The Impact of the Adult Awareness about Global Warming on Renewable Energy Consumption in the United States.

Mohammad Ismayl Al Masud

Abstract

Due to the expansion of the world economy, the demand for energy keeps increasing. Fossil fuel has become the major source to meet the ever-increasing energy demand with unprecedented environmental damage. The Renewable energy can is a great alternative to the fossil fuels to limit the damage. In this study, using the Ordinary Least Square (OLS) and two stage least square (2SLS) estimation, we find that the adult awareness and fossil fuel price are positively correlated with the renewable energy combustion. However, the coefficient of number of aggregated vehicles is not statistically different than zero. In the survey at Texas Tech University (TTU), we find that at least 80% students are aware of environmental issues and renewable energy use, 87% believe the state should educate citizens about global warming, renewable energy, and environmental protection, and almost 50% wants to pay 0$-$0.20/gallon more for renewable energy.

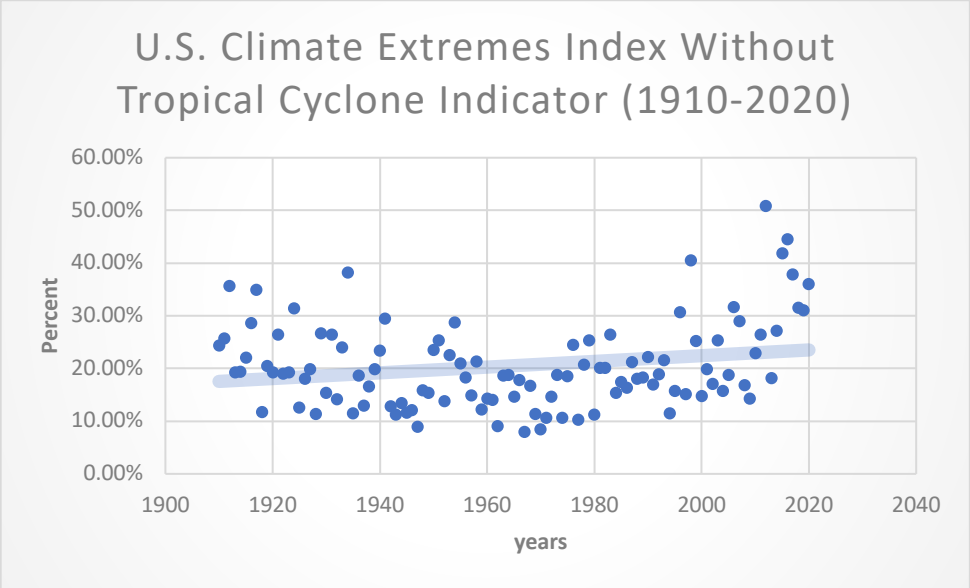
Introduction and Literature Review

''.... politicians don't always do what professors want them to do''

Professor Gregory Mankiw, Harvard University

This was narrated in a documentary (*Before the Flood*) leading by Leonardo Di Caprio on climate change. This study is originally motivated by the documentary on how dramatically the world climate has deteriorated over such a short period of time (see figure 1). Ever since Industrial Revolution, the demand for global energy keeps increasing. According to the report on October 7, 2021, from the US energy information administration (EIA), the demand for energy will keep increasing at least for the next few decades even after experiencing the recent dramatic climate change.

