geographical contexts illustrating a significant linkage between environmental concerns and intentions towards adopting RE technologies, the following hypothesis is formulated for the Mexican scenario:

H_5. ECO has a direct and positive influence on the BIN of individuals towards REs in Mexico (ECO→BIN).

3. Methodology

3.1. Design of a questionnaire

To substantiate the hypotheses delineated in Fig. 1, an extensive literature review was conducted to gather insights from global analogous studies focusing on similar variables. This review facilitated the identification and extraction of relevant items for the following variables:

- Perceived Costs (PCO): Inspired by the findings of Irfan, Elavarasan, et al. [43] and Jabeen et al. [44].
- Perceived Benefits (PBE): Based on the research by Asif et al. [37].
- Environmental Concern (ECO): Derived from studies by Asif et al. [37] and Jabeen et al. [44].
- Behavioral Intentions (BIN): Informed by Jabeen et al. [44], Lin and Qiao [45], and Taneja and Ali [46].

A preliminary questionnaire was designed, comprising two segments: one to gather demographic data (optional) and another dedicated to the variables of interest (mandatory). Given its derivation from international studies, a panel of regional experts underwent a validation process to ensure the questionnaire's applicability to the Mexican context. This panel included four academics, three RE users, and two RE technology providers. They assessed the questionnaire's relevance, conceptual clarity, phrasing, appropriateness of language, and overall structure based on criteria by Kisokanth et al. [47]. The feedback obtained was analyzed using Hernández-Nieto [48]'s algorithm to establish content validity, leading to the refinement of the questionnaire.

The final questionnaire and the project that supported it were reviewed by the Institutional Research Ethics Committee and approved by resolution CEI-2022–1–613 on May 20, 2023. This allowed it to be applied according to the Declaration of Helsinki for experiments involving human participation, and a copy appears as supplementary material.

The questionnaire had two sections. First section was focused on demographic information from responders and was made optional to ensure the participants' privacy, while responses to the second section was aimed to respond the variables analyzed and was mandatory to avoid missing values. Responses were measured on a five-point Likert scale, ranging from 1 (never) to 5 (always) always [49], following the methodology utilized by Alam et al. [50] in their study on RE implementation challenges in Malaysia. See the questionnaire used as supplementary material.

3.2. Sampling and questionnaire distribution

The target demographic for the questionnaire comprised Mexican homeowners who have adopted solar energy solutions via photovoltaic cells in their residences. To facilitate the distribution of the questionnaires, they were hosted on the Google Forms platform, allowing quick and easy access. In addition, an email was sent, and a QR code was generated and distributed, allowing participants to access the survey easily from their mobile devices. Real estate agents played a key role in identifying potential participants and distributing the questionnaires. These participants were specifically chosen based on their recent acquisition of housing units equipped with RE installations.

A description of the research objective was added to the online questionnaire, indicating that the information obtained would be anonymous, used confidentially and grouped in academic and scientific reports. A question was added to the beginning, inviting the respondent to participate; if he/she accepted, the system allowed him/her to continue to the first section of the questionnaire (demographic) and start answering it, but if he/she did not accept, the respondent could not answer it and was sent to the end of the questionnaire, thanking him/her for his/her time.

An invitation via email was dispatched to 1897 identified potential respondents, incorporating a direct link to the online questionnaire. A follow-up email was issued 15 days after the initial invitation to those who had not yet responded. If no response was received after three successive reminders, the potential respondent was excluded from the study. The survey window spanned from October 10th to December 10th, 2023, after which the online platform was closed, and the collected data were downloaded in a CSV file format. This dataset was then imported into Excel for initial processing and subsequently transferred to SPSS version 25 [51] for comprehensive analysis.

3.3. Data cleaning and validation process

Prior to the data analysis phase, a rigorous data cleaning and validation procedure was implemented on the collected dataset as follows:

- Extreme Value Identification: Standardization was applied to each item within the survey's second section. Absolute values exceeding four were deemed outliers and subsequently replaced with the median value of the responses, as per Hoffman [52]'s guidelines.
- Detection of Disengaged Respondents: The standard deviation for responses in the second section was calculated for each item.

Responses exhibiting a standard deviation lower than 0.5 were considered to reflect a lack of respondent engagement and were thus excluded from further analysis, aligning with the approach recommended by Meade and Craig [53].

Following the data purification stage, the latent variables within the dataset underwent validation employing a set of indices as suggested by Kock [54], which included:

- Parametric Predictive Validity: Assessed using the R^2 and adjusted R^2 values, with acceptable thresholds set above 0.02.
- Nonparametric Predictive Validity: Evaluated via Q^2 values, where any values above zero and surpassing the R^2 values was deemed acceptable.
- Internal Validity: Determined through Cronbach's alpha and the composite validity index, with the criterion for acceptance being values exceeding 0.7.
- Convergent Validity: Validated using the Average Variance Extracted (AVE) and factor loadings, with benchmarks set at values greater than 0.5 and 0.7, respectively, for acceptance.
- Collinearity Assessment: Conducted via the Variance Inflation Index (VIF), with values below 3.3 indicating acceptable levels of collinearity among items within the latent variables.

It is noteworthy that some indices, such as the Cronbach's alpha index, underwent iterative adjustments. This process entailed the strategic removal of certain items that, when excluded, contributed to an enhancement of the index's value. Additionally, items influencing collinearity within variables were identified and removed to refine the overall validity.

3.4. Application of structural equation modelling

To rigorously examine and statistically test the hypothesized interrelations among the variables, Structural Equation Modeling (SEM) technique was employed since it can handle complex models where variables perform both as dependents and independents simultaneously. SEM's capability to dissect these multifaceted relationships has been previously leveraged in studies such as the one by Nazir and Tian [32], which explored the factors driving RE purchase intentions in Pakistan. The SEM was evaluated using the Partial Least Squares (PLS) since it is recommended when information is in ordinal data scales, smaller sample sizes, or data normality is absent [55]. Thus, the PLS-SEM technique was utilized to statistically validate the proposed hypotheses according to Hair et al. [56].

