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PERSONAL COGNITIVE AND MORAL ALTRUISTIC ASPECTS IN THE INTENTION TO USE SOLAR ENERGY

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1 INTRODUCTION

Emissions of atmospheric pollutants, derived from various human actions, have been a concern in recent years (Rahmani & Naeini, 2023). Among these actions is the extensive consumption of energy resources (Xu et al., 2024). This has led to delays in climate action and reduced secure carbon budgets for the sustainable energy transition (Desing et al., 2024).

For this reason, global targets for carbon neutrality have been set for countries worldwide (Galimova et al., 2023). This can be seen in the Paris Agreement, which aims to meet the global climate target of 1.5°C (Irena, 2022; Galimova et al., 2024). And the Sustainable Development Goals (SDGs) agenda sets seventeen goals, the seventh of which is to promote the guarantee of affordable, reliable, sustainable and modern energy. In addition to targets nine (industry, innovation, and infrastructure), eleven (sustainable cities and communities), twelve (responsible production and consumption) and thirteen (climate action) (SDGs, 2018).

Against this backdrop, there has been intense research into clean fuel technologies and new energies (Johannsen et al., 2020; Singh et al., 2023). The focus can be on firms (Asadi et al., 2021) or the end consumer (Bila & Andaji, 2023). However, there is a gap in the literature when it comes to investigating consumer intentions in the face of the diffusion of environmental technologies (Agarwal et al., 2023), especially in developing countries (Ahmed et al., 2022).

For this reason, we decided to study the diffusion of solar energy, an environmental technology, focusing on the end consumer in a developing country, Brazil. In terms of a sustainable energy matrix, Brazil has stood out, as it has one of the least carbon-intensive energy sectors in the world (IEA, 2023). And solar energy is on the rise, accounting for 17% of its energy generation, resulting, since 2012, in a benefit of more than 45 million tons of Co2 avoided (Absolar, 2024).

However, to theoretically and experimentally analyze the diffusion of technologies and innovations, the literature presents various theories (Schulte et al., 2022). Rogers' (2003) Innovation Diffusion Theory (IDT) was chosen as the theoretical basis for this study. It presents five characteristics of innovation perceived by individuals: relative advantage, compatibility, complexity, trialability and observability (Rogers, 2003). This theory has been enshrined in various fields of research, including being applied to environmental and renewable energy Technologies (Bilal & Andajani, 2023).

Although RTD is a well-established theory, it is not sufficient on its own, as it focuses on self-interested factors in rational models. However, in addition to individual cognitive influences, there are also socio-psychological ones, which are often neglected when they are not integrated into research (Singh et al., 2023). Thus, this research was motivated by the scarcity of studies investigating self-interest factors and socio-psychological factors in an integrated way in the diffusion of environmental technologies with a focus on the end consumer in a developing country.

Within this context is Schwartz's Norm Activation Theory (NAT) (1977). NAT adopts a different perspective when considering altruistic behavior (Schwartz & Howard, 1981). Thus, this theory points out that altruistic actions/desires can be derived from personal norms (NP) influenced by two constructs: Ascription of responsibilities (AR) and awareness of consequences (AC) (Schwartz, 1977).

Thus, compared to the single theoretical model, the integration of these theories can explain more variance in behavioral intentions (Rahmani & Naeini, 2023). With this, we aimed to narrow the gap related to consumer intention on studies of self-interest combined with

altruistic interest, in a developing country, since they are neglected (Ahmed et al., 2022; Agarwal et al., 2023).

This raises the question: how do the personal cognitive aspects of innovation diffusion and the moral altruistic aspects of Norm Activation influence consumers' intention to use solar energy? Its objective is to investigate the influence of personal cognitive aspects (Diffusion of Innovation theory) and altruistic morals (Norm Activation theory) on consumers' intention to use solar energy.

Thus, this study aims to contribute to studies in the literature and advance research related to the intention to use solar energy, especially in developing countries. In a practical sense, to provide insights for industries, policy makers and companies and/or marketers about the intention to use solar energy through short-, medium- and long-term goals. As well as providing contributions to the promotion of sustainable energy development in Brazil.

And socially, to contribute to the global discourse that calls for conscious practices, including clean energy, promoting social progress. Finally, to disseminate a technology that can promote the reduction of energy poverty, especially in developing countries. Given that approximately 17 million people do not have access to electricity in the countries that make up Latin America and the Caribbean (LAC) (IEA, 2023).

2. LITERATURE REVIEW

2.1 Intention to use solar energy

The use of solar energy is a means of mitigating CO2 emissions derived from the burning of fossil fuels, as it is a clean energy (Galimova et al., 2024). In the context of intention to use solar energy, it is defined as an individual's willingness to engage in green energy adoption behavior, especially as an indication of pollution reduction awareness (Hasheem et al., 2022). Thus, adoption behavioral intentions are the consumer's intentions to use a prospective product or service (Ajzen, 1991).

2.2 Personal cognitive aspects and intention

Rogers' Diffusion of Innovations Theory (DIT) (2003) is probably the most widely used within the field of research on technology diffusion and innovation (Johannsen et al., 2020). This theory was first described in 1962 in the book Diffusion of Innovations and one of its purposes is to present the characteristics of individuals in terms of their likelihood of adopting technologies (Doyle et al., 2014).

IDT was developed to explain why individuals choose to adopt or reject an innovation based on personal cognitive aspects (Yuen et al., 2021). These aspects are voluntary and involuntary processes of rational decision-making (Sun et al., 2022).

RTD has five personal cognitive characteristics: relative advantage, compatibility, observability, complexity and trialability (Rogers, 2003).