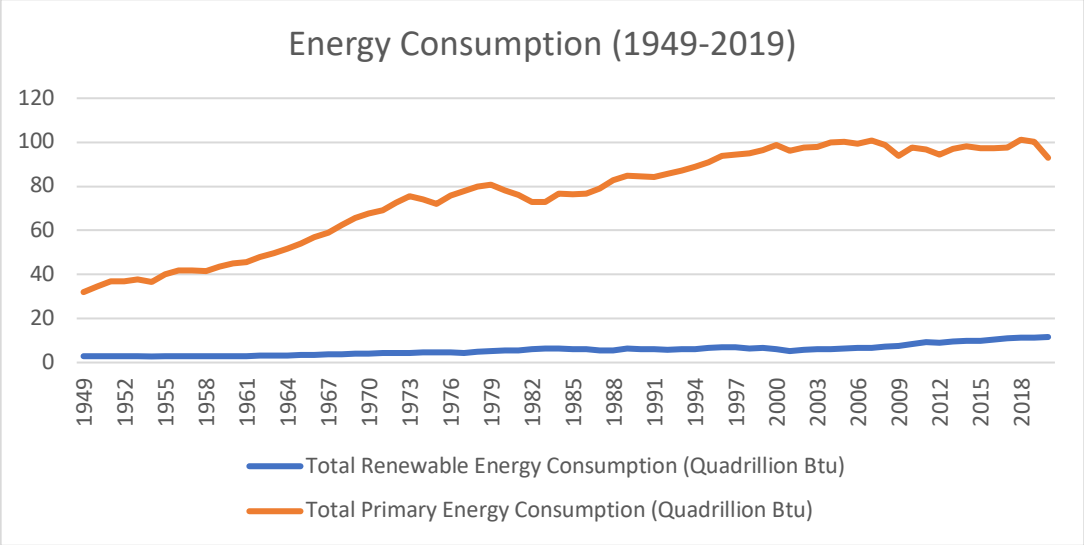
Figure 1: U.S climate extremes index (without Tropical Cyclone indicator).



Source: *National Centers for Environmental Information.*

One major sources of climate deterioration are consuming fossil fuels (Coal, crude oil, and natural gas) as major energy source. The comparative cost advantage to renewable energy sources (biomass energy, hydropower, geothermal power, wind energy, and solar energy) leads to be the major sources of energy (see figure 2). But consuming fossil fuels costs more than just

Figure 2: Historical U.S. Energy Consumption.



Source: *U.S. Energy Information Administration (EIA).*

the nominal price, it contributes heavily to global warming by emitting massive amount of carbon dioxide and other harmful air pollutants. The potential economic costs of climate change had mostly been ignored in past decades. For the U.S., according to the Natural Resources Defense Council (NRDC), suggest that the cost of global climate change might cause a loss of 3.6 percent of gross domestic product (GDP) if there is no change in the current climate trend. For the U.S., the predicted costs to be around 1.8 percent of total GDP by 2100. So, government should be more aggressive in implementing more environmentally friendly policies that facilitate promoting renewable energies and limiting consumption of fossil fuels.

Historically, Carson published “Silent Spring” in 1962 which first raised a concern regarding environmental issues in North American society. Additionally, on 22 April 1970, the first “Earth Day” was held in New York to extend the environmental consciousness across the world. Moreover, Meadows et al., (1972) published the ''The limits of growth'' that predicted perilous negative externalities could result from failing environmental protection. Later countries voluntarily signed in action plans in United Nations Conference on Environment and Development which was held in 1992 in Rio de Janeiro. The conference was designed to voluntarily adopt environmental-friendly policies and promote training, education, and raising environmental awareness. However, the effectiveness of the conference can often be questioned. Similarly, the Paris agreement was voluntarily signed by 196 countries in Paris to limit the world temperature. Unfortunately, as the current climate stands, the Paris treaty is already looking failure as most of the countries failed to adopt environmental-friendly policies including the United States.

One of the hypotheses behind failing to implement the commitment in the past treaties could be that the lobbies from the regular fuel (mostly coal, crude oil) industry dominated the ''weak'' public interest. Because it is often the case that governments are highly influenced by both lobbies and strong public interest. But it could be true that a very small segment of people compared to the whole population are aware of how environmental components works and how it has been over the years. Hence it crucial to educate people on such a significant issue and only then, on a mass level, they can demand more environmentally friendly actions.