3.4.1. Model evaluation and determination of sample adequacy

The analysis through PLS-SEM was conducted using WarpPLS version 8.0 software, setting a confidence level of 95%. Prior to interpreting the results, the model's robustness was assessed against efficiency indices as outlined by Kock [54]:

- Average Path Coefficient (APC) was scrutinized to affirm the model's hypothesized paths, with a requisite p-value below 0.05 for validation.
- Average R-Squared (ARS) and Adjusted Average R-Squared (AARS) were evaluated for their predictive validity, where associated p-values were expected to be under 0.05.
- The Average Variance Inflation Index (AFVIF) and the Complete Average Variance Inflation Index (CAFVIF) served as indicators of multicollinearity, with acceptable values capped at less than 5.
- Tenenhaus GoF (Goodness of Fit) index was employed to gauge the model's fit to the data, with a threshold value set above 0.36 for satisfactory fit.
- The Jarque-Bera index was applied to justify the use of the PLS-SEM approach through the assessment of data normality.

Furthermore, the adequacy of the sample size for PLS-SEM analysis was verified by employing the inverse square root and gamma-exponential methods suggested by Kock and Hadaya [57] integrated in WarpPLS v.8. These methods calculate the minimum sample size based on the smallest regression parameter present in the variable relationships, ensuring the statistical power and reliability of the analysis.

3.4.2. Evaluation of direct effects

Direct effects are crucial for the empirical validation of the study's hypotheses, quantified by a standardized beta (β) coefficient. This coefficient reflects the change in the dependent variable's standard deviations in response to a single-unit change in the independent variable [55]. To statistically validate these relationships, the null hypothesis (H_0: $\beta=0$) was tested against the alternative (H_1: $\beta\neq0$) at a 95% confidence interval. A β value significantly different from zero implies a substantive relationship between the variables in question. Alongside, the R-squared (R^2) value for each dependent variable provides insight into the proportion of variance explained by the independent variables. Additionally, the effect size (ES) is reported to assess the individual impact of variables, with the cumulative ES equating to the R^2 value.

Graphical representations of non-standardized data show direct impacts between factors, enabling β value changes and impact assessment. This study helps identify optimal reaction triggers, guiding resource allocation to improve results.

3.4.3. Indirect and total effects

Indirect effects manifest through mediating variables like PBE and ECO, depicting the influence of one variable on another via one or more intermediaries within the model. This study focuses on the aggregate of indirect effects, assessed through the standardized β coefficient, subject to similar statistical validation as direct effects. The sum of direct and indirect effects yields the total effect between variables, with reported standardized β values, p-values for statistical relevance, and ESs [58].

3.4.4. Sensitivity analysis

Utilizing WarpPLS v.8, the study conducts a sensitivity analysis by calculating and reporting the occurrence probabilities of standardized variables to gauge low-level variable risks [59]. A variable is deemed to have a low occurrence probability if its standardized value is less than minus one ($P(Z<-1)$), and a high probability if it exceeds one ($P(Z>1)$). Reported probabilities in this study include:

- The chance of observing either a dependent or independent variable individually at its extreme low or high state, specifically $P(Z<-1)$ for low and $P(Z>1)$ for high occurrences.
- The likelihood of concurrent extreme states between two variables, capturing scenarios where both are low ($P(Z_i<-1)$ and $P(Z_d<-1)$), one is low and the other high ($P(Z_i<-1)$ and $P(Z_d>1)$, $P(Z_i>1)$ and $P(Z_d<-1)$), and both are high ($P(Z_i>1)$ and $P(Z_d>1)$).
- The conditional probabilities of witnessing the dependent variable at an extreme level (high or low), given the independent variable's state has already been occurred as either high or low. These are articulated as $P(Z_i<-1)\backslash P(Z_d<-1)$, $P(Z_i<-1)\backslash P(Z_d>1)$, $P(Z_i>1)\backslash P(Z_d<-1)$, and $P(Z_i>1)\backslash P(Z_d>1)$.

4. Results

4.1. Descriptive analysis

In this study, a comprehensive collection of 511 responses to the distributed questionnaire was obtained, offering a detailed glimpse into the demographic and residential ownership characteristics of the participants. The gender distribution among the respondents was diverse, with 211 identifying as female, 297 as male, and a minimal subset of three respondents opting to abstain from revealing their gender. An overwhelming majority, 402 individuals (which represents 78.67% of the total respondents), indicated complete ownership of their residences, as opposed to the 109 individuals (21.33%) still in the process of mortgage repayment. A significant portion, 480 respondents (making up 93.93% of the total), had been homeowners for a period exceeding a decade, contrasting with a smaller group of 31 respondents (6.07%) who had a shorter homeownership experience of less than ten years.

Employment status emerged as a critical factor, with 100% of the survey participants being employed at the time of responding. The employment sectors were notably varied, highlighting the cross-industry interest in RE solutions. Specifically, a majority of 54.2% were engaged in the automotive industry, underscoring its prominence within the respondent pool. This was followed by 23.9% of respondents working in the medical field and 8.5% in the electronics sector, illustrating the wide-reaching relevance and application of RE technologies across diverse professional fields. Demographic information of the respondents can be found in Table 1.

4.2. Assessing the validity of construct measures

Table 2 presents the validation metrics for the constructs under study, highlighting that the R-squared, adjusted R-squared, and Q-squared values confirm robust parametric and non-parametric predictive validity according to the cut-off value. Furthermore, indicators of internal consistency, such as Cronbach's alpha and composite reliability, exhibit satisfactory levels, affirming the constructs' internal validity. The average variance extracted (AVE) values exceed the threshold of 0.5, ensuring adequate convergent validity, while the variance inflation factors (VIF) remain below the critical value of 5, eliminating concerns over multicollinearity. These findings justify the interpretability of the PLS-SEM results.

4.3. Model validation

The integration of variables into the SEM framework facilitated the derivation of efficiency and quality metrics, as delineated in Table 3. The analysis revealed that the model possesses interpretability, underscored by the statistical significance of the p-values for Average Path Coefficient (APC), Average R-squared (ARS), and Average Adjusted R-squared (AARS), all of which fall below the 0.01 threshold, thereby affirming predictive validity. Additionally, the Average Variance Inflation Factor (AVIF) and the Average Full Collinearity VIF (AFVIF) registered values of 1.298 and 1.766, respectively, effectively dispelling concerns about collinearity by not exceeding the 3.3 benchmark. The Tenenhaus Goodness of Fit (GoF) index stood at 0.479, signaling a satisfactory data alignment with the proposed model.

