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Evolution and Determinants of Consumer Interest in Renewable Energy in Ecuador: A Temporal Perspective

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ABSTRACT

Through an empirical analysis of the evolution of Ecuadorian consumers' interest in renewable energy and the factors influencing it, this study seeks to provide an understanding of the popularity and uptake of clean energy in a Latin American country with a significant renewable energy sector. Relevant data on economic and socio-environmental variables were collected and the effect of these variables on indicators of consumer interest in renewable energy was evaluated. The results indicate that Ecuadorian consumers' interest in renewable energy has shown a growth trend in recent years and is influenced by multiple factors, such as the relative production of renewable energy, energy prices and information about natural disasters. Overall, this research contributes to understanding the dynamics of public interest in renewable energy in developing economies such as Ecuador, emphasizing the importance of understanding the evolution of consumer perspective considering not only cost-benefit relationships but also responses to environmental events.

Keywords: Renewable Energies, Consumer Interest, Energy Industry, Ecuador
JEL Classifications: Q42, M14, P48

1. INTRODUCTION

In the context of a world increasingly aware of environmental challenges and the need to move towards more sustainable forms of energy, public acceptance and interest in renewable energy has become a key issue on political agendas. In Ecuador, a country with rich natural diversity and a growing use of renewable energy, the search for clean energy alternatives has become a topic of interest for citizens and policymakers alike (Villamarín-Tapia et al., 2023). This article aims to examine the evolution of this interest over time, using data collected from Google Trends (GT), in order to shed light on trends and changes in public perception regarding renewable energy in the Ecuadorian context.

The situation of Ecuador, a country privileged by its abundant biodiversity and natural resources, reflects this paradigm shift in energy perception. The nation has demonstrated a remarkable commitment towards the expansion of renewable energy, with significant investments in wind, solar, hydropower, and geothermal projects in recent years. This approach not only responds to the need to diversify the energy matrix and reduce dependence on fossil fuels, but also reflects a growing awareness of the importance of preserving the country's natural environment and harnessing its resources in a sustainable manner. However, understanding the evolution and dynamics of public interest in renewable energy in Ecuador is critical to guide effective policies and communication strategies that further drive this transition to a cleaner and more resilient economy.

Is Ecuadorian consumers' interest in renewable energy a natural result of the increase in clean energy production at the initiative of the government and companies? Are there other phenomena such as the price of energy or natural disasters that increase

public interest in these energy sources? These are the questions that we try to answer in this paper and that guide our empirical strategy. By analyzing data obtained from search tools, we seek to identify temporal patterns and correlations between key events and search behavior related to renewable energy in Ecuador. By better understanding the drivers behind the shift in the public interest towards renewables, we can more effectively inform communication policies and strategies aimed at promoting a broader and more sustainable energy transition in the country.

In addition, this information is of great value to the private sector, given that the positive perception of products associated with renewable energy can have a significant impact on consumer behavior and, therefore, on marketing and product development strategies. The study by Mydock III et al. (2018) revealed that consumers respond favorably to products touted as being made with renewable energy, which can not only lead to more sustainable business practices, but also changes in company policies. These findings underscore the importance for companies to understand and capitalize on consumer interest in sustainability and renewable energy, not only as a way to meet today's market demands, but also as an opportunity to differentiate themselves from the competition and build a more positive, future-oriented brand image.

In order to contribute to the growing literature examining the determinants of consumer preference and interest in renewable energy, this study focuses on a detailed analysis of the effects of economic and environmental events and information on consumer interest in renewable energy in Ecuador. Unlike previous research that used consumer-level analysis in cross-sections or panels with short periods of time, this research takes a temporal aggregate approach by analyzing time series that capture the evolution of these phenomena over a 10-year period.

For this, we use monthly data from Ecuadorian public sources and data from search engines. The empirical strategy is divided into two parts with econometric methods that complement each other. Initially, we performed Ordinary Least Squares (COD) estimates with Newey West matrices to evaluate the effects of economic and environmental phenomena and information on consumer interest in renewable energy in Ecuador. Subsequently, we use similar models to assess the effects of information shocks related to specific natural disasters on public interest in clean energy sources and their use. In addition, we complement the robustness of the statistical specification with a VAR model that allows us to examine how the impacts of these crashes vary over time.

The results indicate that Ecuadorian consumers' interest in renewable energy has shown a growth trend in recent years and is influenced by multiple factors, such as the relative production of renewable energy and fossil fuel prices. A positive and significant effect of renewable energy production on consumer interest was observed, while an increase in fossil fuel prices was associated with a decrease in interest in renewables. In addition, natural disasters, especially wildfires, floods, and acid rain, also have a significant impact on consumer interest in renewable energy. The public's response to these events can vary depending on the severity and duration of the disaster, with an immediate increase in interest in renewables for some and a later but persistent response for others. These findings highlight the importance of energy policies that encourage the production and use of renewable energy, as well as public education on the need to adopt more sustainable energy sources to mitigate the impacts of climate change.

The structure of the article is organized into four sections: The introduction, which presents the problem addressed and highlights the relevance of the study in the Ecuadorian context; a theoretical framework that explores the current state of the study on consumer preferences and interest in renewable energy and its determinants; methodology, which details the data and methods used in the statistical analysis; the results, which present and explain the empirical evidence obtained by the implemented models, discussing the main findings and reflecting on their scope and implications; and finally, the conclusions, which summarize the contribution of the study and propose possible directions for future research in this field.

2. THE CURRENT STATE OF LITERATURE

The existing scientific literature on renewable energy indicates a broad social acceptance of these sustainable energy sources. However, it is important to note that, beyond this general approval, there is a limited level of consensus and understanding in the literature regarding specific consumer preferences in relation to renewable energy. This lack of consensus can be attributed in part to the inherent complexity of the research topic and the variety of methods used to measure consumer preferences, making it difficult to compare and synthesize findings. In addition, the divergence in preferences for renewables can also be attributed to the nature of public goods in this market. Since the benefits of renewable energy, such as reduced greenhouse gas emissions and energy security, extend to the whole of society, while the costs may fall on a few, it creates a challenge for the widespread adoption of these technologies.

In the commercialization of renewable energy in competitive markets, consumers face contradictory demands. On the one hand, many individuals value the moral satisfaction derived from voluntary activities that promote environmental respect and the development of renewable energy. On the other hand, they prefer political mechanisms that guarantee the development of these energies through collective obligations that minimize the possibility of taking advantage of the expenses of other individuals (Menges and Beyer, 2017).[1] As this is a dilemma that is difficult to measure and answer from an empirical point of view, several studies try to find out what are the determinants of consumer preferences in relation to renewable energies using the most varied methodologies.[2]

1 The dilemma between the moral satisfaction derived from individual action and the preference for political mechanisms that guarantee the development of renewable energies is a complex issue with an extensive literature behind it. Studies are needed to explore how individual action can be encouraged without neglecting the importance of public policies, particularly for the consumption of renewable energy.