The relative advantage is when the innovation is perceived by a certain group of users as better than the precursor practice or idea (Rogers, 2003). There is a positive relationship between advantages and the Intention to Use variable (Bilal & Andajani, 2023; Schulte et al., 2022). A study carried out in Malaysia showed that the intention to use solar photovoltaic technology is predicted by the relative advantage, as it had a significant positive effect (Alam et al., 2021). The following hypothesis is therefore proposed:

H1: Relative advantage has a direct and positive effect on the intention to use solar energy.

Compatibility is when an innovation is perceived by a certain group of users as consistent with the existing values, needs and past experiences of potential adopters (Rogers, 2003). The literature shows that compatibility is positively associated to use green technology (Ahmed et al., 2022). A study in Malaysia with potential adopters of solar energy showed that the intention to use solar photovoltaic technology is predicted by compatibility, as it had a significant positive effect (Alam et al., 2021). The following hypothesis is therefore proposed:

H2: Compatibility has a direct and positive effect on the intention to use solar energy.

Observability is when the innovation is perceived as achieving results that are more visible than the precursors (Rogers, 2003). One study revealed that looking at solar panels contributes positively to consumer intention, pointing out that the more easily observable the panels are, the greater the effect on consumer intention towards this technology (Kapoor & Dwivedi, 2020). In addition, there is evidence that observability significantly influences consumer attitudes towards the use of solar energy (Ahmed et al., 2022). Thus, the following hypothesis is proposed:

H3: Observability has a direct and positive effect on the intention to use solar energy.

Complexity is when the innovation is perceived as complex or difficult both to understand and to use (Rogers, 2003). According to Alam et al. (2021), there is a robust literature that solar technology is seen as easy to use, i.e., it is not complex. For this reason, this variable will be discarded for this study. In turn, trialability is when the innovation is perceived as being able to be tried before its adoption (Rogers, 2003). We also decided to exclude this construct because it is impossible to measure, since it cannot be tried before adoption (Kapoor & Dwivedi, 2020).

2.3 Altruistic moral aspects and intention

The Norm Activation Theory (NAT) proposed by Schwartz (1973) was developed to explain behavior through social and material reinforcements rather than through the benefit of others, i.e. altruistic behavior (Arkorful, 2022). According to Schwartz (1973), the process begins with social norms, which are related to moral behavior that people generally agree with.

However, these social norms are too general, so they are adopted on a personal level (Davies et al., 2002). Personal norms are feelings of moral obligation, i.e. internal obligations to do or not to do something specific (Schwartz & Howard, 1981). The literature points to evidence of personal norms influencing intention in the energy context (Wittenberg et al., 2018). Thus, the following hypothesis is proposed:

H4: Personal Norm has a direct and positive effect on the Intention to adopt solar energy.

As NAT points out, there are two variables that must be considered for a personal norm to derive altruistic behaviors. Firstly, there is the awareness of the consequences and, secondly, there is the responsibility attributed (Schwartz, 1977). Awareness of consequences refers to the individual's perception of the multiple ramifications of not carrying out pro-social behavior (Schwartz, 1973). In this variable, individuals need to realize that their behavior has consequences for the environment (Govaerts & Olsen, 2022). Thus, it refers to the individual being aware of the negative consequences of not behaving pro-socially (De Groont & Steg, 2009). Thus, the following hypothesis is proposed:

H5. Awareness of consequences has a direct and positive effect on Personal Norm.

Ascription of responsibilities refers to how individuals feel responsible for the negative consequences of not behaving pro-socially (De Groont & Steg, 2009). Thus, it is assumed that those who take responsibility for the problems arising from a certain action will feel more pressured to help solve these problems by reducing this action more than those who do not take this responsibility (Abrahamse et al., 2009). Thus, the following hypothesis is proposed:

H6: Ascription of responsibilities has a direct and positive effect on Personal Norm.

Although the literature presents several studies using NAT, the relationships between its main constructs are not entirely clear (De Ruyter & Wetzels, 2000). Therefore, in addition to NAT being interpreted from the perspective of mediation, it can also be interpreted from the perspective of moderation (De Groont & Steg, 2009). Because of this, the following hypothesis will be established:

H7: Ascription of responsibilities mediates awareness of consequences in the influence of personal norms.

2.4 Integration of innovation diffusion and norm activation

RTD and NAT are two widely used theories in the field of personal pro-environmental behavior (Ganjipour & Edrisi, 2023; Zhao et al., 2019). People who use green technology are found to have a higher level of personal norms compared to those who do not (Jansson, 2011). Given that the individual is more likely to put the collective interest before the selfish interest (Nordlund et al., 2018). Because of this, the following hypothesis was drawn up:

H8: Relative advantage mediates personal norm and intention to use solar energy.

The literature also points out that innovations that are in line with consumers' lifestyles, or that are updated to meet their future needs, are likely to be more attractive to them (Kapoor & Dwivedi, 2020). Within this context, a study on the acceptance of photovoltaic systems based on solar energy points out that these systems are inclined to be compatible with existing standards (Muller & Rode, 2013). Because of this, the following hypothesis was drawn up:

H9: Compatibility mediates personal norms and intention to use solar energy.