Table 1
Demographic information.

Variable		Frequency	Percentage
Gender	Female	180	41.30%
	Male	253	58.10%
Age	18–29	435	85.10%
	30–39	44	8.60%
	40–49	23	4.50%
	50–65	9	1.80%
Marital status	Single	435	85.10%
	Married	42	8.20%
	Free union	26	5.10%
	Widower	2	0.40%
	Divorced	6	1.20%
Number of children	0	427	83.60%
	1 a 2	69	13.50%
	3 a 4	14	2.70%
	5 or more	1	0.20%

Table 2
Construct validation summary.

	ECO	PBE	BIN	PCO	Best if
R-squared	0.283	0.183	0.559	–	>0.02
Adj. R-squared	0.280	0.181	0.557	–	>0.02
Composite reliab.	0.902	0.953	0.936	0.819	>0.7
Cronbach's alpha	0.854	0.943	0.915	0.705	>0.7
Avg. Var extract AVE	0.696	0.716	0.746	0.531	>0.5
Full collin VIF	1.581	1.980	2.245	1.258	<3.3
Q-squared	0.282	0.183	0.559	–	>0
Normality JB	No	No	No	No	–

Table 3
Model evaluation and quality indices.

Index	Value	p-value	Best if
Average path coefficient (APC)	0.380	$p < 0.001$	$p < 0.05$
Average R-squared (ARS)	0.342	$p < 0.001$	>0.02
Average adjusted R-squared (AARS)	0.339	$p < 0.001$	>0.02
Average block VIF (AVIF)	1.298		<3.30
Average full collinearity VIF (AFVIF)	1.766		<3.30
Tenenhaus GoF (GoF)	0.479		>0.36

4.4. Direct effects and hypothesis validation

The structural equation model's assessment is visually represented in Fig. 2, showcasing the beta (β) coefficients that quantify the relationships among variables, alongside the effect sizes and corresponding p-values, substantiating the statistical significance of all examined effects. Prior to delving into the interpretation of the model, it was imperative to ascertain an adequate sample size. The determination was based on the minimal β value of 0.240 observed in the PCO to ECO linkage, calculated under a significance threshold of 0.05 and a power level of 0.90. The Inverse Square Root Method suggested a requisite sample size of 149 units, while the Gamma Exponential Method indicated a need for 133 units. These requirements were comfortably exceeded by the actual sample size of 511 responses.

Fig. 2 elucidates on the model evaluated, illustrating, for instance, that PCO exerts a direct and positive influence on PBE, characterized by a β coefficient of 0.427 and a p-value less than 0.001. This suggests that a one-unit standard deviation increase in PCO translates to 0.427 units increase in PBE. Table 4 encapsulates the derived insights for each tested hypothesis and the effect size (ES) evaluations. Table 4 summarizes the outcomes of hypothesis testing within the structural equation model analysis, detailing the direct effects and significant relationships between variables. It highlights the β coefficients, p-values, and effect sizes, demonstrating the statistically significant and positive impacts of independent variables on dependent ones across all tested hypotheses. This concise presentation not only validates the structural equation model but also elucidates the intricate dynamics within the studied phenomena. The acceptance of all hypotheses, underpinned by strong statistical significance and practical effect sizes, reinforces the theoretical framework and offers actionable insights. Moreover, Fig. 2 associates each dependent variable with an R-squared (R^2) value; for instance, BIN's R^2 of 0.559 signifies that 55.9% of its variance is explained by ECO and PBE acting as independent variables, with PBE and ECO contributing 37.7% and 18.2%, respectively, as indicated by ES values in Fig. 2.

4.5. Analysis of indirect and total effects

The model revealed three statistically significant indirect effects among the variables, as detailed in Table 5. Notably, while PCO does not directly influence BIN, it exerts an indirect impact via PBE and ECO, serving as mediators. This indirect effect is quantified by a beta (β) coefficient of 0.306, accounting for 11.1% of the variance observed in their relationship.

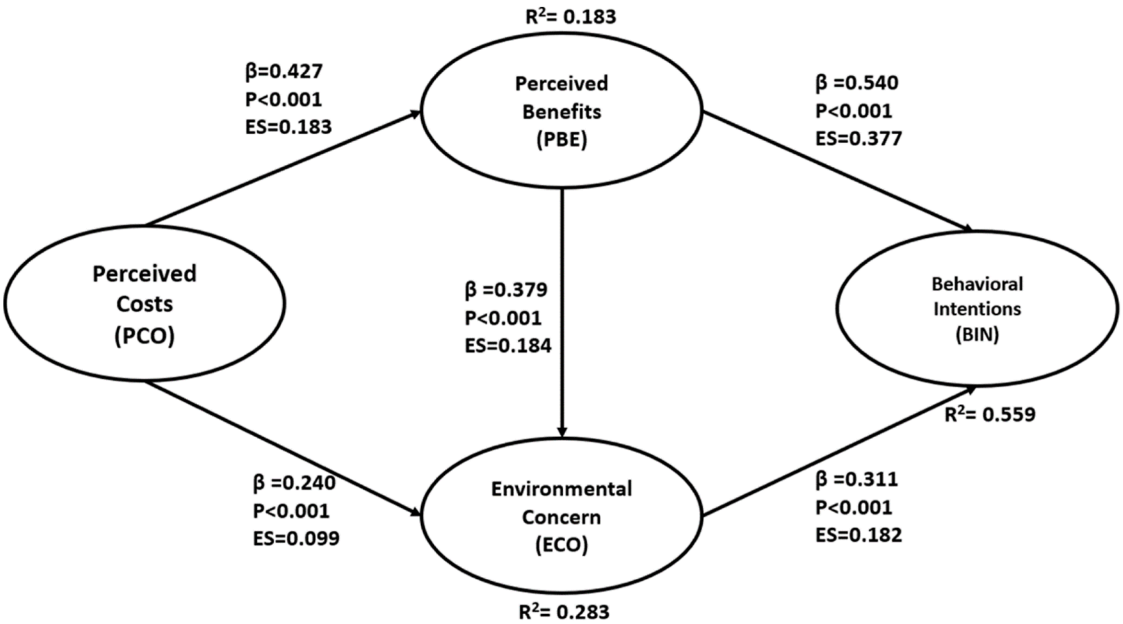

Fig. 2. Model evaluated.