2 This challenge underscores the importance of effective public-private collaboration to promote the transition to a more sustainable and equitable energy system.

Individual attitudes and perceptions play an important role in willingness to adopt renewable energy technologies. Hast et al. (2015) point out that factors such as age and perception about renewables can influence consumers' willingness to purchase green energy systems, highlighting the importance of considering demographic preferences when designing marketing strategies and energy policies. The authors noted that, in the case of Shanghai, China, economic reasons motivate consumers to buy clean energy more strongly than environmental issues.

In addition, cognitive and emotional aspects are also relevant in the formation of attitudes towards renewable energies. Bang et al. (2000), in a study using reasoned action theory as a theoretical framework, found that beliefs about the consequences of using renewable energy are positively related to consumer attitudes toward paying more for renewable energy. However, this study also revealed that consumers' environmental concerns do not always translate into increased knowledge about renewable energy, highlighting the importance of educating consumers about the benefits and features of these technologies. The study suggests that environmental concerns and consumer beliefs about renewable energy to date are more emotionally charged than based on facts or knowledge.

Khalid et al. (2021) found that environmental concerns, ease of use, and financial incentives have a positive influence on the adoption of renewable energy technology, suggesting that addressing environmental concerns and improving the economic accessibility of renewables can encourage consumer adoption. On the other hand, the results of Mozumder et al. (2011) indicate that while many consumers are willing to pay more for a higher share of renewable energy in the energy portfolio, concerns about price and reliability of supply may also negatively affect the acceptance of renewables by some consumers.

At the same time, some studies have emerged in the literature that evaluate how natural phenomena and disasters can impact consumer behavior and preference towards renewable energies. Baccini and Leemann's (2021) study investigates how voters respond to extreme weather events, such as floods, and how this may influence their support for climate protection measures. They argue that direct experience of natural disasters can prepare voters for climate change and affect their political behavior. Using micro-level geospatial data on natural disasters and referendum votes in Switzerland, the authors explore the impact of these experiences on supporting policies related to climate change. Their findings reveal a significant effect on voting behavior, with a 20% increase in the percentage of votes in favor of climate policies after experiencing a flood. This study contributes to the literature by examining how local conditions can influence political support for climate change mitigation measures, highlighting the importance of considering voters' personal experience when designing environment-related strategies and policies.

The study by Goebel et al. (2015) examined the impact of the Fukushima disaster on environmental concerns, well-being, risk aversion, and political preferences in Germany, Switzerland, and the United Kingdom. Although overall life satisfaction did not decrease significantly in these countries, the disaster greatly increased environmental concerns among Germans. This is attributed to an underlying mechanism operating through the perceived risk of a similar domestic reactor meltdown. In the aftermath of the disaster, more Germans considered themselves "very risk-averse." However, the drastic German political action that shut down the older reactors and proclaimed the transition to renewables contributed to a subsequent decline in environmental concerns, especially among women, Green Party supporters, and people living near the older reactors. Consequently, political support for the Greens increased significantly in Germany, while in Switzerland and the UK this increase was limited to people living near the reactors. This study highlights how natural disasters can have lasting effects on environmental concerns, risk perception, and policy preferences, and how policy responses can influence the evolution of these attitudes over time and in different geographic contexts.

In turn, the work of Lane et al. (2023) analyzes how natural disasters can increase pro-environmental behavior in the short term. The study authors found that people who experienced a natural disaster were more likely to exhibit behaviors such as energy conservation, recycling, and reduced consumption after the event. The authors suggest that this change in behavior can be explained by the "shock doctrine," a theory that argues that people are more receptive to radical changes in their environment after experiencing a traumatic event. In this case, the natural disaster acts as a traumatic event that can open people up to the possibility of changing their behaviors to protect the environment.[3]

The increasing attention of the literature to the effects of both natural phenomena and the public perception of them reflects a more complete understanding of the factors that influence human behavior and individual and collective decisions. Recent research, such as that by Hagen and Pijawka (2015), Hamilton et al. (2018), Goebel et al. (2015), Baccini and Leeman (2021), and Lane et al. (2023), have expanded the traditional approach to natural disasters to include the crucial role of information and public perception in shaping attitudes and behaviors. This shift in perspective has been especially prominent in the social sciences, where it has been consistently shown that consumer opinions and predictions can significantly influence real variables, such as investment decisions, consumption of products and services, and adoption of technologies (Juster, 1960; Ruef and Markard, 2010; Kakeu and Byron, 2016; Montes and Díaz, 2023). This trend reflects a more sophisticated understanding of the dynamic interaction between natural and socioeconomic factors in shaping human responses to environmental and climate challenges.

The diversity of methodologies used in research on consumer preferences regarding renewable energy reflects the complexity of the issue and the need to address it from multiple approaches.

3 While environmental concerns and consumer beliefs about renewable energy may be more emotionally charged than based on facts or knowledge, education plays a crucial role in forming positive attitudes towards these technologies. There is a need to develop effective communication strategies that provide accurate and engaging information about renewable energy so that consumers can make informed decisions.

In addition, the interaction between demographic, economic, psychological, and environmental factors in the formation of attitudes towards renewable energy highlights the importance of considering a broad spectrum of variables when designing policies and communication strategies. This multidisciplinary approach is critical to fully understand the underlying dynamics driving consumer interest in renewable energy and to develop effective interventions that promote greater adoption of these technologies in Ecuadorian society.

On the other hand, recent research highlights the importance of addressing environmental concerns and improving the economic accessibility of renewable energy as key strategies to encourage consumer adoption. These findings underscore the need for policies and programs that not only promote environmental awareness, but also facilitate access to affordable and readily available renewable energy technologies for all sectors of the population. By better understanding the factors influencing the adoption of renewable energy, policymakers and market players can develop more effective strategies to promote a broader and more sustainable energy transition in Ecuador, thereby contributing to climate change mitigation and improved energy security at the national and global levels.

3. DATA AND ESTIMATION TECHNIQUES

3.1. Data

To study the dynamics and determinants of Ecuadorian consumer interest in renewable energies, the renewable energy sources widely used in Ecuador were selected: Biogas, biomass, wind, hydro and solar energy. The analysis covers the period from January 2011 to January 2023. The period of analysis was chosen based on the availability and quality of the data.[4] The approach used is time series and the frequency of the data is monthly.