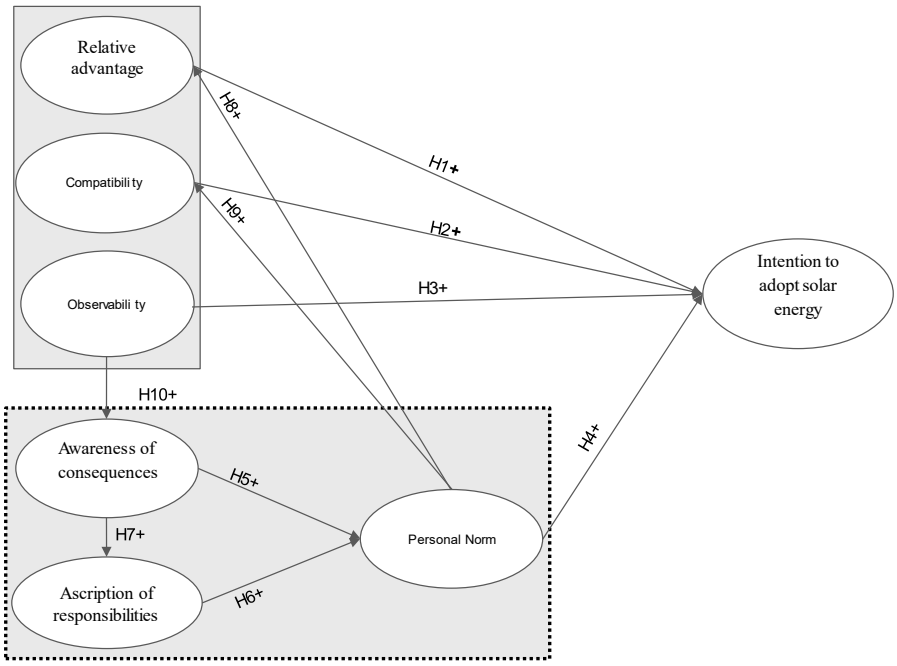
The literature also shows that awareness of the problem is the beginning of responsible behavior towards the environment (Ganjipour & Edrisi, 2023). This can be seen in a study which found that respondents who were aware of conventional pesticide-based methods and integrated pest management (IPM) opted for IPM because other aspects came into play, such as protecting the soil, water, wildlife, beneficial insects and the entire community (Ahmad et al., 2014). Because of this, the following hypothesis was established:

H10: Awareness of consequences mediates observability on personal norms.

2.5 Theoretical model

The conceptual model proposed in Fig. 1 presents the theories used in the theoretical framework and their central concepts. Thus, an integrated framework of IDT that provides the cognitive personal perspective and NAT that provides the altruistic moral perspective are employed, and the relationships between them are investigated.

Figure 1 - Conceptual model of intention to use solar energy



Source: The authors (2024)

3 METHODS

This is a quantitative, descriptive study (Sampieri et al., 2013). Potential adopters of solar energy in Brazil over the age of 18 were considered for the population. This country was chosen because solar energy is the second largest source of energy in its electricity matrix, accounting for 17% of its generation. The majority of solar distribution is concentrated in residential consumption, accounting for 48.20% of consumption classes (Absolar, 2024). It is estimated that by 2027 solar energy will be the global leader, overtaking hydro, natural gas and coal (IEA, 2023). For this reason, Brazil needs to increasingly spread the adoption of this technology.

To this end, the non-probabilistic sampling technique (Cochran, 1977) was used. Convenience sampling combined with the snowball technique (Malhotra, 2019). The sample size followed the recommendation of Hair et al. (2017), with five to ten respondents per variable. For this study, 10 cases were used per variable, requiring at least 270 questionnaires. However, the sample was finalized with 356 questionnaires. However, due to the exclusion of the pre-test, the final sample ended up with a total of 321 (n=321) valid questionnaires.

The structured questionnaire as a data collection instrument was developed using the Google Forms platform, via an online survey questionnaire application, consisting of closed and mandatory questions (Hair et al., 2017). Data collection began on 08/11/2023 and ended

on 28/11/2023, totaling 21 uninterrupted days of collection. Some social media were used for dissemination, namely: Facebook, Instagram, Telegran and Whatsapp.

To measure the Intention to use solar energy, a four-item scale adapted from Hasheem et al. (2022) was used, while for Relative advantage, a four-item scale, four-item compatibility and three-item observability were derived from Moore and Benbasat (1991). For Personal Norm, Awareness of consequences and Ascription of responsibilities, all with four items each, adapted from De Groot and Steg (2009), as shown in Table 1.

Chart 1 - Composition of the collection instrument

Construto e Autores	**Itens**	**Código**
Intention to adopt solar energy (Hasheem et al., 2022)	I intend to use solar energy in my home in the future. I am willing to use solar energy in my home. From now on, I intend to buy solar energy for my home. I intend to pay more to have solar energy in my home.	INT1 INT2 INT3 INT4
Relative advantage (Moore & Benbasat, 1991)	Solar energy makes electricity easily and readily available. The advantages of using solar energy (energy savings, investment and cost-effectiveness) far outweigh its disadvantages (price, aesthetic change, financial disadvantage). Overall, solar energy is advantageous for meeting my electricity needs. The use of solar energy leads to the effective use of energy.	VR1 VR2 VR3 VR4
Compatibility (Moore & Benbasat, 1991)	The use of solar energy is compatible with my requirements for this type of electricity. The use of solar energy is well suited to successfully supplying the amount of this type of electricity that I need. The geographical and environmental conditions of my home are suitable/compatible with my choice of solar energy use. The use of solar energy suits my lifestyle.	CP1 CP2 CP3 CP4
Observability (Moore & Benbasat, 1991)	In my society (locality) you see solar energy in many houses. I have seen the use of solar energy outside my society (locality). It's easy to observe other people using solar energy in my society (locality).	OB1 OB2 OB3
Personal norm (De Groot & Steg, 2009)	I feel a strong personal obligation to use energy wisely. I feel a moral obligation to protect the environment. I feel it is important to use as little fossil fuel energy as possible (oil, coal, etc.). I feel it is important for people in general to protect the environment	NP1 NP2 NP3 NP4
Awareness of consequences (De Groot & Steg, 2009)	Conventional energies (which use non-renewable resources) contribute to environmental damage. Fossil fuel depletion is a problem. Consuming conventional energies (which use non-renewable resources) affects global warming. Global warming is a problem for society.	CC1 CC2 CC3 CC4
Ascription of responsibilities (De Groot & Steg, 2009)	I have a responsibility to conserve energy resources and guarantee quality of life for future generations. I have a responsibility to influence the energy industry towards greener solutions. I feel personally responsible for the environmental problems resulting from the type of energy I consume. I feel joint responsibility for the negative consequences of conventional energies (which use non-renewable resources).	RA1 RA2 RA3 RA4