Table 4
Summary of hypothesis testing outcomes highlighting direct effects and relationships between variables.

Hypothesis	Independent variable	β(p-value)	EN	Conclusion
H_1	PCO→PBE	0.427 ($p < 0.001$)	0.183	Accept
H_2	PCO→ECO	0.240 ($p < 0.001$)	0.099	Accept
H_3	PBE→ECO	0.379($p < 0.001$)	0.184	Accept
H_4	PBE→BIN	0.540($p < 0.001$)	0.377	Accept
H_5	ECO→BIN	0.311($p < 0.001$)	0.182	Accept

Table 5
Quantitative assessment of indirect relationships in the structural model.

Relation	Mediating variables	β	P-value	EN
PCO→ECO	PBE and ECO	0.162	<0.001	0.066
PCO→BIN	PBE and ECO	0.306	<0.001	0.111
PBE→BIN	ECO	0.118	<0.001	0.082

Furthermore, Table 6 enumerates the total effects exerted by variables, integrating both direct and indirect influences. It is critical to note that for some relationships, the total effects are synonymous with direct effects, attributable to the absence of indirect influences, such as between ECO and BIN.

4.6. Conducting a sensitivity analysis

Table 7 provides a detailed sensitivity analysis for the direct effects observed among the variables, focusing on the likelihood of these variables manifesting at different levels—both low, denoted by P($Z<-1$) and represented with a "−", and high, denoted by P($Z > 1$) and represented with a "+". This analysis extends to examine the isolated occurrence probabilities of these conditions, their joint occurrence (denoted by "&"), and the conditional probabilities indicating the likelihood of the dependent variable's occurrence, contingent upon the manifestation of the independent variable (denoted by "IF"). This analytical approach provides a nuanced understanding of the direct effects within the model, highlighting the complex probabilities that define the relationships between variables. Such insights are invaluable for interpreting the model's dynamics and for predicting how changes in one variable might ripple through to affect others, thereby offering a richer perspective on the underlying mechanisms of the model.

Table 6
Comprehensive overview of total effects within the SEM.

To	From		
	PCO	PBE	ECO
PBE	0.427 ($p < 0.001$) ES= 0.183		
ECO	0.402 ($p < 0.001$) EN=0.165	0.379 ($p < 0.001$) EN=0.184	
BIN	0.356 ($p < 0.001$) EN=0.129	0.658 ($p < 0.001$) EN=0.459	0.311 ($p < 0.001$) EN=0.182

For instance, the probability of observing PCO at a high level (PCO+) in isolation is 0.170, contrasting with a 0.160 probability for observing PCO at a low level (PCO−) under similar conditions. Furthermore, the probability of both PCO+ and PBE+ occurring simultaneously stands at 0.049, yet the probability of PBE+ given that PCO+ has occurred is 0.287, illustrating a relatively modest value.

5. Discussion

5.1. Interconnection of PCO with PBE

The empirical findings reveal a clear and positive correlation between Perceived Costs (PCO) and Perceived Benefits (PBE) among RE users in Mexico. Specifically, an increment in PCO by a single unit of standard deviation results in a 0.427 increase in PBE, accounting for as much as 18.3% of its variance. This discovery aligns with the assertions made by Stylidis et al. [60], who posited that perceived costs serve as either a motivator or a deterrent in the adoption of RE solutions and Kamal et al. [61], who indicate that economic analysis regarding investment and returns are the most important. This is predicated on the understanding that when potential users are informed about the initial investments required, they concurrently evaluate the social, environmental, and economic returns these investments might yield. Fig. 3 illustrates the PCO→PBE relationship on a non-standardized scale, showcasing variable β values across different segments. It is noted that PCO exerts a significant influence on PBE, with β values recorded at 1.33 and 1.14, respectively, both surpassing the baseline of one.

Table 7
Detailed sensitivity analysis of direct effects among variables.

To	Probability	From					
		PCO+ 0.170	PCO- 0.164	ECO+ 0.170	ECO- 0.160	PBE+ 0.164	PBE- 0.160
PBE+	0.164	&=0.049 IF=0.287	&=0.018 IF =0.107	–	–	–	–
PBE-	0.160	&=0.008 IF=0.046	&=0.068 IF=0.417	–	–	–	–
ECO+	0.170	&=0.035 IF=0.207	&=0.029 IF=0.179	–	–	&=0.063 IF=0.381	&=0.014 IF=0.085
ECO-	0.160	&=0.010 IF=0.057	&=0.080 IF=0.488	–	–	&=0.022 IF=0.131	&=0.078 IF=0.488
BIN+	0.188	&=0.053 IF=0.310	&=0.018 IF=0.107	&=0.086 IF=0.506	&=0.008 IF=0.049	&=0.098 IF=0.595	&=0.008 IF=0.049
BIN-	0.114	&=0.008 IF=0.046	&=0.057 IF=0.345	&=0.004 IF=0.023	&=0.063 IF=0.390	&=0.004 IF=0.024	&=0.072 IF=0.451