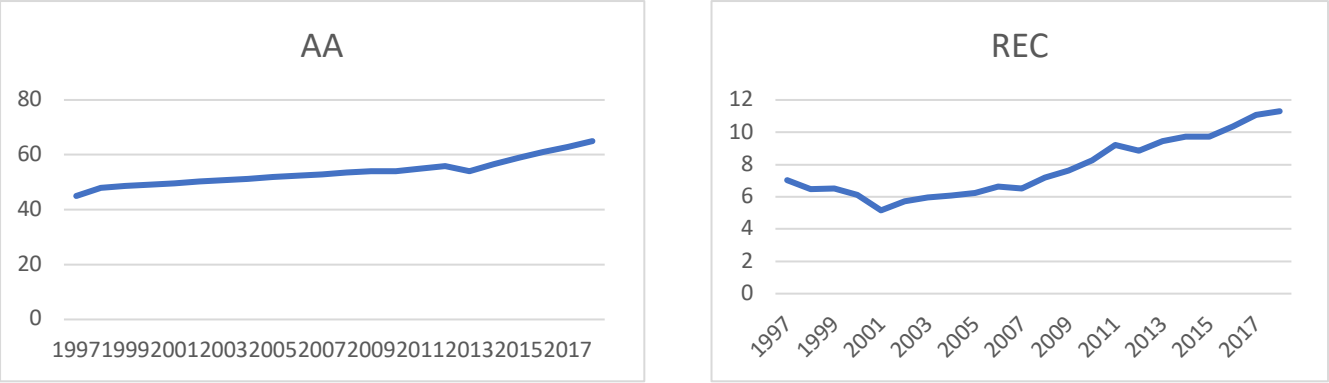
Fan et al. (2014), Sevencan et al. (2017), Zsoka et al. (2013) investigated the environmental consciousness of students among high school and universities, and they found a significant relation between environmental education and awareness, students from rural area tend to be more environmentally conscious than urban areas and female students are more environmentally conscious than male students. Moreover, Gunduz (2013), Bergman (2016) studied similar study in preuniversity level. Chan (1996), Makkiet al. (2003), Shobeiri et al. (2006, 2007), Hassan et al. (2010), Back (2011), Fanet al. (2014), Olufemi et al. (2016), Ari and Yilmaz (2017) investigated in secondary schools.

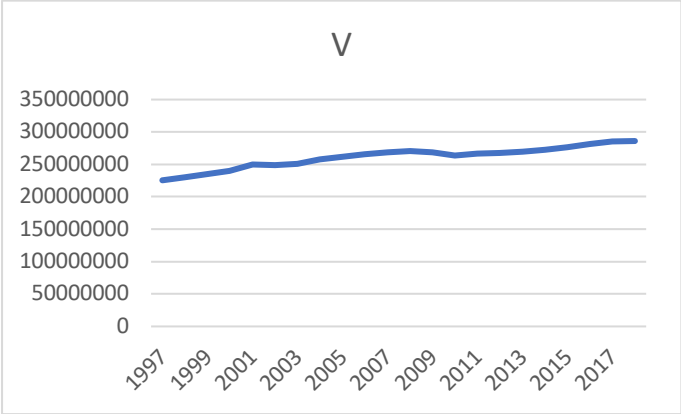
So, the goal of this study measures the environmental awareness among U.S. adults and its impact on the Renewable energy combustion in the United States. The contribution of the proposed research will be twofold. This is the first study not only to survey university students, but also to measure its impact on renewable energy combustion. Secondly, the government can use this study's survey and estimations to figure out peoples' attitude toward the renewable energy use and their willingness to pay for cleaner energy.