Source: The authors (2024)

All constructs were measured according to a Likert-type scale ranging from strongly disagree (1) to strongly agree (7) (Hair et al., 2017). The questions were configured as mandatory (De Leeuw et al., 2008). In addition, a question was included to better understand why respondents do not use solar energy at home. Finally, some questions were asked to collect the socio-demographic profile of the respondents.

The data was analyzed using IBM SPSS - Statistical Package for the Social Sciences (version 20) and AMOS (version 21). Initially, the data was analyzed using descriptive

statistics: frequency, mean, standard deviation and coefficient of variation (Hair et al., 2017). Cronbach's alpha coefficient was used to check the reliability of the scales, considering the level of reliability to be acceptable at 0.7 (Hair et al., 2017).

Structural Equation Modeling (SEM) was then used to test the hypotheses (Gefen et al., 2000). Confirmatory Factor Analysis (CFA) was also carried out to check the reliability and validity of the constructs included in the measurement model (Hair et al, 2017). Next, to test the adequacy of the structural model, the fit indices were checked (HoylE, 2012). Next, the Hair et al. (2017) measurement model was analyzed and checked using the average variance extracted (AVE). Finally, a multi-group analysis was carried out to check whether the structural relationships of the model differed according to income.

4 RESULTS

Basic descriptive statistics showed that of the 321 respondents in the sample, the majority (58.6%) were women. In addition, 36.8% had completed high school, 32.7% had higher education and 30.5% had postgraduate degrees. The majority (53.6%) were single, followed by in a stable union (37.7%), divorced (7.8%) and widowed (0.9%).
The other demographic variables were analyzed using the mean and standard deviation for greater numerical precision. In addition, the coefficient of variation (CV) was also calculated to provide the variation of the data obtained about the mean (Hair et al., 2017), as shown in Table 1.

Table 1 - Sociodemographic profile based on means, standard deviation and coefficient of variation (CV).

Variables	N	Mean	DP	CV
Age	321	34,32	9,82	0,29
Average monthly income (family)	321	R$ 5.940,60	7115,83	0,83
Number of people in the household	321	2,96	1,22	2,43

Source: The authors (2024)

About the measurement model, the Mahalanobis Squared Distance (D2) was initially used to check for and remove outliers from the sample. It should be noted that no observation had high values that needed to be removed from the analysis. Confirmatory factor analysis was then carried out to identify the fit indices (Marôco, 2014).

The results achieved at this stage were: X2/df (636.491) = 2.129 (p = 0.00); GFI = 0.873; IFI = 0.926; TLI = 0.912 CFI = 0.925; NFI = 0.869; RMSEA = 0.059; PCLOSE = 0.008; ECVI = 2.483; MECVI = 2.530. Therefore, it is possible to note that the values obtained show adequate adjustment indices (Hair et al., 2017).

In addition to the reliability analysis (Cronbach's alpha), the Composite Reliability (CC) was also carried out, as well as the Average Variance Explained (AVE) to investigate the level of suitability of the scales for each construct. With regard to Cronbach's alpha, all the constructs measured had satisfactory internal consistency reliability (>0.7), as shown in Table 2.

Similarly, the Composite Reliability (CC) also obtained values above 0.7 in each construct, following the recommendations of Marôco (2014) and Hair et al. (2017). Table 4 also shows the Mean and Standard Deviation (SD) of the responses to the variables, using a Likert scale from 1 to 7. To calculate the mean and standard deviation, it was necessary to create composite variables using the summated scale. It can be seen that the mean of the variables tended to agree with the statements, since it varied between 4 and 6 points.

Table 2 - Descriptive statistics, reliability and validity

Variables	Média	D. P.	C.V	α	CC	AVE
Relative Advantage (RA)	5,571	1,268	22,760	0,795	0,872	0,494
Compatibility (CP)	6,034	1,145	18,975	0,854	0,856	0,601
Observability (OB)	4,672	1,645	35,209	0,700	0,782	0,514
Personal norm (PN)	6,034	1,145	18,627	0,797	0,921	0,573
Awareness of consequences (AC)	6,130	1,137	18,548	0,799	0,877	0,523
Ascription of responsibilities (AR)	5,662	1,233	21,777	0,854	0,921	0,506
Intention (INT)	5,385	1,317	24,456	0,770	0,809	0,532

Source: The authors (2024). Notes. SD (Standard Deviation), CV (Coefficient of Variation), CR (Composite Reliability); AVE (Average Variance Extracted); α = Cronbach.

It can be seen that the variables had an average above the central tendency, given that the scales used have 7 points. It can also be seen that these constructs had a coefficient of variation close to 25%, showing that there is heterogeneity in the responses.

However, about the validity of the construct scales, three validities were also carried out: factorial, convergent and discriminant (Kline, 2023). Factorial validity was based on the values of the standardized coefficients for each item of the constructs, in which all showed coefficients above 0.5, confirming factorial validity and that the specification of the items was correct (Kline, 2023).