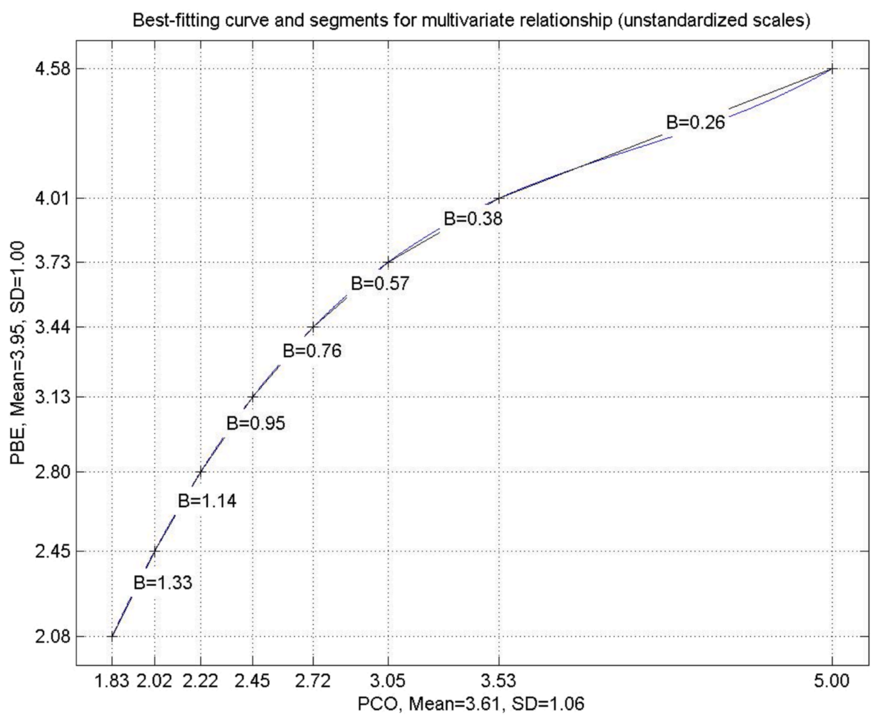

Fig. 3. The dynamics between PCO and PBE.

Nevertheless, as the PBE scores ascend, there is a marked decrement in β value, particularly when PCO escalates to a value of 5, and PBE peaks at merely 4.58 with a β of 0.26. This trend suggests an enhanced PBE perception as individuals become more cognizant of the incurred costs. Given the gradual increase in PBE after a PCO score of 3.53, a strategic recommendation is put forth for authorities and organizations championing the adoption of renewable energies. It is suggested that there be a pivot from a singular focus on cost dissemination towards an approach that emphasizes the initial stages, where the propensity for change exhibits the highest magnitude.

A sensitivity analysis unveils the probabilities of positive (PBE+) or negative (PBE-) evaluations, contingent upon the occurrence of a positive shift in PCO (PCO+), standing at 0.287 and 0.046, respectively. This indicates that users who delve into a comprehensive analysis of the garnered benefits in conjunction with the borne costs are likely to strive for an equilibrium. Conversely, the probability of encountering PBE+ or PBE- in scenarios of a negative shift in PCO (PCO-) is reported at 0.107 and 0.407, respectively. This illustrates a scenario where insufficient dissemination of cost-related information pertaining to RE can lead to a diminished PBE, thus posing a significant risk. Therefore, it is imperative for entities promoting RE to maintain transparency in articulating both the costs and benefits, as inadequate or misleading information pertaining to investments can culminate in a reduced perception of benefits.

5.2. *Dynamics between PCO and ECO*

The study unveils that there exists a direct and positive linkage between Perceived Costs (PCO) and Environmental Concerns (ECO) among RE users in Mexico. Specifically, a unit increase in the standard deviation of PCO leads to a 0.240 unit increase in ECO. This correlation suggests that individuals directly correlate the costs of renewable energies with environmental considerations, manifesting a heightened awareness and concern for issues such as climate change, air pollution, and waste management. Such findings underscore the presence of an environmental consciousness within Mexican society. Considering this, it is imperative for organizations facilitating the adoption of RE to address and clarify cost-related uncertainties comprehensively. This is particularly crucial, as highlighted by Li et al. [62], who note that focusing on costs can obscure the perceived benefits of adopting such technologies.

In Fig. 4, the PCO-ECO relationship demonstrates that at lower PCO values, β values commence at a higher rate, progressively diminishing as PCO values escalate. This trajectory begins with a β of 0.43, dwindling to 0.33, and further to a mere 0.04 before transitioning into negative values (at a PCO of 4.5). This trend indicates that an excessive emphasis on cost dissemination can eclipse the perceived environmental benefits among users. Notably, at a PCO value of 3.81—deemed average—a corresponding ECO value of 4.20 is observed, which is considered acceptable. Consequently, it is advisable for entities advocating for RE adoption to exercise caution in overemphasizing costs, as this could potentially detract from the interest in environmental benefits.

Further insights from the sensitivity analysis reveal the probabilities of positive (ECO+) and negative (ECO-) environmental concerns following an increase (PCO+) at 0.207 and 0.057, respectively. Moreover, the analysis indicates probabilities of ECO+ and ECO- in scenarios where a decrease in PCO (PCO-) is observed at 0.179 and 0.488, respectively. These findings indicate that an appropriate increase in PCO does not necessarily ensure a corresponding positive environmental concern, as evidenced by the relatively low probability. Conversely, decreasing PCO significantly heightens the risk of adverse environmental concerns, with a probability of 0.488. This suggests that inadequate knowledge of the costs associated with renewable energies correlates with a diminished environmental consciousness.

5.3. Interplay of PBE and ECO

The analysis presents a clear, positive correlation between Perceived Benefit Evaluation (PBE) and Environmental Concerns (ECO), evidencing that an increase in PBE by one standard deviation correspondingly elevates ECO by 0.379 units. This relationship underscores that as individuals become more knowledgeable about the advantages offered by REs, their environmental concerns concurrently intensify. Such findings align with the research conducted by William Philip Wall et al. [8] in Thailand, who demonstrated that enhanced PBEs lead to increased ECO and bolster the adoption rates of RE technologies—a conclusion similarly drawn by Khalid et al. [42] in Poland. Depicted in Fig. 5 is the dynamic between PBE and ECO, highlighting a significant initial impact of PBE on ECO, with β values of 0.67 and 0.57. Nonetheless, this impact markedly diminishes as PBE escalates to a value of 5, where β drops to a negligible 0.07. This suggests that despite vigorous efforts to promote the benefits of REs, the incremental influence on environmental concerns seems to plateau. Therefore, it is crucial for organizations championing RE adoption to strategically allocate their efforts and resources toward effective benefit dissemination.