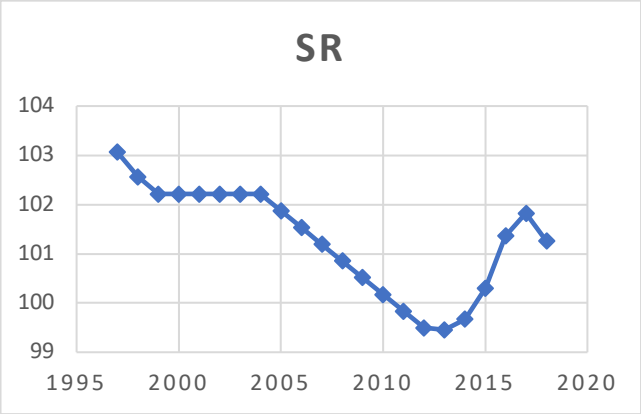
Data and Methodologies

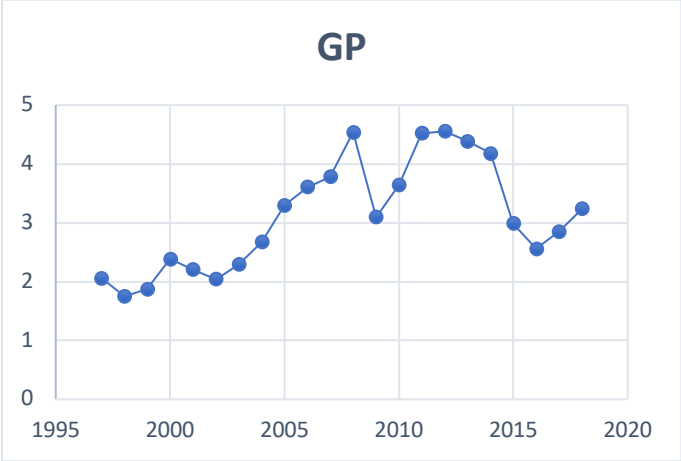
Given the significance of this issue, we use both primary and secondary data in our analysis. For the primary data, we conducted a survey across TTU campus, and the number of participants is 50. For the secondary data, we use the exiting time series of 1997-2018, from research done by the Political Psychology Research Group at Stanford University. The historical trend of the variables is presented in figure 3. The Renewable energy consumption (REC) is our dependent variable, and the adult awareness level (AA) is our treatment variable. As control variable, we have the aggregate number of vehicles (V), gasoline price (GP), the consumer price index (CPI), the schooling rate (SR), the change in Gross Domestic Product (CGDP), the Climate extreme rate (CE).

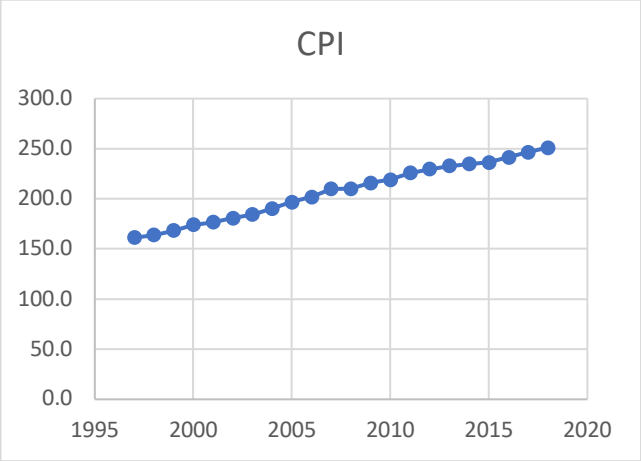
Figure 3: Historical Trend of the Variables (1997-2018).











To measure the environmental awareness among U.S. adults, we conducted a survey of 50 students at TTU. We designed survey captures a general knowledge regarding environmental issues and Renewable energy of TTU students. For the secondary data, we run both OLS and 2SLS to investigate the relationship among the variables. Finally, we also run some robustness tests to check the consistency level of our estimation.