Convergent validity was investigated based on the Average Variance Explained (AVE) values, with a value of 0.5 being appropriate for measuring AVE (Kline, 2023). Table 3 shows that the constructs obtained a value above the recommended value (Kline, 2023). Only one construct (relative advantage) obtained a slightly lower value (0.494), but this was still considered acceptable for the analysis (Kline, 2023). Therefore, based on the AVE values, it is possible to state that convergent validity was met.

Table 3- Correlations, shared variance and AVE

Variables	RA	CP	OB	AC	AR	PN	INT
RA	**0,494**	0,901	0,162	0,140	0,272	0,224	0,468
CP	0,949	**0,601**	0,183	0,130	0,230	0,227	0,466
OB	0,403	0,428	**0,514**	0,032	0,077	0,191	0,058
AC	0,374	0,361	0,178	**0,523**	0,624	0,570	0,114
AR	0,522	0,480	0,278	0,790	**0,506**	0,674	0,162
PN	0,473	0,476	0,191	0,755	0,821	**0,573**	0,182
INT	0,684	0,683	0,240	0,337	0,404	0,427	**0,532**

Source: The authors (2024). Note: The AVE values are on the diagonal of the table (in bold), the values below the diagonal are the correlations and those above are the shared variances (squared correlations).

To verify discriminant validity, we sought to compare the AVE of each construct with the shared variance (Fornell & Larcker, 1981). In order to confirm the specific structure proposed, the AVE values must be above the shared variances (Fornell & Larcker, 1981). Thus, discriminant validity was confirmed, as demonstrated in the table above.

After evaluating the measurement model, the second stage of Structural Equation Modeling follows. Thus, the results achieved at this stage were: X2/df (987.798/309) = 3.197 (p = 0.00); GFI = 0.828; IFI = 0.851; TLI = 0.830 CFI = 0.850; NFI = 0.797; RMSEA = 0.083; PCLOSIS = 0.000; ECVI = 3.518; MECVI = 3.559. Therefore, it is possible to note that the values obtained show adequate adjustment indices (Hair et al., 2017).

Furthermore, the hypothesized model was evaluated by path diagram with the help of standardized regression weights (β) and p-values in order to evaluate (predict) the effect of

independent variables on the dependent variable in a similar model. In this sense, it is verified through the p-value that four direct hypotheses, among the six that were proposed, were confirmed, namely: H1, H2, H5, H6, as they presented values lower than 0.05, as shown in Table 4.

Table 4- Tests of the research's direct hypotheses

Hipóteses	***Standardized coefficient***	***Unstandardized coefficient***	***S.E.***	***R.C.***	***P***	***Status***
H1(+): RA -> INT	0,336	0,345	0,079	4,362	***	Supported
H2(+): CP -> INT	0,431	0,313	0,044	7,044	***	Supported
H3(+): OB -> INT	-0,056	-0,030	0,029	-1,009	0,313	**Not supported**
H4(+): PN -> INT	0,110	0,113	0,075	1,511	0,131	**Not supported**
H5(+): AC -> PN	0,305	0,357	0,115	3,089	0,002	Supported
H6(+): AR -> PN	0,554	0,542	0,114	4,760	***	Supported

Source: The authors (2024)

To test mediation relationships, an analysis of indirect effects was conducted. The results reveal that three indirect hypotheses, among the four that were proposed, were confirmed, namely: H7, H8 and H9, as they presented values lower than 0.05, as shown in Table 5.

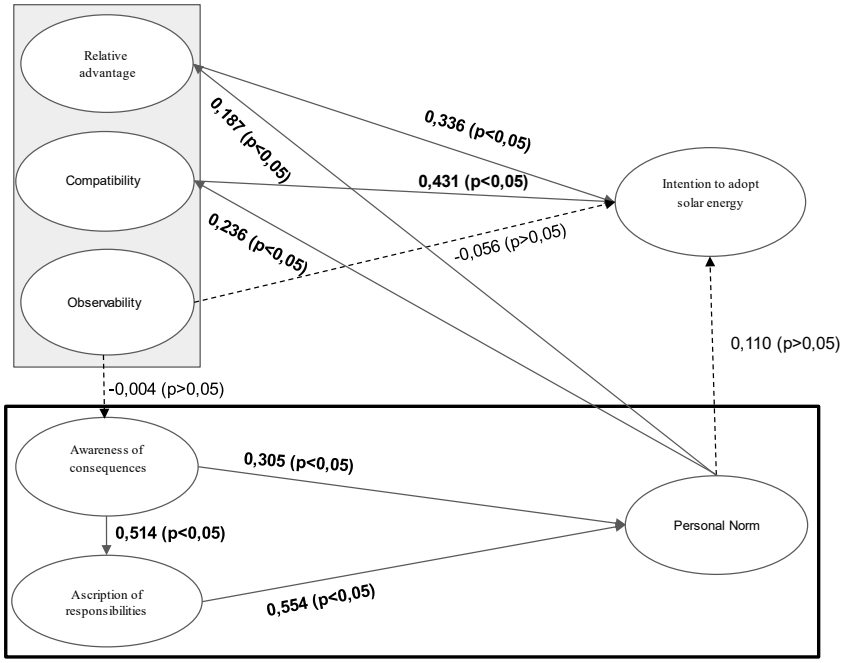
Table 5 – Tests of the research's indirect hypotheses

Hipóteses	**Coeficiente padronizado**	*P*	***Status***
H7: Awareness of consequences → Ascription of responsibilities → Personal norm	0,514	0,005	Supported
H8: Personal norm → Relative advantage → Intention to adopt solar energy .	0,187	0,002	Supported
H9: Personal norm → Compatibilidade → Intention to adopt solar energy	0,236	0,003	Supported
H10: Observability → Awareness of consequences → Personal norm.	-0,004	0,874	**Not supported**