The temporal dynamics and determinants of public interest in renewable energy have been little studied in Latin America due to the limited availability of data that can capture this phenomenon. The majority of studies that assess consumer interest use consumption as a proxy, however, in developing countries, where the adoption of renewable energy is often inaccessible due to the high cost and is often only adopted by households through government programs and incentives, it is necessary to use an interest proxy that is less dependent on the level of income. In this paper, data from the GT search mechanism is used to estimate consumer interest in renewable energy in Ecuador for each of the sources used in the country.[5]

One of the main advantages of using this search engine as a source of information lies in its ability to provide real-time data on how consumer interest in renewable energy is evolving. Unlike traditional surveys or market research, which can require significant time and resources, GT provides instant access to up-to-date search trends, allowing researchers and policymakers to capture changes in the public interest in near real-time.[6]

GT provides access to a sample of actual search requests made on Google, which is anonymous and organized into categories based on the topic of the queries. This tool allows you to show users' interest in a topic at a global or local level. To facilitate comparisons between terms, the search data is normalized considering the time and location of the queries. This process involves dividing each data point by the total searches in the region and the corresponding time range, and then scaling the results to a range of 0-100. In doing so, the data represents relative popularity. For our dependent variables of interest, the results of this index can be seen in Figure 1.

In our case, we use the scale of 1-100 of the keywords related to renewable energy as a base reference for calculation and calibrate the other energies accordingly. This process was straightforward as the key word renewable energy alone is more popular than the types of energy. In addition, we calibrate each type of renewable energy according to all the keywords associated with it. In particular, the following keywords and their derivatives were used for each of the variables of interest in renewable energies:

Keywords:

1. Renewable energy: Renewable energy, renewable energy percentage, renewable energy production, clean energy, sustainable energy, green energy.
2. Biogas energy: Biogas, biogas energy, biogas production, anaerobic digestion, biogas plant.
3. Biomass energy: Biomass energy, biomass production, biomass power, biomass fuel, bioenergy, biomass combustion systems, biomass boilers.
4. Wind energy: Wind energy, wind power, wind turbine, wind farm, wind energy production.
5. Hydraulic energy: Hydraulic energy, hydro energy, hydroelectric power, hydropower, hydroelectric plant, hydropower systems.
6. Solar energy: Solar energy, solar power, solar panel, photovoltaic, solar energy production, photovoltaic systems.

Some interesting details can be gleaned from this figure. First, there is a clear change in the interest in Renewable Energy and Solar Energy, the two most important series in our set. This may

4 While GT is a valuable tool for analyzing search trends, it is not recommended for use for studies that require historical data prior to 2011. There are mainly 3 main reasons: i) Changes in methodology: Google has modified its search algorithms and data coverage, making it difficult to compare between periods. ii) Lower volume of data: The use of the internet and search engines was not as widespread before 2011, reducing the granularity and reliability of data. iii) Potential biases: Pre-2011 data may be biased due to lower internet penetration and limited device availability.

5 The use of Google Trends as a tool to estimate consumer interest in renewable energy has gained recognition in academic research and business decision-making in recent years. Google Trends, a platform that provides data on search volume for specific terms on Google's search engine, offers a single window into users' search preferences and trends online.

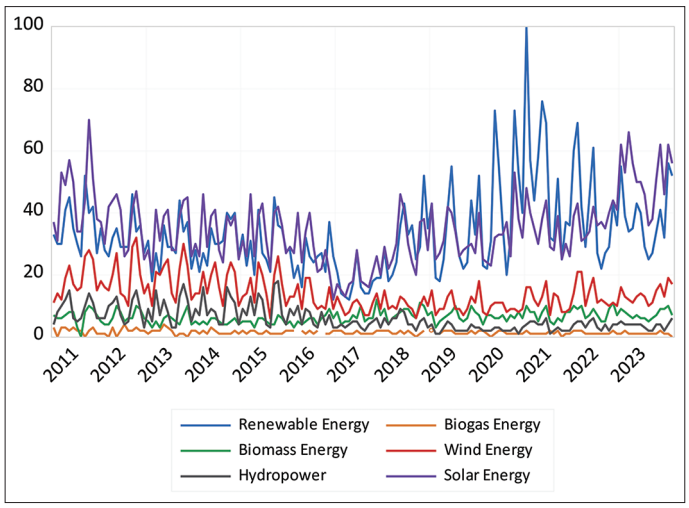
6 Another key advantage of Google Trends is its ability to identify emerging trends and ever-changing topics of interest in the renewable energy space. By analyzing specific search patterns, researchers can identify relevant keywords and topics that reflect consumers' current concerns and priorities regarding clean and sustainable energy. This capability allows researchers to stay on top of the latest trends and adapt their analyses and strategies accordingly.

Table 1: Descriptive statistics and source of variables

Name	Description	Source	Mean	Median	Maximum	Minimum	SD
RE	Renewable energy (percentage of total produced)	ARCER	64.2	66.7	85.5	30.6	14.5
BgE	Biogas energy (percentage of total produced)	ARCER	0.1	0.1	0.2	0	0.1
BmE	Biomass energy (percentage of total produced)	ARCER	1.4	1.1	3.5	0	1.3
WE	Wind energy (percentage of total produced)	ARCER	0.2	0.2	0.5	0	0.2
HE	Hydraulic energy (peercentage of total produced)	ARCER	62.4	65.0	85.0	29.2	14.6
SE	Solar energy (percentage of total produced)	ARCER	0.1	0.1	0.2	0	0.1
PI	Price index for electricity, gas and fuels	INEC	108.4	112.2	118.8	92.7	8.7
RE_CI	Renewable energy - consumer interest	GT	33.5	30	100	12	14
BgE_CI	Biogas energy - consumer interest	GT	1.5	1	4	0	0.8
BmE_CI	Biomass energy - consumer interests	GT	6.4	6	12	0	2.1
WE_CI	Wind energy - consumer interest	GT	14.2	13	32	6	5.7
HE_CI	Hydropower - consumer interest	GT	6.1	5	18	1	4
SE_CI	Solar energy - consumer interest	GT	33.3	32	70	12	9.6
ND_II	Natural disaster - information index	GT	17.4	14	100	0	19.5
EP_II	Environmental pollution - information index	GT	13.2	11	100	0	11
Ls_II	Landslide - information index	GT	15.9	12	77	0	12.3
FF_II	Forest fire - information index	GT	10.9	8	100	3	10.3
Fl_II	Flood - information index	GT	26	23	100	10	13.2
AR_II	Acid rain - information index	GT	40.6	38	100	7	18.3

ARCER: Energy and resources regulation and control agency, INEC: National institute of statistics and censuses, GT: Google trends, SD: Standard deviation

Figure 1: Consumer interest in renewable energy by type of energy source



Source: Authors' own elaboration with data from the Google Trends.