Sensitivity analysis further elucidates the probabilities of positive (ECO+) and negative (ECO-) environmental concerns arising when positive perceived benefits (PBE+) are present, standing at 0.381 and 0.131, respectively. Conversely, in scenarios where PBE is negative (PBE-), the likelihood of encountering ECO+ and ECO- shifts to 0.085 and 0.488, respectively. This indicates that individuals with a heightened perception of benefits (PBE+) also exhibit increased environmental concerns (ECO+). In contrast, those with a diminished perception of benefits (PBE-) face a greater risk of low environmental concerns (ECO-). Consequently, agencies dedicated to promoting RE should strongly emphasize the benefits associated, as this approach significantly enhances environmental consciousness among potential adopters and facilitates investment.

5.4. Dynamics between PBE and BIN

This underscores a significant, positive linkage between perceived benefit (PBE) and behavioral intentions (BIN) towards REs. Specifically, an augmentation in PBE by one standard deviation induces a substantial increase in BIN by 0.540 units. This pivotal finding highlights the critical role of PBE in shaping an individual's intention to adopt eco-friendly practices and foster pro-environmental behaviors. This observation is congruent with the insights provided by Asif et al. [37] in China and Zahari and Esa [17] in Maylasia, who emphasize the paramount influence of perceived benefits in the decision-making process related to the acquisition of solar energy solutions. They point out that awareness regarding the reduction of greenhouse gas emissions and the conservation of natural resources acts as a potent intrinsic motivator for the adoption of sustainable environmental practices. Similarly, Nguyen et al. [63] affirm the significant influence of perceived benefits on the

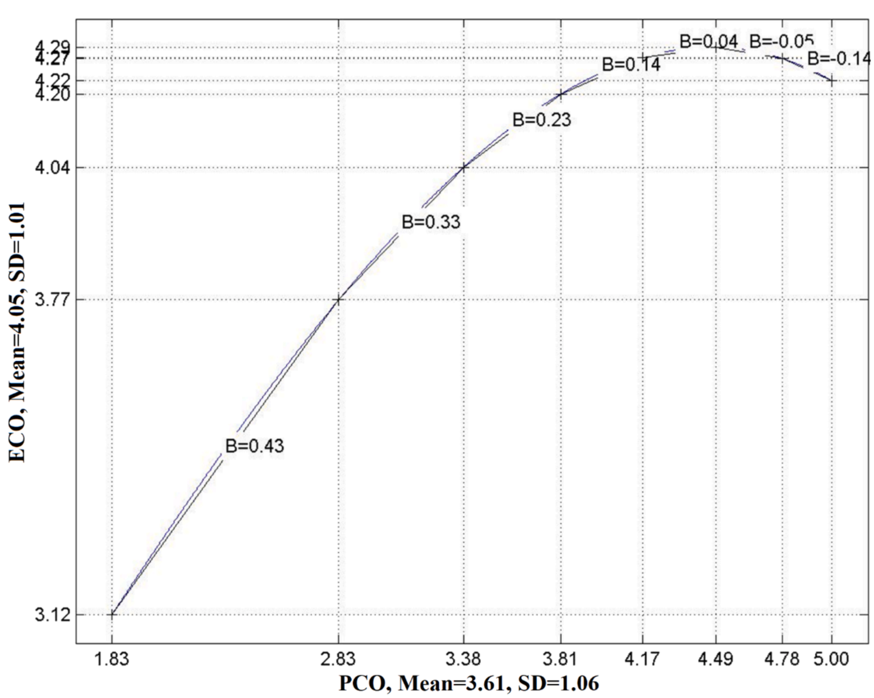

Fig. 4. The interplay between PCO and ECO.

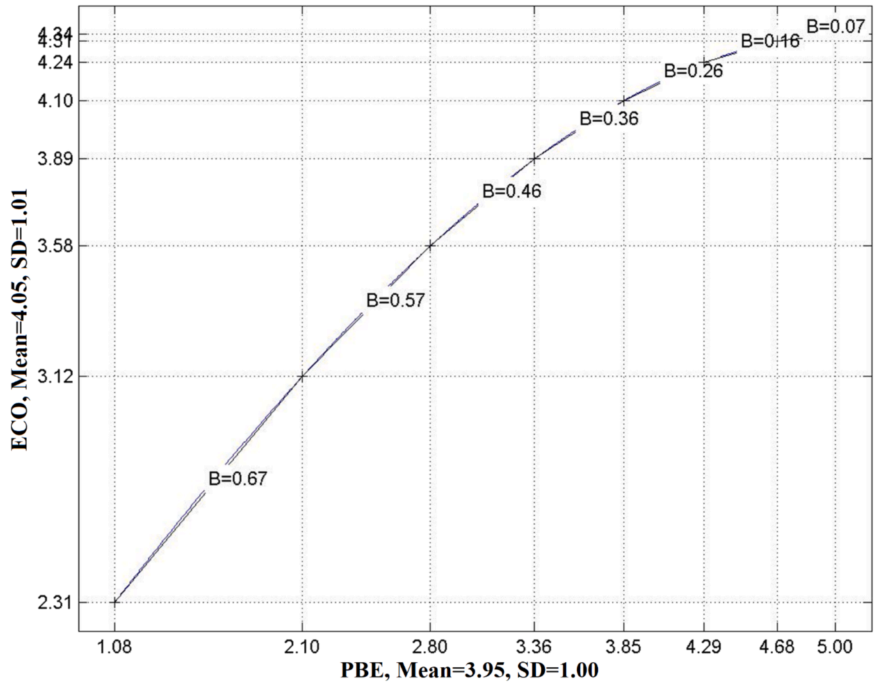

Fig. 5. Dynamics between PBE and ECO.

intentions associated with RE usage, identifying them as key predictors of intentionality among small-scale solar energy consumers, a notion further supported by Waris et al. [64].