Source: The authors (2024)

This time, in order to provide a better graphical visualization of the relationships between the hypotheses and constructs with their respective coefficients and significance, figure 2 is presented:

Figure 2 – Theoretical model with coefficients



Source: The authors (2024)

Because the majority of the sample indicated that the main motivation for not using solar energy in their homes was the high cost, multigroup analysis was used. To test whether the structural relationships of the model differed depending on income. As income was collected as a quantitative variable, income was transformed into a categorical variable. Considering the sample size, the data was divided into three income levels, namely: low (600 to 3000), medium (3100 to 5940) and high (6000 to 70000). Although the last group has a high amplitude, observations with incomes above 15000 are less frequent cases, meaning they do not significantly interfere with the analysis. This done, we proceeded to examine the invariance of the model between the groups at the configural (number of factors and items per factor) and metric (equivalence of factor loadings) levels (Byrne, 2010).

Configural invariance assesses whether the factorial structure is equivalent between groups. To this end, the adjustment indices $\chi 2/gl$, CFI and RMSEA were verified in the model without equality restrictions on the parameters, as suggested by Byrne (2010). Metric invariance was verified based on the CFI difference test, which should not have a high reduction when restrictions are imposed ($\Delta CFI > 0,01$) (Cheung & Rensvold, 2002). Table 6 presents the results, indicating that there is configural and metric invariance. Thus, we continued with the other analyses.

Table 6 – Model invariance

Categorical variable		Fit indices				ΔCFI
		χ^2/gl	*p-value*	CFI	RMSEA	
Income	Configural invariance	2,129	0,000	0,787	0,06	-
	Metric invariance	2,127	0,000	0,773	0,06	-0,01

Source: The authors (2024)

The Chi-Square test was performed to check whether the paths were statistically different between the groups. The results show that three relationships vary significantly depending on the groups (Table 7): consequences of the consequences and personal norms; assigned responsibility and personal norm; and Consciousness of the consequences and assigned responsibility.

Table 7 – Difference tests for income

	χ^2	Graus de liberdade	*p-value*
Relative advantage → Intention	1,388	2	0,500
Compatibility → Intention	2,611	2	0,271
Observability → Intention	3,113	2	0,211
Norma pessoal → Intention	3,151	2	0,207
Consciousness of the consequences → Personal norm	13,357	2	0,001
Assigned responsibility → Personal norm	9,910	2	0,007
Consciousness of the consequences → Assigned responsibility	8,955	2	0,011
Personal norm → Relative advantage	3,043	2	0,218
Personal norm → Compatibility	5,522	2	0,063
Observability → Consciousness of the consequences	0,781	2	0,677

Source: The authors (2024)

5 DISCUSSION

The overall results confirm that the intention to use solar energy can be predicted by Rogers' diffusion of innovation theory (2003) and Schwartz's Norm Activation theory (1977). Thus, this research demonstrates that potential consumers of solar energy can be influenced by both cognitive and moral altruistic aspects, corroborating the study by Alam et al. (2021).

In this sense, concerning the hypotheses proposed in this study, it can be seen that the first hypothesis H1: relative advantage positively influences the intention to use solar energy, obtained a $p<0.05$, therefore confirmed, corroborating with (Bilal & Andajani, 2023; Schulte et al., 2022; Kapoor & Dwivedi, 2020).

According to Alam et al. (2021), individuals who have a positive view of the potential benefits of adopting solar technology are more attracted and more inclined to adopt solar energy. Users concerningwho adhere to energy perceive it as a better practice than its precursor, since they begin to see advantages in the technology made available, which may be financial or otherwise (Rogers, 2003).

Hypothesis H2: compatibility positively influences the intention to use solar energy, with a $p<0.05$, was also confirmed, corroborating Kapoor and Dwivedi (2020). According to Alam et al. (2021), individuals who feel that the use of solar technology is compatible with their culture are more motivated to adopt this energy. And this is in line with the principles of compatibility, pointing out that when innovation is perceived as consistent with the existing values, needs and past experiences of potential adopters, it is accepted quickly (Rogers, 2003).

Hypothesis H3: Observability has a positive influence on the intention to use solar energy, was refuted because it showed a $p>0.05$. Thus, this result points to two reflections. The first is that individuals are unable to observe solar energy in their society, so there was no influence on the intention to use solar energy. The second is that even though these consumers were able to observe solar energy in their society, observability was not significant in influencing their intention to use solar energy.

However, although there is literature that contradicts the results found here (Ahmed et al., 2022; Alam et al., 2021), some studies have already shown that the relationship between observability and the intention to use solar energy is fragile. One study found no significance between visual observation and behavioral intention to use solar energy (Liu et al., 2023). This

can be justified by the gap between observation and action, so observation alone is ineffective in influencing intention. In addition, use ends up being the same for the end user.

Hypothesis H4: Personal norm has a direct and positive effect on the intention to adopt solar energy, obtained p=0.902, and was therefore refuted. This indicates that the respondents did not have feelings of moral obligation, i.e. internal obligations, regarding their intention to use solar energy. Refuting the work of (Arkorful, 2022; Wittenberg et al., 2018).

On the other hand, a possible justification for refuting this hypothesis is that individuals can internalize norms and still not act per them. This is because personal norms need to be defined as relevant and applicable to a situation, otherwise they will not be activated (Davies et al., 2002).

Thus, activated personal norms can result in altruistic behavior when no barriers are perceived or when no high costs are involved (Abrahamse et al., 2009). However, this assumption was not perceived by the respondents, since the majority pointed out that the main reason for not using solar energy is related to the cost. Therefore, users perceive a high cost involved and this barrier could become an impediment to the personal standard being applied.