be the result of several phenomena such as, for example, the various policies and legal reforms implemented by the Ecuadorian government since 2016 that created a more attractive regulatory environment for investment in renewable energies, the exponential increase in energy with renewable resources or even the increase in incidences of natural phenomena.[7]

On the other hand, it is curious that although solar energy is the least produced and developed in Ecuador, it is the most popular renewable energy. It's possible to intuit that this happens because sunlight is abundant and virtually inexhaustible, making it a reliable source of energy in the long run. In addition, solar technology has seen significant advancements in recent decades, making solar panel installation more efficient and affordable. This has led to a reduction in solar energy production costs, making it more competitive compared to other energy sources.[8]

Among the most relevant independent variables of our study is the production of energy from renewable sources, for which we obtained data from the Energy and Resources Regulation and Control Agency of Ecuador. In addition, we use price indices for energy, gas, and water in Ecuadorian households to simulate the opportunity cost of renewable energy. Finally, we tried to capture the effect of natural disasters from searches in the GT engine. We selected this data against proxies of dummy variables, since in the latter we do not have information on the intensity and impact that the natural phenomenon captured in the lives of Ecuadorians. The variables used, their sources and descriptive statistics can be found in Table 1.

3.2. Model Specification

The empirical strategy of this work was divided into two parts. First, we evaluate the internal components of the time series of interest in renewable energies, trends, cycles and seasonality. Subsequently, the effect of renewable energy production, information on natural disasters and electricity, gas and fuel prices on consumer interest in renewable energy is evaluated. In this first model, we hope to reach results compatible with the economic literature, which in turn has shown that interest in renewable energies has an autonomous tendency to grow and that some elements such as natural disasters, the opportunity cost of energy and the productive development of these energies can affect the current state of knowledge and popularity of these energy sources (Batel, 2020; Segreto et al., 2020).

In the second stage of our study, we focused on exploring in greater depth the impact of information on natural disasters on interest

7 In 2017 alone, Ecuador suffered 2 earthquakes and several floods with several victims and damage to the economy.

8 Solar energy is a very versatile option with facilities to please the public, as it can be used both on a large scale in solar plants and on a small scale in residential or commercial installations. In addition, this energy source is clean and environmentally friendly, as it does not produce greenhouse gas emissions or air pollutants during its operation.

in renewable energies, paying special attention to the variation of this effect according to the type of disaster. We recognize that different types of natural disasters, such as floods, landslides, or wildfires, can uniquely influence public perception and awareness of renewable energy. Therefore, we seek to understand how these variations can modulate consumer interest in these sustainable energy sources. In addition, we aim to investigate the temporal duration of these effects, i.e., to determine how long the increase in interest in renewable energy persists after the occurrence of a natural disaster. This analysis will allow us not only to identify the nature and magnitude of the influence of natural disasters on the public interest in renewable energy, but also to provide valuable information on the temporal dynamics of this phenomenon, which can be crucial for the formulation of effective energy and environmental policies and communication strategies.

In summary, our models are as follows:

$$RE\_CI_{t,i} = \alpha_0 + \alpha_1 RE\_CI_{t-1,i} + \alpha_2 RE_{t,i} + \alpha_3 PI_t + \alpha_4 ND\_II + \varepsilon_t \quad (1)$$

Where $\varepsilon_t \sim N(0,\sigma^2)$

$$RE\_CI_{t,i} = \beta_0 + \beta_1 RE\_CI_{t-1,i} + \beta_2 EP\_II_t + \beta_3 FF\_II_t + \beta_4 Fl\_II_t + \beta_5 AR\_II_t + \beta_6 Ls\_II_t + \mu_t \quad (2)$$

Where $\mu_t \sim N(0, \sigma^2)$

Model control variables, as discussed in the literature reviewed in section 2, are critical to capturing the various factors that may influence consumer interest in renewables. These variables are carefully selected based on their theoretical and empirical relevance in previous studies.

We expect a positive coefficient from the autoregressive component of consumer interest in renewables. This would mean that previous searches on renewables continue to impact current interest. We hypothesize that this effect would be due to the growing awareness of sustainability.

In addition, in this context, the vector of renewable energy production variables ($RE_{t,i}$) is expected to have a positive effect on consumer interest in these energy sources. This is because an increase in renewable energy production, whether driven by government initiatives, private sector investments, or technological advancements, tends to increase the visibility and availability of these forms of energy in the market. Therefore, consumers may show greater interest in renewable energy as a result of increased public awareness and more accessible options. However, it is important to note that the exact impact of these renewable energy production variables may vary depending on the specific context and other external influences, underscoring the need for careful and detailed analysis within the framework of the proposed model.

On the other hand, the effect of the price of energy, gas and fuels on consumer interest in renewables may be more difficult to predict. At first, we know that in high-yielding countries, an increase in the price of fossil fuels and traditional energy can lead consumers to become interested in alternatives. However, we are not working with a developed economy, but with Ecuador, a Latin American economy with a large informal sector and low levels of income. For this reason, an increase in the price of fossil fuels could also have a negative effect on the immediate interest in renewable energy, mainly for two reasons or barriers to entry. (1) Initial cost: The initial investment in renewable energy systems, such as solar panels or wind turbines, can be higher than that of traditional fossil fuel-based systems. An increase in the price of fossil fuels may reduce the economic attractiveness of renewables for some consumers, especially those with limited budgets or looking for more accessible energy solutions in the short term. (2) Financing:

Table 2: Unit root test

Variable	PP		Augmented dickey-fuller		
	P	Bandwidth	Lag	P	Max lag
RE_CI	0.000	6	0	00.000	13
BgE_CI	0.000	15	0	00.000	10
BmE_CI	0.000	8	11	00.590	13
WE_CI	0.000	0	11	00.996	13
HE_CI	0.000	4	11	00.904	13
SE_CI	0.000	5	13	00.750	13
ND_II	0.000	3	0	00.000	13
EP_II	0.000	2	0	00.000	13
Ls_II	0.000	5	0	00.000	13
FF_II	0.000	1	0	00.000	13
Fl_II	0.000	2	0	00.000	13
AR_II	0.000	6	11	00.908	13
RE	0.010	3	0	00.019	13
BgE	0.441	4	1	00.727	13
BmE	0.000	2	6	00.002	13
WE	0.012	6	0	00.010	13
HE	0.008	3	0	00.018	13
SE	0.931	5	0	00.907	13
PI	0.991	7	5	00.930	13

The t-statistics for ADF and PP were−7.838 and−9.050, respectively. Akaike and Schwarz information criteria were used to determine the exogenous terms of the test equation (intercept only - I or trend and intercept - I+T), when tied, the Hannan-Quinn criterion was used as the deciding vote. PP: Philips-Perron