Depicted in Fig. 6 is the nuanced relationship between PBE and BIN, which starts off with an initial β value of 1.29, indicating a strong effect that exceeds the baseline of unity. However, as PBE intensifies, the impact on BIN begins to wane, evidenced by decreasing β values of 0.49 and ultimately 0.43 in the latter segments, signifying a decline in the strength of behavioral intentions. Consequently, it is advisable for entities promoting renewable energies to embark on informational campaigns that accentuate the benefits, as these significantly influence BIN levels and, by extension, their adoption rates.

The sensitivity analysis corroborates these findings, showing that the occurrence of PBE+ leads to probabilities of BIN+ and BIN- at 0.595 and 0.024, respectively. This suggests a robust influence of PBE+ on BIN+, with only a minimal association with BIN-, underscoring the idea that the perception of RE benefits directly facilitates a shift in behavioral attitudes. Conversely, should PBE- manifest, indicating a failure to recognize the benefits of REs, there emerges a considerable risk of BIN- occurring at 0.451, with BIN+ plummeting to 0.049. In summary, individuals who fail to discern the advantages offered by REs are unlikely to alter their attitudes and behaviors in favor of RE adoption.

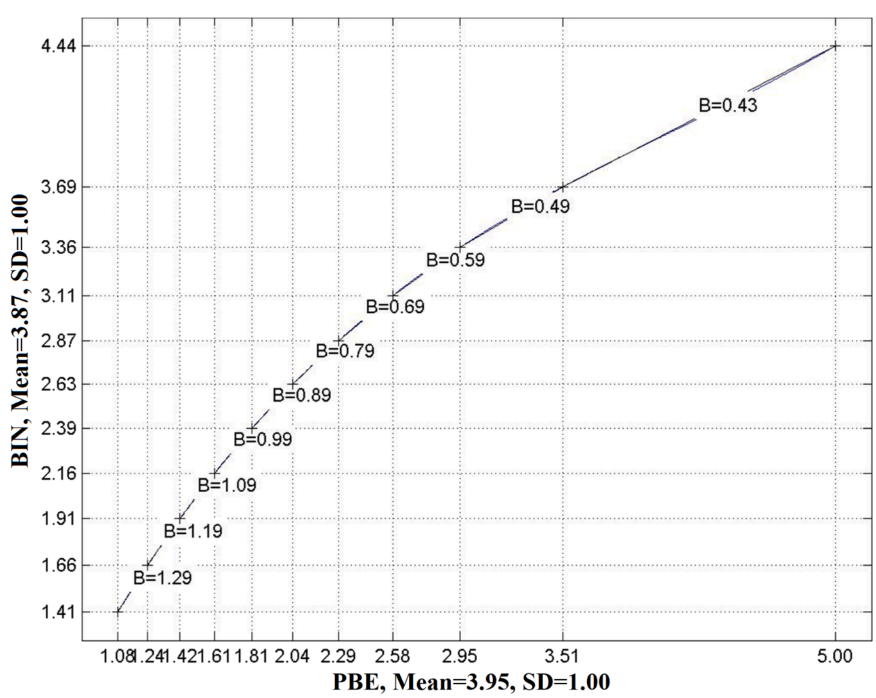

Fig. 6. The interrelation between PBE and BIN.

5.5. Relationship of ECO and BIN

The analysis reveals a distinct and positive connection between Environmental Concerns (ECO) and Behavioral Intentions (BIN) towards RE adoption. A unit increment in ECO's standard deviation leads to a 0.311 unit increase in BIN. This finding suggests that individuals with heightened environmental concerns are more inclined to exhibit behaviors that align with the adoption of renewable energies, thereby promoting eco-friendly practices. These outcomes resonate with the principles of the Theory of Planned Behavior, highlighting the pivotal role of informed environmental concern in influencing behavioral intentions, as discussed by BIN Athaya Tsamara and Sri Rahayu Hijrah [65]. Moreover, this research corroborates earlier studies that identify ECO as a fundamental factor in cultivating green consumption behaviors and shaping purchase intentions towards green products, as evidenced by the works of Pagiaslis and Krontalis [66] and Zhang et al. [67]. This significant impact of ECO on the inclination to procure green products readily extends to RES. Depicted in Fig. 7 is the ECO-BIN relationship, commencing with an initial β value of 0.72, which signifies a robust correlation at the outset. Nonetheless, as these variables' magnitude escalates, the change rate experiences a decrease. Despite this, the relationship remains statistically significant. However, upon ECO reaching a value of 5, BIN attains a figure of 4.22, with a β of 0.28, illustrating that those elevated levels of ECO result in minimal shifts in behavioral intentions.

Sensitivity analysis further elucidates that a positive ECO (ECO+) predicates the likelihood of positive behavioral intentions (BIN+) and negative behavioral intentions (BIN-) at probabilities of 0.506 and 0.023, respectively. This suggests that individuals with pronounced environmental concerns are predisposed to intentions of purchasing RE while also being unlikely to exhibit disinterest. Conversely, should a negative environmental concern (ECO-) manifest, the likelihood of exhibiting negative behavioral intentions (BIN-) and positive behavioral intentions (BIN+) are at 0.390 and 0.049, respectively, indicating a diminished propensity towards RE procurement among those with low or absent environmental concern.

5.6. Comprehensive discussion of adoption factors

This comprehensive analysis of adopting RE technologies in Mexico intricately demonstrates how perceived costs, perceived benefits, environmental concerns, and behavioral intentions interact with each other and shape individuals' attitudes and behaviors towards RE. The increase in perceived costs positively influences individuals' evaluations of perceived benefits and environmental concerns, leading to increased behavioral intentions toward RE technologies. These findings highlight that individuals' environmental concerns and perceived benefits are critical motivational sources for adopting RE solutions. Specifically, increased perceived benefits positively affect environmental concerns and behavioral intentions toward REs. This indicates that the likelihood of individuals adopting eco-friendly behaviors is contingent upon their belief in the benefits offered by REs. On the other hand, the relationship between perceived costs and environmental concerns reveals that costs directly impact environmental concerns, strengthening the intentions to adopt renewable energies.

These analyses underscore the importance of highlighting individuals' environmental concerns and perceived benefits when developing strategies for adopting RE technologies in Mexico. Communicating the costs and the environmental and socio-economic benefits of RE solutions clearly and understandably can facilitate their broader acceptance by users. Particularly, balancing the presentation of perceived costs and benefits can aid in increasing environmental concerns, thereby helping individuals develop positive behavioral intentions towards RE technologies. This points towards a significant strategy for policymakers and related organizations in Mexico to consider while promoting adopting RE technologies.