Concerning hypothesis H5: Awareness of Consequences has a direct and positive effect on Personal Norm, it obtained a $p<0.05$, therefore confirmed, corroborating (Arkorful, 2022; Hynes & Wilson, 2016; Abrahamse et al., 2009). The results show that the majority of the sample is aware of the need for pro-environmental behavior. They are aware of the consequences of using conventional energy, fossil fuel depletion and global warming.

Concerning hypothesis H6: attributed responsibility has a direct and positive effect on Personal Norm, obtaining a $p<0.05$, therefore confirmed, corroborating (Arkorful, 2022; Hynes & Wilson, 2016; Abrahamse et al., 2009). In addition, the results of this sample are in line with the results presented by (Hasheem et al., 2022), pointing out that people are more concerned about energy-efficient products and want to protect the environment and reduce the depletion of natural resources.

Concerning hypothesis H7: attributed responsibility mediates awareness of consequences in the influence of personal norms, obtaining a $p<0.05$, therefore confirmed, corroborating (Wang et al., 2018; Kim; Woo & Nam, 2018). Conforming the mediating structure.

Concerning hypothesis H8: relative advantage mediates personal norm in the intention to use solar energy, obtained a $p<0.05$, therefore confirmed. Thus, this hypothesis can be justified by the fact that personal norms derive from a sense of pride (Abrahamse et al., 2009), as well as being applicable to a factual situation (Davies et al., 2002). As a result, respondents perceive a greater value on the advantages of this adoption (Alam et al., 2021), generating an impact on the intention to use solar energy.

In addition, the literature points out that the personal norm is not activated when there are barriers, as can be seen in the negation of hypothesis H4. However, this study shows that the mediating effect of relative advantage can reduce this barrier. Since individuals can perceive the real benefits of using solar energy compared to conventional energy sources (Colmenares-Quintero et al., 2020). This can lead to an encouraging belief in the benefits (Irfan et al., 2021) and thus a positive effect on the intention to use solar energy.

Hypothesis H9: Compatibility mediates personal norms and the intention to use solar energy, obtained a $p<0.05$ and was therefore confirmed. Thus, this hypothesis can be justified by the fact that the absence of risk perceived by the technology (Wolske et al., 2017), results in compatibility with the practices, values and needs of potential adopters (Rogers, 2003). In this way, personal norms activate compatibility, since normative concerns are related to people's lifestyles (Thøgersen, 1996).

Thus, the results of this sample indicate that feelings of moral obligation alone were not enough to influence the intention to use solar energy. However, when they perceive the benefits

of solar energy (mediating effect) over conventional energy, the influence is positive and significant. Since they can see that the benefits (energy savings, investment, cost-benefit ratio) overcome the barriers (price, aesthetic change, financial disadvantage). In addition, when they perceive compatibility (mediating effect) to the detriment of conventional energy, the influence is positive and significant. They realize that the use of solar energy is in line with their practices, values and needs.

Hypothesis H10: awareness of consequences mediates observability of personal norms, obtained p=0.984, and was therefore refuted. This is in line with the study by Ahmad et al. (2014). The denial of this hypothesis can be justified by the fact that the majority of respondents pointed out that they were unable to observe solar technology in their society. In other words, the lack of observability can be a barrier, and the personal norm cannot be activated in the context of barriers (Abrahamse et al., 2009), or if the situation is not applicable (Davies et al., 2002).

For this sample, 73% pointed out that the main reason for not using solar energy was the high cost. However, income showed no significant difference when analyzing personal cognitive aspects. On the other hand, altruistic moral aspects were significant. Interestingly, people with a lower income had a greater impact on both the awareness of consequences and personal norm, and the awareness of consequences and attributed responsibility. This result confirms that respondents have feelings of internal obligation to use solar energy, but because they have a low income, the high cost becomes a barrier that prevents them from using it.

In order to better visualize the hypothetical deductive model after the analysis and discussion of the results discussed above, Table 2 is presented, showing a summary of the results of the ten hypotheses and their respective justifications.

Table 2 - Results of the hypothetical-deductive model

Hipótese	Pressupostos teóricos preliminares e possíveis justificativas	Resultado
H1	Relative Advantage has a direct and positive effect on the Intention to use solar energy. ✓ They corroborate (Bilal & Andajani, 2023; Schulte et al., 2022) • Positive view of the potential benefits. • Encouraging belief in the benefits. • They perceive the practice better than its predecessor.	Supported
H2	Competitiveness has a direct and positive effect on the Intention to use solar energy. ✓ - Corroborates (Alam et al., 2021; Kapoor & Dwivedi, 2020) • Compatible with your culture. • Existing values, current needs and past experiences.	Supported
H3	Observability has a direct and positive effect on Intention to use solar energy. ✓ Refutes the findings of (Ahmed et al., 2022; Alam et al., 2021). • Weakness of observability - (Liu et al., 2023). • Gap between observation and action.	Not supported
H4	Personal Norm has a direct and positive effect on the Intention to use solar energy. ✓ Refutes (Wittenberg et al., 2018; Van der Werff & Steg, 2015). • No feelings of moral obligation, i.e. internal obligations. • Internalize norms and still do not act in accordance with them. • Barriers or when a high cost is involved.	Not supported
H5	Awareness of the consequences has a direct and positive effect on the Personal Norm. ✓ They corroborate (Arkorful, 2022; Hynes & Wilson, 2016). • Awareness of the consequences of using conventional energies. • Awareness of the consequences of fossil fuel depletion and global warming.	Supported
H6	Attributed responsibility has a direct and positive effect on Personal Norm. ✓ They corroborate (Hynes & Wilson, 2016; Abrahamse et al., 2009). • Feel joint responsibility for the negative consequences of conventional energies. • They feel responsible for ensuring quality of life for future generations.	Supported
H7	Attributed responsibility mediates awareness of consequences in influencing personal norms. ✓ Corroborate (Wang et al., 2018; Kim et al., 2018).	Supported
H8	Relative advantage mediates personal norms and the intention to use solar energy. • Perceived benefits (energy savings, investment, cost benefit). • Overcoming barriers (price, aesthetic change, financial disadvantage).	Supported
H9	The compatibility of personal norms with the intention to use solar energy. • Absence of perceived risk for the technology (Wolske et al., 2017). • Overcoming barriers (lifestyle, needs and values).	Supported
H10	Awareness of consequences mediates observability over personal norm. • Lack of observability can be a barrier (Abrahamse et al., 2009).	Not supported