Table 3: OLS estimation of internal elements of the consumer interest in renewable energy series

Regressors	Coefficient	SE	t-statistic	P
C	21.999	11.315	1.944	0.054
TREND	0.092	0.052	1.766	0.080
Month=January	13.886	4.873	2.850	0.005
Month=February	1.436	7.591	0.189	0.850
Month=March	−0.746	9.835	−0.076	0.940
Month=April	−0.414	10.133	−0.041	0.968
Month=May	13.881	10.251	1.354	0.178
Month=June	11.472	10.526	1.090	0.278
Month=July	−0.286	10.715	−0.027	0.979
Month=August	−3.565	11.225	−0.318	0.751
Month=September	5.395	10.649	0.507	0.613
Month=October	3.970	10.399	0.382	0.703
Month=November	10.073	10.153	0.992	0.323
AR (1)	0.563	0.083	6.797	0.000
SIGMASQ	91.514	8.086	11.317	0.000
Adjusted R^2	0.459	SD dependent variable		13.675
SE of regression	10.056	Akaike info criterion		7.547
Sum squared resid	14459.280	Schwarz criterion		7.837
Log likelihood	−581.186	Hannan−Quinn criter		7.665
F-statistic	10.527	Durbin−Watson stat		2.006
P (F-statistic)	0.000			

SE: Standard error, SD: Standard deviation

Financing options for the installation of renewable energy systems, such as loans or government incentives, may be affected by changes in economic or political conditions. An increase in the price of fossil fuels could make it harder to access financing for renewables, discouraging some potential consumers.

The most promising variable in our analysis is the natural disaster information index, whose inclusion in the model is based on the assumption that it will have a positive effect on consumer interest in renewable energy. This hypothesis is based on the idea that natural disasters can increase public awareness of the importance of adopting more sustainable and climate-resilient energy sources. Direct or indirect exposure to these extreme events can sensitize people to the negative environmental impacts of conventional energy sources, such as fossil fuels, and increase their willingness to consider cleaner, renewable alternatives. In addition, natural disasters can highlight the need to strengthen energy infrastructure and promote diversification of energy sources to reduce vulnerability to future extreme weather events (Goebel et al., 2015; Lane et al., 2023).

The vector of information indices on natural disasters is composed of (i) Air pollution; (ii) Forest fires; (iii) Flooding; (iv) Acid rain and (v) Landslides. These terms, in addition to being the most popular in Ecuador according to Google search engines, also have a close relationship with the use of fossil fuels and the use of non-renewable energies. The burning of fossil fuels, such as coal, oil, and natural gas, releases a variety of pollutants into the air, including nitrogen oxides, sulfur dioxide, volatile organic compounds, and fine particulate matter. These pollutants can cause a number of health problems, including respiratory, cardiovascular, and carcinogenic diseases, as well as contributing to climate change.

On the other hand, while wildfires can occur naturally, human activity, such as burning fossil fuels and deforestation, can significantly increase their frequency and severity. Climate change induced by the burning of fossil fuels can also create climate conditions more conducive to the spread of wildfires by increasing temperature and dryness. On the other hand, climate change can intensify weather patterns, increasing the frequency and intensity of torrential rains and floods. In addition, the melting of glaciers and polar ice caps due to global warming may further contribute to sea level rise and thus increase the risk of coastal flooding.

In relation to acid rain, the burning of fossil fuels, particularly the combustion of coal, oil, and natural gas in power plants and vehicles, releases sulfur dioxide and nitrogen oxides into the atmosphere. These gases can react with water and the other atmospheric components to form sulfuric acid and nitric acid, which can then fall to earth in the form of acid rain. This phenomenon can damage soils, freshwater bodies, and terrestrial ecosystems, negatively affecting agriculture, wildlife, and human health.

While landslides can be triggered by a variety of natural factors, such as topography, geology, and meteorology, deforestation associated with fossil fuel extraction and other human activities can significantly increase susceptibility to landslides by reducing soil stability and increasing erosion. In addition, climate change induced by the burning of fossil fuels can increase the intensity of rainfall and thus the risk of landslides.

Equations (1) and (2) are estimated using ordinary least squares (COQS) and use the Newey-West matrix (HAC) to avoid problems arising from autocorrelation or heteroscedasticity, which are so common in time series (Newey and West, 1986).[9] To check if the series has unit root, we performed the Fisher (ADF) and Philips-Perron (PP) unit root tests which can be found in the Table 2 below.

The results indicate that all the important series of our model exhibit a behavior without order of integration (I(0)), so we can consider them stationary. Based on these results, the models are estimated in their level forms.

Finally, in order to obtain more robust results and understand the temporal dynamics in the effects of the second equation, we reestimated the model using Autoregressive Vectors (VAR) of order 1 determined from the Johansen cointegration test.[10] The impulse response function of the generalized var model uses innovations of 1 S.D with 95% confidence interval using Hall,s percentile bootstrap with 1000 bootstrap reps.

4. EMPIRICAL RESULTS

To evaluate the components of the series of interest in renewable energies of Ecuadorian consumers, Table 1 shows how the trend, seasonality and cycle behave in this variable. In this regression, the time trend variable (TREND) has a positive coefficient of 0.092 and a t-value of 1.766. This indicates that there is a positive trend in interest in renewables over time. In addition, month-specific variables (MONTHs) are included as dummy variables. Among these variables, the coefficient of MONTH=1=January is significantly positive (13.886) with a t-value of 2.849 and a P = 0.005. This suggests a significant increase in interest in renewables in January compared to the year-end baseline in December, although no effects are observed.

The results suggest that there is a positive trend in interest in renewable energy over time. However, the positive coefficient in the time trend variable indicates that interest in renewables tends to increase gradually over time. This could be interpreted as a reflection of the growing global interest in sustainability and environmental concerns over the years. In addition, the results show that interest in renewables is significantly higher in January compared to other months. This could be due to a variety of reasons, such as renewable energy awareness campaigns at the beginning of the year or the influence of sustainability-related New Year's resolutions. This observation highlights the importance of considering seasonality in the analysis of public

9 The estimator is used to try to overcome autocorrelation, or correlation, and heteroskedasticity in the error terms in the models. This is often used to correct the effects of correlation of error terms in regressions applied to time series data.

10 To determine the order of a VAR model using the Johansen cointegration test, the number of significant component vectors is examined. This number can range from zero to the total number of variables in the system.

interest in renewable energy and could have practical implications for communication and marketing strategies in this field. These insights are detailed in Table 3 below.