The estimated OLS equation is as follows:

$$Renewable\ Energy\ Consumption = \beta_1 + \beta_2\ Adult\ Awareness + \beta_3\ Aggregate\ number\ of\ Vehicle + \beta_4 Fossile\ Fuel\ Frice + \varepsilon$$

The estimated 2SLS equation is as follows:

1st Stage Regression:

$$\widehat{\boldsymbol{Adult\ Awareness}} = \beta_1 + \beta_2 \text{Schooling Rate} + \beta_3 \text{Climate Exterme} + \beta_4 \text{Fossil Fuel Price} + \mu$$

2nd Stage Regression:

$$Renewable\ Energy\ Consumption = \beta_1 + \beta_2 \widehat{\boldsymbol{Adult\ Awareness}} + \beta_3\ Aggregate\ number\ of\ Vehicle + \beta_4 Fossile\ Fuel\ Frice + \varepsilon$$

Results and Conclusion

Our goal of this study to investigate whether the US adult awareness level of global warming affect the aggregate Renewable Energy Consumption. We adopted both OLS and 2SLS method to analyze the historical data. Additionally, we also conducted a survey at TTU campus to check the awareness level. The summary statistics of the variables adopted in this study are presented below. All the variables have an increasing trend over time. The climate extreme has increased a lot during the given period. Moreover, the average of the gasoline and gas price also increased sharply.

Table 1: Summery Statistics.

Variables	Mean	Std. Dev.	Min	Max
Adult Awareness	53.67	6.49	45	65
Climate Extreme	26.59	10.79	14.24	50.82
Renewable Energy Consumption	7.78	1.87	5.15	11.30
Fossil Fuel Price	3.11	0.93	1.75	4.56
Consumer Price Index	206.92	28.60	161.3	251.2
Schooling Rate	101.28	1.08	99.45	103.06

Instrumental Variable Test.

It is possible that our OLS estimation might suffer from omitted variable bias. It is possible that our dependent variable (REC) may be correlated with the error term. For example, the increasing trend of the REC may be results from more access to the information compared to before on environmental damage to over fossil fuel combustion, or the news medias have just become more interested on environmental issue, and people get automatically informed about the issue who follow them. However, our macro level time series data doesn't have the scope to answer those question, Hence, for our treatment variable (AA), we consider the schooling rate as a good candidate as an Instrument variable (IV). We assert that a positive trend in SR might have the information spillover effect where people have more access to the information, and they can get educated on contemporary environmental issues. Table 2 presents our IV results. Our dependent variable is not statistically correlated with the schooling rate.

Table 2: IV Test (Regression of Renewable Energy Consumption on).

Variables	**Coefficient**
Schooling Rate	-0.971 (0.589)
Climate Extreme	0.069 (0.031) **
Fossil Price	-0.2012 (0.671)
Constant	104.936(61.7763)

**Refers to 10% significance level, **Refers to 5% significance level, ***Refers to 1% significance level. Standard Errors are inside parenthesis.*

Table 3 refers to the association between the AA on SR controlling for the climate extreme rate and the consumer price index. All the coefficients are statistically significant which validates our assertion on the choice of our instrumental variable.

Table 3: IV Test (Regression of Adult Awareness Rate on).

Variables	Coefficients
Schooling Rate	1.928(0.298) ***
Climate Extreme	0.041(0.022) *
Consumer Price Index	0.209(0.012) ***
Constant	-186.011(32.028) ***

**Refers to 10% significance level, **Refers to 5% significance level, ***Refers to 1% significance level. Standard Errors are inside parenthesis.*

Regression Analysis.

From table, the coefficients do not change a lot in two different estimations. An 1% increase in adult awareness would lead to increase renewable energy consumption by 0.64%. This coefficient seems plausible as not all the informed people may not go to the change their preferences. Additionally, the elasticity of the fossil fuel price is understandable (an increase of $1/gallon would lead to increase REC by only 0.83%) as most of the people does not have appropriate cars to consume Renewable Energy. However, the coefficient of the aggregate vehicle is statistically not very different than zero in our study. One explanation could be that our data set only covers until 2018 and the production of Renewable energy consumable vehicles only increased very recently. So, the total effect of the aggregate vehicles does not get captured in this model.

Table 4: The OLS and 2SLS Output.