Source: The authors (2024)

6 CONCLUSION

Solar energy reduces climate change and the carbon footprint, so its use has been encouraged by scholars, institutions, governments and society. In this sense, the solar energy consumption movement is gaining momentum not just as the antithesis of conventional energy, but as a reflection of conscious decisions that seek to bring about changes in energy production and consumption.

The findings of this research make three major contributions. Firstly, they add information related to the analysis of altruistic rational and moral aspects of consumer decision-making, advancing energy consumption studies in particular. Secondly, the results provide empirical evidence of the importance of relative advantage, compatibility, awareness of

consequences and attributed responsibility, so that this relationship occurs not only directly, but also positively. Thirdly, the integration of theories demonstrates how the mediation of elements such as relative advantage and compatibility enable consumers to overcome barriers that may impede their intention to use solar energy.

This research specifies that rational decisions such as relative advantage and compatibility influence the intention to use solar energy. In addition to cognitive findings, it specifies that altruistic moral decisions such as awareness of consequences and assigned responsibility influence feelings of obligation related to solar energy.

In addition, three novel perspectives were specified in this study. The first is that the existence of an encouraging belief in benefits may be able to break down barriers and this may have a positive effect on the intention to use solar energy. Secondly, the results indicate that the presence of compatibility minimizes the barriers that could be perceived by the consumer, which could potentially be neutralizing the feeling of obligation. Finally, the high cost of using solar energy could be a barrier related to altruistic moral aspects.

7 THEORETICAL, PRACTICAL AND SOCIAL IMPLICATIONS

As far as theoretical contributions are concerned, the study is unprecedented. Since no similar work was found in the databases consulted that integrated the constructs of the Technology Diffusion Theory and the Norm Activation Theory and the Intention to use solar energy. This contributes to literature studies and advances in research related to sustainable energy consumption, specifically the use of solar energy. In addition, at the academic level, most research is carried out in developed countries, so this research contributes with new explanations in developing countries, since this field of study has been little explored.

Concerning practical contributions, the results of this research supported that individuals consider rational and ethical aspects when making decisions. However, there are barriers on the way to achieving real behavior. It is therefore recommended that industries, policymakers and managers consider cognitive and altruistic aspects in the scope of their decisions. In view of this, some practical actions are suggested:

Short-term: Carry out educational and information campaigns on the use of solar energy; publicize the cognitive benefits (energy savings, investment, cost-benefit, compatibility with your energy needs, suitability for the geographical and environmental conditions of your home); make society aware of the altruistic aspects (reducing environmental problems, contributing to ecological solutions and guaranteeing quality of life for future generations); Spreading the word about the social advantages of using solar energy (generating employment, reducing energy poverty, improving the environment); Increasing the observability of solar technology through social media; investigating more accessible alternatives for using solar energy.

Medium term: make incubation projects for new solar technologies viable through public/private partnerships; partner with associations and cooperatives to offer training and educational courses on solar energy; promote virtual events among solar energy entrepreneurs to share ideas on the diffusion of solar energy; spread the word about the decarbonization potential of using solar energy.

Long-term: invest in research and development into solar technologies and innovations; call for a municipal and state renewable energy adoption plan; demand that municipalities and states make it compulsory to invest in research into renewable energy sources through the LOA and PPA; call for the implementation of public policies that promote the development of the sustainable energy sector; call for a reduction in renewable energy taxes.

In addition, this study contributes to society, as it brings positive associations about the consumption of sustainable energy, which improves the environment, saves energy and reduces

energy poverty. This contributes to a better quality of life for the population. Thus, at a micro level of intervention, this research aimed to expand the dissemination of renewable energy technology and thus contribute to achieving the UN's seventh sustainable goal, which is to provide affordable and clean energy for all (SDGs, 2018).

For this reason, it is recommended that final consumers: get more involved in sustainable practices; adopt pro-environmental behaviors despite the higher costs; value products and services that have not only cognitive advantages, but also altruistic ones; demand the promotion of solar technology from the executive, legislative and judicial branches.

8 LIMITATIONS SUGGESTIONS FOR FUTURE RESEARCH

Despite the innovative nature and theoretical and empirical advances presented so far, some limitations stand out: online research, there is always the probability that consumers will not respond truthfully or objectively, leading to the occurrence of so-called Social Desirable Responding (SDR); difficulty in making a self-assessment of their consumption behaviour; the impossibility of generalization given the sampling technique used.

As for suggestions: use a focus group or other qualitative approach with open-ended answers to resolve questions related to the occurrence of SDR; approach other theories that would provide new results, especially marketing theories, such as the Means-End Chain Theory (Gutman, 1982); compare the intention to use and the actual behavior of using solar energy in order to contribute to the intention/behavior gap.

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