The term AR(1) (first-order autoregressive) has a positive coefficient of 0.563 and is highly significant, indicating the presence of positive autocorrelation in errors. This implies that interest in renewables in one period is positively correlated with interest in the previous period. This could indicate the existence of feedback effects or the persistence of public attention towards renewables over time. In addition, the SIGMASQ term (error term variance) has a value of 91.514, indicating the amount of unexplained variability in the model. This variance is statistically significant, suggesting that there is a significant amount of variability in interest in renewables that is not captured by the variables included in the model, which justifies the use of our specification 1, which can be found in Table 4.

When we replicate this exercise for each renewable energy analysed, we get more detail about individual behaviours. It is possible to note, for example, that solar energy has seen remarkable growth in interest over the years, showing a steady upward trend since 2011. This increase may reflect increased public recognition and awareness of the viability and potential of solar energy as a clean and sustainable energy source.

Wind energy has also shown significant growth in interest, albeit with some seasonal and annual variability. This pattern may be related to factors such as the availability of wind resources, investment in wind energy projects, and changes in energy policies. Interest in hydropower appears to have seen more moderate fluctuations compared to other renewable energy sources. This may be due to the historical prevalence of hydropower in Ecuador and the relative stability of this energy source compared to other renewable options.

Biogas and biomass energies show lower and less consistent levels of interest over time. This may reflect less familiarity or availability of these technologies compared to solar and wind, as well as potential technical or economic challenges associated with their implementation. Although these results are interesting, they are not sufficient on their own to explain the behavior of consumer interest in renewable energies in Ecuador and it is necessary to include other variables in the model and exclude those without explanatory power.

Table 4 shows a regression with the main candidates of market, social and environmental determinants for determining consumer interest in renewable energies. First, the P-values associated with the F-statistic of all models are remarkably low, close to zero, suggesting high statistical significance and a substantially better fit than that of a model without explanatory variables. In addition, the P-values of the Lagrange Multiplier Test are relatively small in 4 of the 6 models, indicating significant evidence of serial autocorrelation in the model residuals. Likewise, the p-values of the ARCH (Autoregressive Conditional Heteroskedasticity) test are also low in 2 of the 6 models, suggesting the presence of conditional heteroscedasticity in the model residuals. Together, these results support the application of Newey-West matrix correction in estimates, which strengthens the robustness of our model against possible autocorrelations and heteroscedasticities in errors.

OLS regressions highlight essential connections between explanatory variables and consumer interest in renewable energy. Overall, we have observed that the relative production of renewable energy has a positive and statistically significant impact on consumer interest in these sustainable energy sources. This finding suggests that as the proportion of energy generated from renewable sources increases compared to other conventional sources, the public tends to show greater interest in renewables. This result is consistent with existing literature that has highlighted the crucial role that renewable energy production plays in shaping public attitudes and perceptions towards these technologies. However, it is important to note that the relationship between

Table 4: OLS estimates of the effect of economic and socioenvironmental variables on consumer interest in renewable energy

OLS 1	DV					
Regressors	**RE_CI**	**BgE_CI**	**BmE_CI**	**WE_CI**	**HE_CI**	**SE_CI**
C	40.544***	3.686**	1.001	47.334***	25.242***	15.457
	13.003	1.576	1.761	6.520	3.060	19.522
AR (1)	1.393***	0.037	0.231***	0.227***	0.179***	0.374***
	0.532	0.088	0.064	0.060	0.068	0.079
Produced energy	23.015**	−26.995	12.370	21.351	−7.559***	−53.034*
	10.267	154.626	12.252	279.261	2.284	2931.115
PI	−0.282*	−0.021	0.028	−0.356***	−0.147***	0.082
	0.143	0.015	0.017	0.057	0.034	0.192
ND_II	0.326***	−0.001	0.056***	0.137***	0.032**	0.128**
	0.071	0.008	0.017	0.029	0.015	0.053
Adjusted R^2	0.209	0.152	0.228	0.428	0.440	0.287
F-statictis	8.484	2.551	10.282	25.989	27.318	13.978
F (p)	0.000	0.042	0.000	0.000	0.000	0.000
LM test	8.701	3.389	0.384	4.968	2.993	0.110
P LM	0.000	0.037	0.682	0.008	0.053	0.896
ARCH test	0.540	0.133	0.857	16.741	10.501	1.303
P ARCH	0.464	0.716	0.356	0.000	0.002	0.256

Levels of significance: ***denotes 0.01, **denotes 0.05 and *denotes 0.1. Standard errors in parentheses. OLS equation based on Newey and west estimators

Table 5: OLS estimates of the effect of information shocks in relation to natural disasters on consumer interest in renewable energy

OLS 2	DV					
EP_II	0.079	0.110	0.055	0.076	0.097	0.088
	−0.061	0.002	0.004	0.012	0.002	0.033
	0.049	0.004	0.008	0.019	0.013	0.048
FF_II	0.367**	−0.002	0.004	0.157***	0.067*	0.163**
	0.145	0.005	0.010	0.033	0.038	0.065
Fl_II	0.188**	−0.006	0.043***	−0.037	−0.045*	0.129**
	0.090	0.005	0.016	0.035	0.023	0.070
AR_II	0.171***	0.006*	0.014	0.129***	0.079***	0.183***
	0.063	0.003	0.010	0.019	0.020	0.037
Ls_II	−0.129	0.001	−0.028**	0.015	0.015	0.015
	0.088	0.004	0.012	0.029	0.021	0.079
Adjusted R^2	0.374	0.151	0.203	0.498	0.425	0.497
Adjusted R^2	14.958	1.283	6.355	24.811	18.514	24.689
F-stat	0.000	0.069	0.000	0.000	0.000	0.000
F P value	0.543	0.160	2.332	3.908	2.132	3.764
LM test	0.582	0.852	0.101	0.022	0.122	0.025
P LM	0.043	2.188	0.271	2.813	4.702	0.005
ARCH test	0.836	0.141	0.603	0.096	0.032	0.945

Levels of significance: ***denotes 0.01, **denotes 0.05 and *denotes 0.1. SEs in parentheses. OLS equation based on Newey and West estimators. SEs: Standard errors

renewable energy production and public interest can be influenced by a number of contextual factors, such as energy policies, environmental events, and awareness campaigns, which can modulate the public's perception and attention towards renewable energy (Mozumder et al., 2011; Mydock III et al., 2018).

However, we also observed negative and significant coefficients of hydroelectric and solar produced renewable energy on interest in renewables of the same types, which is an intriguing finding in our results. This phenomenon suggests a complex dynamic that deserves further analysis. One possible interpretation of these findings could be that, in certain contexts, an increase in hydroelectric or solar production may lead to a perception of market saturation or a sense of normalization of these technologies among the public. As a result, consumers might show relatively less interest in seeking additional information about these specific forms of renewable energy. In addition, these results could indicate the presence of substitution effects, where an increase in production of a particular form of renewable energy could crowd out public interest in other forms of renewable energy.