Variables	OLS	2SLS
Adult Awareness	0.640 (0.0927) ***	0.662(0.1300) ***
Aggregate Vehicle	0.0001(0.000001) ***	0.0001(0.0001) ***
Fossil Fuel Price	0.834(0.2544) ***	0.870(0.2732) ***
Constant	1.578(3.5049)	2.1104(3.9848)

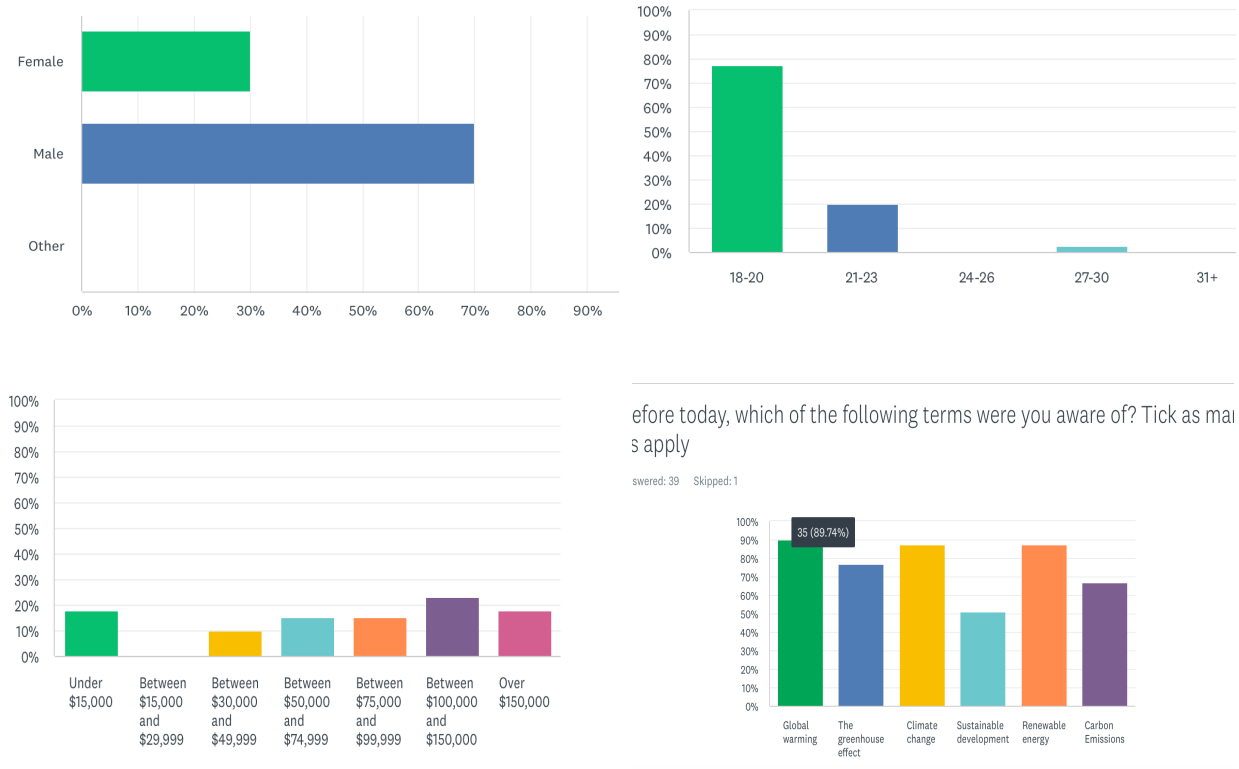
	Adj R=0.85	R=0.87

**Refers to 10% significance level, **Refers to 5% significance level, ***Refers to 1% significance level. Standard Errors are inside parenthesis.*

