

Emissions and Perceptions of Climate Change

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Introduction

In the great pursuit of mitigating climate change, countries have differed greatly in their strategies and successes. Denmark has one of the most ambitious mitigation plans in the world pledging to cut 70% of its emissions by 2030.¹ As other countries trail behind, illuminating how Denmark is successfully reducing its emissions is pertinent for other countries. Although reducing emissions involves extensive effort from multiple sectors, the citizens also greatly determine the success of mitigation plans.² What determines people's perceptions and willingness to decrease their own emissions, is therefore important for countries to understand. To delve into this question data from two global surveys on climate perceptions will be analyzed along with green house gas emissions and the reduction rate of countries. Special emphasis will be on comparing Denmark due to the country's success, and the United States, due to its world's leading production of oil and natural gas.³

This data analysis will consist of three sections: the greenhouse gas emissions of the U.S. and Denmark, the climate change perceptions of their citizens, and the correlation between emissions and climate change perceptions, using data from many countries.

In the emissions section Denmark's the United State's per capita emissions and the rate of decrease will both be compared. We hypothesize that Denmark will have less emissions and a faster emission reduction rate than the United States, because the U. S. had the highest cumulative greenhouse gas emissions from 850-2021 whereas Denmark has one of the most ambitious emission reduction plans in the world.⁴

The second section will include an analysis of several questions regarding climate change for both the U.S. and Denmark. These will include what Americans and Danes believe caused climate change, how worried they are about it, how big of a threat they believe climate change is in the next 20 years, and if they believe fossil fuel usage should decrease, increase, or stay the same. We hypothesize Denmark will have a significantly higher percentage of people who believe climate change is human caused than the U.S, because Denmark hosted COP15, which sparked national social media attention on climate change, exposing many Danes to the concept.⁵ We further hypothesize that more Danes will be very worried about climate change and see it as an extreme threat than U. S. citizens, because climate change is uniformly depicted in Danish media as a problem, but it is not uniformly depicted in this manner in the U.S.⁴ Lastly, we hypothesize that more Danes will answer that fossil fuel usage should be reduced than Americans, due to the aforementioned reasons.^(1,3,4)

In the third section we will overlay the survey data with the emissions data to determine the percentage of causation. We predict that people's perceptions of climate change impacts about 30% of greenhouse gas emissions of a country, given there are several other significantly related variables, such as population, income,

¹Etsy, D. C., "Why Denmark Wants to Be a 'Frontrunner' in the Fight Against Climate Change." Yale School of the Environment.2021.

²Weber, E. U., "What Shapes perceptions of climate change?," WIRES Climate Change.2010

³Gross, S., "The United States can take climate change seriously while leading the world in oil and gas production." Policy 2022 Brookings. 2022.

⁴Evans, S., "Analysis: Which countries are historically responsible for climate change?." Carbon Brief, 2021.

⁵Gunster, Shane. "Covering Copenhagen: Climate Change in BS Media." Canadian Journal of Communication 36, no.3 (Nov 2011): 477-502. DOI: 10.22230/cjc.2011v36n3a2367

and political structure.⁶

Preparing R

```
rm(list=ls())
library(tidyverse)
library(here)
library(ggfortify)
library(forecast)
library(gridExtra)
```

Statistical Analysis and Results

Statistical analysis will consist of the aforementioned three sections.

Climate Change Emissions of Countries

Pulling in the corrected Emissions data. For the raw data see the raw data folder on github. Please also see the metadata txt files per each data set in the metadata folder.

Lets first view the emissions of Denmark and the United States.

Reading in the Data

```
emissions<-read.csv(here("Data for the Code", "Corrected_Data_sets", "emissions_corrected_US_Denmark.csv"))
```

Lets turn the date column into date data using the lubridate package.

To do that we need to put in the day and the month using paste.

```
emissions$year<-paste0("01-01-", emissions$year)
```

Now tell R the year column are dates so we can better perform statistical analysis.