Regarding the effect of the price of energy, gas and fuels on consumer interest in renewables, we found that only negative coefficients were statistically significant in explaining such interest, particularly in relation to total renewable energy, wind energy and hydropower. This finding suggests that an increase in the price of fossil fuels may have a negative effect on interest in renewable energy, consistent with the initial cost and financing assumptions. In other words, an increase in the price of fossil fuels can reduce the economic attractiveness of renewable energy for consumers in low-income countries, especially those consumers with limited budgets or looking for more affordable energy solutions in the short term. In addition, financing options for the installation of renewable energy systems, such as loans or government incentives, may be affected by changes in economic or political conditions. An increase in the price of fossil fuels could make it harder to access financing for renewables, discouraging some potential consumers.[11]

Our study identified that the natural disaster information index stood out as the most promising and novel variable in our model. In almost all specifications with the exception of biogas energy, this index showed positive and statistically significant coefficients to explain consumer interest in renewable energy. These findings suggest that the occurrence of natural disasters could positively influence public interest in renewable energy. This result is relevant as it reaffirms the results found in the literature that catastrophic events could raise awareness among the population regarding the importance of adopting more sustainable and resilient energy sources (Goebel et al., 2015; Lane et al., 2023). However, further analysis is needed to better understand the nature and extent of this relationship between natural disasters and interest in renewable energy. For this purpose, the second model of this work is made.

Table 5 presents in detail the results obtained from the estimates for equation (2). At this stage of the analysis, we have broken down the effect of the natural disaster information index on the 5 most sought-after sets of natural disasters by the Ecuadorian public: (i) pollution, (ii) forest fires, (iii) floods, (iv) acid rain, and (v) landslides. This approach allows for a deeper understanding of how each type of natural disaster influences people's interest in renewable energy. This detailed analysis allows us not only to assess the magnitude and direction of the effect of each natural disaster, but also to better understand the underlying mechanisms that drive the relationships observed in our statistical model.

According to the results of the second model, the informational shocks of natural disasters that most affect Ecuadorian consumers' interest in renewable energy are forest fires, floods, and acid and

11 It is common for an increase in the price of fossil fuels and therefore of energy and fuels to be accompanied by a contractionary monetary policy to avoid an escalation in the price level. However, these policies generate a higher interest rate that compromises financing options for poor people.

AQ1 **Table 6: A proposed agenda for future studies**

Method	Dependent variables	Independent variables	Research proposal
Time series analysis	Consumer interest in renewable energy	Energy prices, government policies, man-made environmental disasters, advertising and environmental awareness campaigns	Impact of government policies and extreme weather events on consumer interest in renewable energy
Surveys and regression analysis	Intent to purchase residential solar energy systems	Income level, education, environmental attitudes, perceived cost of installing solar systems, financial benefits	Socioeconomic factors and attitudes toward the environment influencing purchase intent for residential solar energy systems
Social media analytics	Level of engagement on social media platforms with renewable energy content	Frequency of posts about renewable energy, interaction with promotional content from renewable energy companies, comments and shares	Assessing the impact of social media content on the level of public engagement with renewable energy
Discrete choice experiment	Consumer preference for specific sources of renewable energy	Cost, reliability, environmental impact, energy source (wind, solar, hydroelectric, biomass), distance from generation site	Identifying consumer preferences and attributes that influence the choice of a renewable energy source

polluting rain. For the case of wildfire information effects, the prominence of wind and solar energy in the public response can be attributed to the perception that these technologies are more compatible with climate change mitigation and protection of the natural environment compared to other forms of renewable energy. In addition, visibility of the visual impacts of wildfires, such as landscape destruction and air pollution, can increase public awareness of the importance of harnessing energy sources that do not contribute to deforestation or emit greenhouse gases.

At the same time, information about natural disasters such as floods increases the interest of Ecuadorian consumers in renewable energies, particularly biomass and solar energy. This trend suggests that floods, as they represent a direct threat to the security and stability of local communities, can raise awareness of the need to seek energy alternatives that are more resilient and less susceptible to adverse environmental impacts. The preference for biomass energy could be related to the perception that this source is more accessible and adaptable to local conditions, especially in rural areas where natural resources are more available. On the other hand, interest in solar energy could be driven by the perception that it is a cleaner and safer option, which can provide a reliable source of energy even during extreme weather events. This finding underscores the importance of considering the specific contexts of natural disasters when designing renewable energy promotion strategies in Ecuador, as well as the need to integrate these events into the planning and management of energy and environmental policies at the national level.

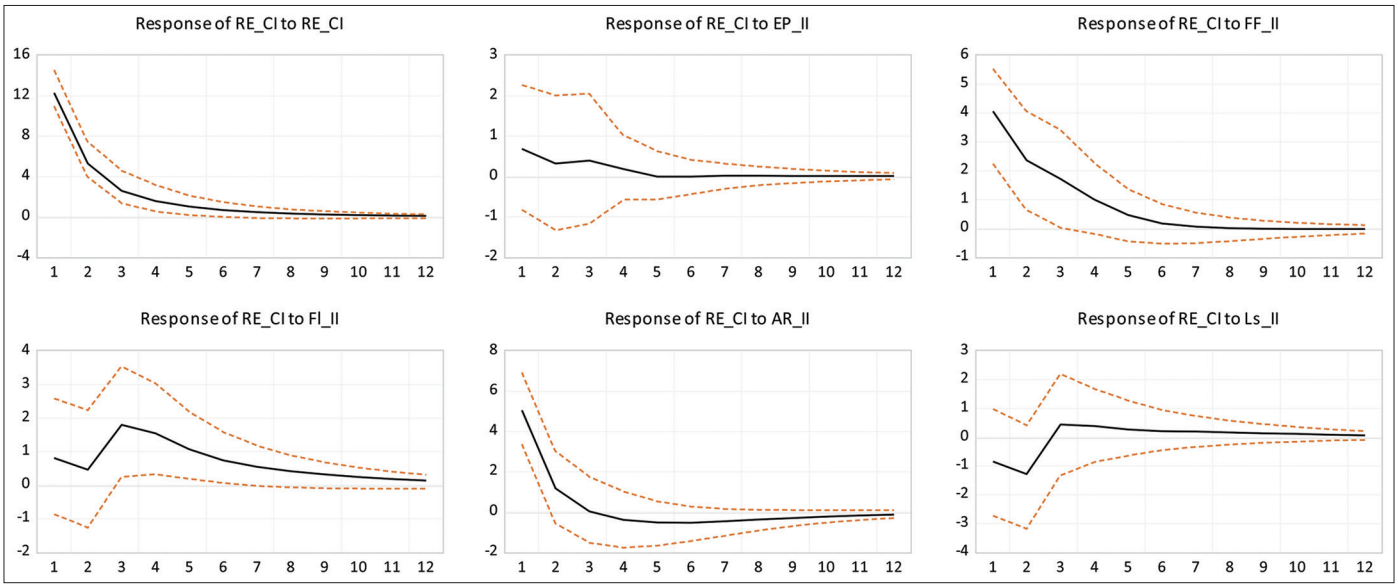
The results of the model also reveal that information about extreme natural phenomena related to acid rain generates a significant increase in Ecuadorian consumers' interest in wind, hydro and solar renewable energies, with emphasis on the latter. Acid rain, as a result of air pollution, represents a serious environmental threat that can affect human health, biodiversity and ecosystems. In this context, Ecuadorian consumers may perceive renewable energies, especially wind, hydro and solar, as safer and more sustainable alternatives compared to traditional energy sources, which contribute to air pollution and, therefore, to the phenomenon of acid rain. Wind and solar energy, in particular, are perceived as viable solutions to reduce greenhouse gas emissions and mitigate the impacts of climate change, including reducing air pollution that leads to acid rain. In addition, we know that acid rain is a phenomenon that strongly affects large urban poles and that solar energy is the most popular in large cities, since it is not possible to install other alternative sources, so the geographical coincidence can make consumers react to acid rain with interest in installing solar panels.