Survey Results

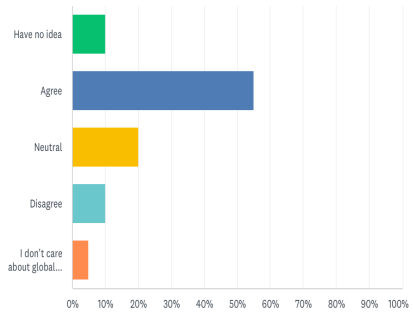
From the figure 4, 70% of participants are male and 30% are female who are mostly between 18 to 20 years old from different financial background. Most of the students are very aware of the recent environmental issue compared to the Stanford's survey in 1997. It may be that medias have become more interested these issues and they are more exposed to the environmental facts. Majority of the students believe that both government and citizen to act together to hand the global warming issues. Interestingly 50% students even want to pay around $0.20/gallon to consumer Renewable energy.

Figure 4: Survey Response.



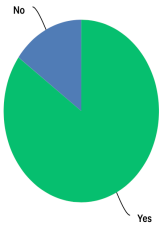
"Global warming is a really fact and the earth is warmer than past decades." What you think about this statement?

Answered: 40 Skipped: 0



Do you believe that State should educate citizens about global warming renewable energies, environmental protection?

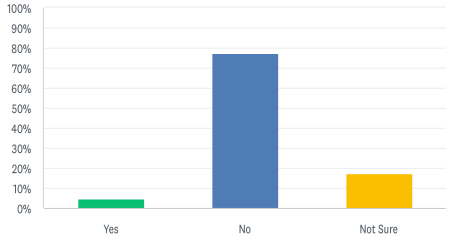
Answered: 40 Skipped: 0



ANSWER CHOICES	RESPONSES
Yes	85.00%
No	15.00%

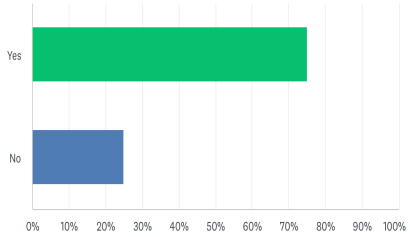
y government is responsible for protecting environment not genera ic"-what do you think?

d: 40 Skipped: 0



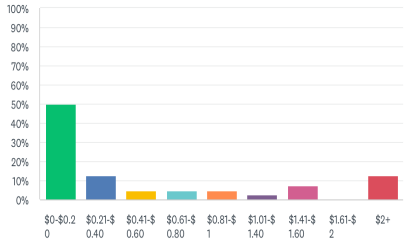
Do you know renewable fuels (Biodiesel, Gasoline etc) costs more tha regular fuels?

Answered: 40 Skipped: 0



As a student, If you were to contribute limiting global warming, how muc would like to pay more for renewable energies to buy your car gasoline?

Answered: 40 Skipped: 0



Robustness Test

To test the robustness of our estimation, we check our coefficient consistency, we include the change in the growth rate in GDP and Climate Extreme rate and from table, our target coefficient does not deviate by far from our original estimation. We further include the total number of populations in the states and from table, we coefficient stays close to our original estimation. So, our overall estimation is quite consistent.

Table 5: Regression of REC on

Variable	**Coefficient**
Adult Awareness Level	0.71(0.286) ***

**Refers to 10% significance level, **Refers to 5% significance level, ***Refers to 1% significance level. Standard Errors are inside parenthesis.*

Table 6: Regression of REC on

Variable	**Coefficient**
Adult Awareness Level	0.78(0.247) ***

**Refers to 10% significance level, **Refers to 5% significance level, ***Refers to 1% significance level. Standard Errors are inside parenthesis.*

One of the limitations of this study is the duration of the data itself. The estimations would be more accurate if the longer version is available. Moreover, we believe our survey doesn't represent the US adult awareness level, not even represent the TTU itself. So, a detailed version of our and it can be conducted across all the states, the government would get an overall idea of the perception of cleaner energy to the US adults and implement environmentally friendly policies. Finally, in future study, the Global Trade Analysis Project (GTAP) modeling can be adopted to illustrate a potential shock that could arise from higher public awareness (demand shock) and potential changes in global energy equilibrium.

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