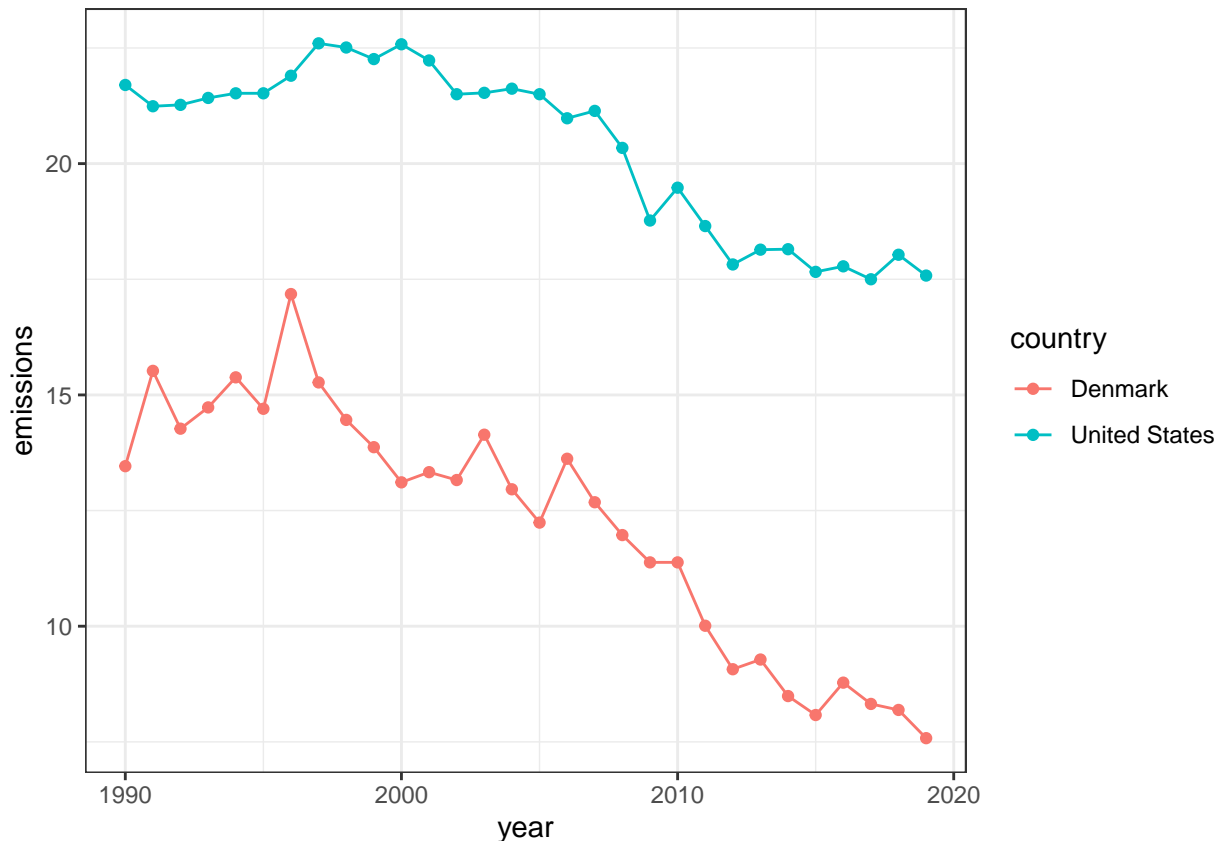
```
emissions$year<-as.Date(emissions$year, format="%d-%m-%Y")
#format tells R the dates are just a four digit year, a two digit year is %y, origin informs R where it
# must do the - in the %d- because the dates are entered with a -.
```

Now when running statistical tests R will know the data are dates.

Creating the figure Lets see the emissions of Denmark and the United States from 1990 to 2019.

```
ggplot(emissions, aes(year, emissions, colour= country, group=country)) + geom_line() +
  geom_point(aes(colour=country))+ theme_bw() #colour colors by country, and group tells R to group the
```

⁶Wang, Q., Feng, G., Wang, H., Chang. C., " The influence of political ideology on greenhouse gas emissions" Global Environmental Change 74, no.1 (May 2022):102496. DOI: <https://doi.org/10.1016/j.gloenvcha.2022.102496>.



Already it is apparent that Denmark produces less GHG emissions per capita each year than the United States. Both countries have been decreasing their emissions since 1990, but Denmark seems to have a greater rate of decrease in emissions, especially since 2006, than the United States. Running a _____ statistical test will let us compare the rate of decrease in emissions of both these countries.

Running the Test First determine the minimum date

```
min_date=min(emissions$year)
max_date=max(emissions$year)
```