The analysis also reveals that generally information related to environmental pollution and landslides does not have a significant impact on consumer interest in renewable energy within the evaluated model. This lack of effect suggests that, in the specific context of this research, these variables are not being perceived by consumers as determining factors in their disposition towards renewable energies. One way to interpret the lack of reaction to environmental pollution is to consider this to be a less shocking phenomenon, since it occurs gradually and does not occupy panic headlines in the media. On the other hand, landslides may be little associated by the public with polluting gases, avoiding a response in interest towards renewable energies.

As an extra exercise, the equations were reestimated from an autoregressive vector model to understand how informational shocks about natural disasters affect interest in renewable energy as a whole over time. This approach makes it possible to capture the dynamic interactions between the variables of interest and to analyze how the effects of natural disasters propagate and evolve over time. Figure 2 visually presents the results obtained from this model, offering a graphical representation of the relationships identified between the informational shocks of natural disasters and the interest in renewable energies as a whole. This further analysis provides a more detailed perspective on the nature and dynamics of the influence of natural disasters on consumer behavior in relation to renewable energy, significantly enriching our understanding of this complex and dynamic phenomenon.

The findings reveal an immediate response of interest in renewable energy to informational shocks from wildfires and acid rain, which then tend to dissipate over the following months (3.5 months for wildfires and 2 months for acid rain). This pattern suggests a close connection between these events and public perception of

Figure 2: Impulse function response of consumer interest in renewable energies to shocks in the natural disaster information index
Response to generalized one S.D. innovations 95% confidence interval.



renewable energy. It is consistent with the notion that wildfires and acid rain are closely linked to human activity, especially the burning of fossil fuels. Since these natural phenomena are associated with the release of pollutants and greenhouse gases, their initial impact can generate an immediate response in public awareness of the need to adopt more sustainable energy sources.

The reaction of interest in renewable energy to informational flood shocks exhibits a peculiar pattern: It can take up to 3 months to manifest itself after the event, and once it is initiated, it persists for another 3 months. This dynamic suggests that floods, given their severity in terms of economic losses and sometimes human losses, initially capture the full attention of the public. Once the event has passed, the population looks for solutions to prevent future disasters or mitigate their impacts, which sparks greater interest in renewable energy. This protracted response suggests that floods not only generate immediate awareness of the need to adopt more sustainable energy sources but may also influence society's long-term attitudes and behaviors towards energy and the environment.

5. CONCLUDING REMARKS

This paper presents a rigorous analysis of the evolution of Ecuadorian consumers' interest in renewable energies and how this interest responds to different economic and socio-environmental phenomena. This study is based on a sound empirical approach and presents a rigorous time series methodology. A thorough compilation of pertinent data related to the popularity and interest in renewable energy-related terms and variables related to public opinion on these clean energy sources was carried out. Subsequently, these data were subjected to a thorough statistical analysis, allowing an accurate assessment of the complex and dynamic relationships that exist between interest in renewable energy by type of source and the independent variables of greatest interest.

After a thorough analysis of the data and results obtained in this research, several significant conclusions were drawn about Ecuadorian consumers' interest in renewable energy and its relationship to natural disasters and other economic factors. First, it was noted that public interest in renewable energy is influenced by a number of factors, including the relative production of renewable energy and the prices of energy, gas and fossil fuels. The results revealed a positive and significant effect of renewable energy production on consumer interest, while an increase in fossil fuel prices was associated with a decrease in interest in renewables. This finding highlights the importance of energy policies that encourage the production and use of renewable energy as a way to mitigate the impact of volatile fossil fuel prices on the public interest.

In addition, natural disasters, especially wildfires, floods, and acid rain, were found to have a significant impact on consumer interest in renewable energy. The results suggest that the public's response to these events may vary depending on the severity and duration of the disaster. For example, while wildfires and acid rain generate an immediate surge in interest in renewable energy, the flood response may take longer to manifest and persist for a longer period. This relationship between natural disasters and interest in renewable energy underscores the importance of public education and awareness of the need to adopt more sustainable energy sources to mitigate the impacts of climate change.

As one of the limitations of this study, it is crucial to consider that, beyond the natural disasters analyzed in this work, there are other environmental events that can have a considerable impact on the public interest in renewable energies. For example, directly human-caused events such as oil spills also have the potential to influence the perception and demand for renewable energy. These events can raise awareness of the need to adopt cleaner and more sustainable energy sources, thereby driving interest in and adoption of renewable technologies.

Overall, the findings highlight the complexity of the factors influencing consumer interest in renewable energy in Ecuador and highlight the need for policies and strategies that promote their adoption. In addition, they point out the importance of considering not only economic and technological aspects, but also social and environmental impacts when designing energy and climate change mitigation policies. These results provide valuable information for policymakers and decision-makers in designing energy and environmental policies that foster a transition to a more sustainable and resilient energy system.

The significant contribution of this study lies in its ability to provide valuable information based on solid evidence, offering a more comprehensive understanding of how public interest in renewable energy has evolved in Ecuador and how this variable has responded to other economic and socio-environmental phenomena in the country. This insight can be beneficial for policy formulation and future research in this field. Consequently, we have formulated the Table 6 outlining potential studies derived from this work and their methods of analysis and measurement.

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