6. Conclusion and policy implications

This study provides an empirical investigation into the factors driving RE adoption in Mexico, offering substantial contributions to the discourse on sustainable energy within environmental economics and sustainable development fields. Employing structural equation modeling to analyze data from 511 homeowners, the research meticulously evaluates the roles of perceived costs (PCO), perceived benefits

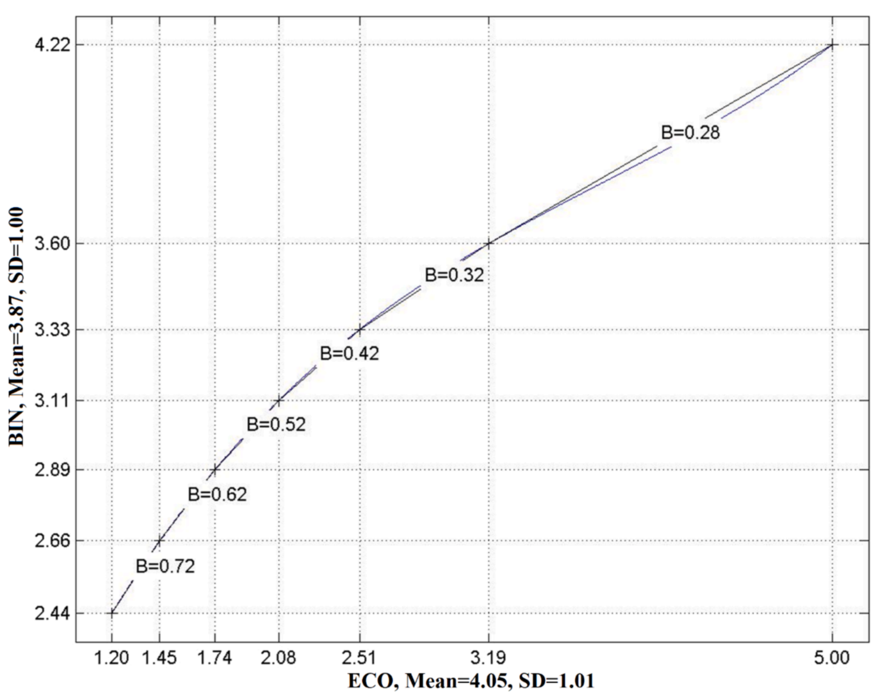

Fig. 7. Dynamics between ECO and BIN.

(PBE), environmental concerns (ECO), and behavioral intentions (BIN) towards RE technologies. These dimensions collectively shape the landscape of RE adoption in a context marked by Mexico's distinct socioeconomic and environmental challenges. Main insights reveal the complex interplay between economic and environmental perceptions and their significant impact on the willingness to adopt RE solutions. Specifically, the study highlights:

- The results underscore the importance of perceived costs in shaping perceptions of the broader benefits associated with RE, suggesting that focusing solely on the initial financial outlay may obscure other significant advantages. This is pivotal in a developing country context, where cost considerations can significantly influence the overall perception and acceptance of RE technologies, due mainly to a low personnel economic income and high cost required for those technologies.
- It is indicated that perceived benefits directly influence environmental concerns. This suggests that recognizing the environmental and societal advantages of RE technologies can heighten awareness of potential environmental damages from conventional energy sources, thereby influencing attitudes towards RE adoption. So, Mexican dependencies promoting RE must focus on future benefits from RE, emphasizing a better environmental context for their children.
- It is demonstrated that an understanding of the associated benefits and environmental concerns significantly predicts pro-environmental behavioral intentions. This finding emphasizes the necessity of promoting clear and comprehensive awareness of RE benefits to foster greater adoption and encourage sustainable practices.

The study suggests actionable recommendations for government and institutions promoting RE, emphasizing the need to communicate the costs and benefits of RE adoption clearly. It advocates for developing sustainable policies aimed at specific RE goals to enhance public perception and acceptance. For example, the governments must:

- Generate public awareness campaigns, establish training programs and provide technical assistance.
- Apply existing research and development policies, consolidating research centers that generate technology for the ER.
- Generate international cooperation agreements between countries to share knowledge and optimize resources.
- Offer direct subsidies to users who join ER networks, promoting tax credits for companies and offering preferential rates to those who use them.
- Simplify internal administrative procedures, streamlining decision-making for potential investors.
- Establish clear and transparent standards that allow users to identify the renewable energy they consume, which will allow them to see the savings obtained.

7. Limitations and future research

The study acknowledges limitations, including focusing on a financially mature audience within Ciudad Juarez (Mexico), a region with unique environmental and industrial characteristics. Future research directions include expanding the demographic scope of participants, conducting comparative analyses across different geographical areas within Mexico and other developing countries, and exploring the influence of government policies and incentive programs on the cost perception and adoption of RE. Thus, this study advances the understanding of RE adoption in developing nations, particularly Mexico, by detailing the nuanced relationships between cost, benefit perceptions, environmental concerns, and behavioral intentions. It lays a crucial foundation for future initiatives to promote a more sustainable and environmentally friendly energy framework, providing valuable insights for policymakers, industry stakeholders, and educators alike.

CRediT authorship contribution statement

Ingrid Iovana Burgos Espinoza: Writing – original draft, Formal analysis, Data curation, Conceptualization. **Jorge Luis García Alcaraz:** Writing – review & editing, Visualization, Supervision, Software. **Alfonso Jesús Gil López:** Writing – review & editing, Visualization, Supervision, Software. **Yashar Aryanfar:** Writing – review & editing, Writing – original draft, Investigation, Conceptualization. **Ali Keçebaş:** Writing – original draft, Visualization, Validation, Conceptualization.

Declaration of competing interest

The authors affirm that they do not have any known conflicting financial interests or personal relationships that might have been perceived as influencing the work presented in this paper.

Data availability

Data will be made available on request.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.sftr.2024.100319.

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