Turning our data into a time series

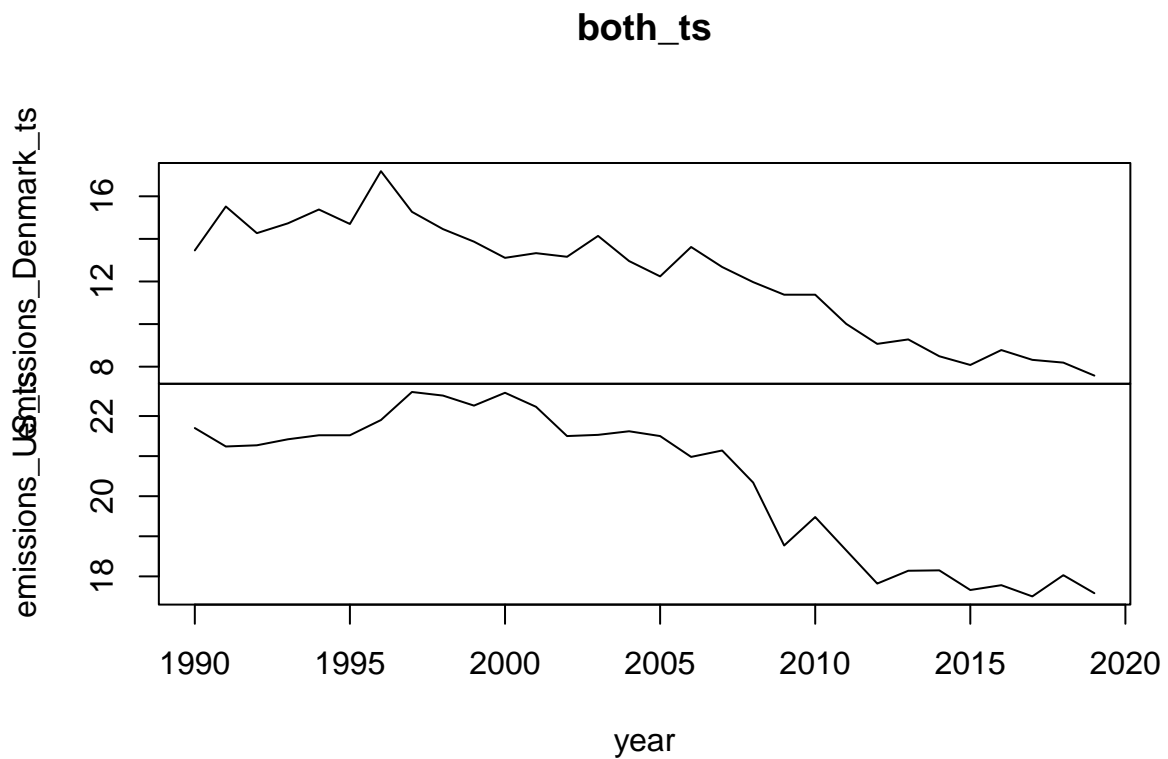
```
emissions_ts<-ts(emissions$emissions, start=c(1990,01), end=c(2019,01), frequency=1)
```

Lets do time series for the individual countries

```
emissions_Denmark<- emissions %>% filter(country=="Denmark")
emissions_US<-emissions %>% filter(country=="United States")
emissions_Denmark_ts<-ts(emissions_Denmark$emissions, start=c(1990,01), end=c(2019,01), frequency=1)
emissions_US_ts<-ts(emissions_US$emissions, start=c(1990,01), end=c(2019,01), frequency=1)
```

Viewing the time series of each individual country to ensure its correct.

```
both_ts<-cbind(emissions_Denmark_ts, emissions_US_ts)
head(both_ts) # ensuring it worked
plot(both_ts, xlab="year", ylab="emissions")
```



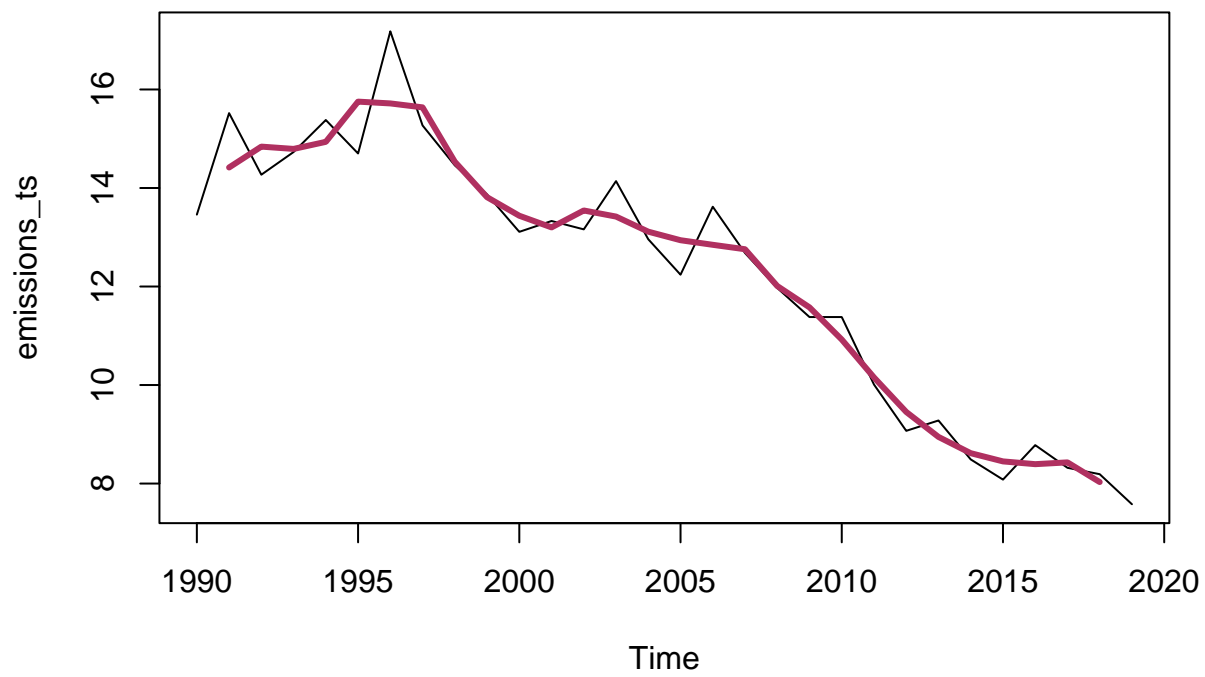
Here is our data smoothed over so we can see the trends without added noise. The bottom one I presume is denmark. We can see that it is decreasing more.

Making a moving average:

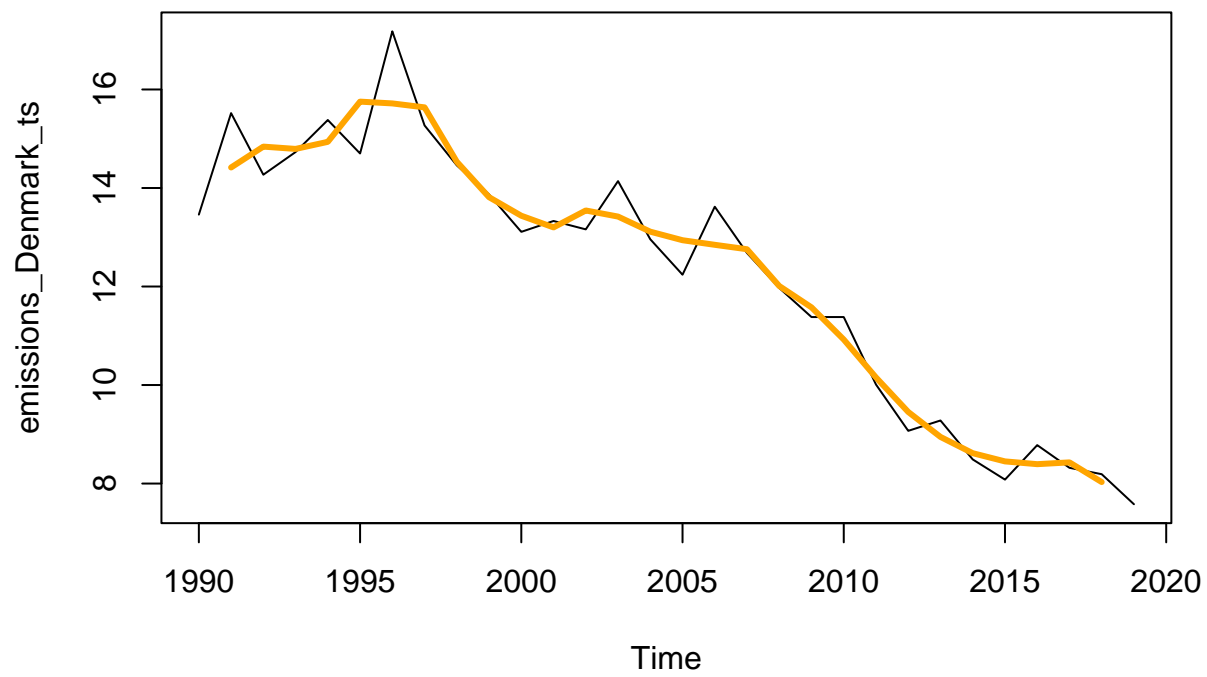
```
Ma_emissions<- forecast::ma(emissions_ts, order=3, centre = TRUE)
Ma_emissions_Denmark<- forecast::ma(emissions_Denmark_ts, order=3, centre=TRUE)
Ma_emissions_US<- forecast::ma(emissions_US_ts, order=3, centre=TRUE)
```

Plotting both the moving average and the time series.

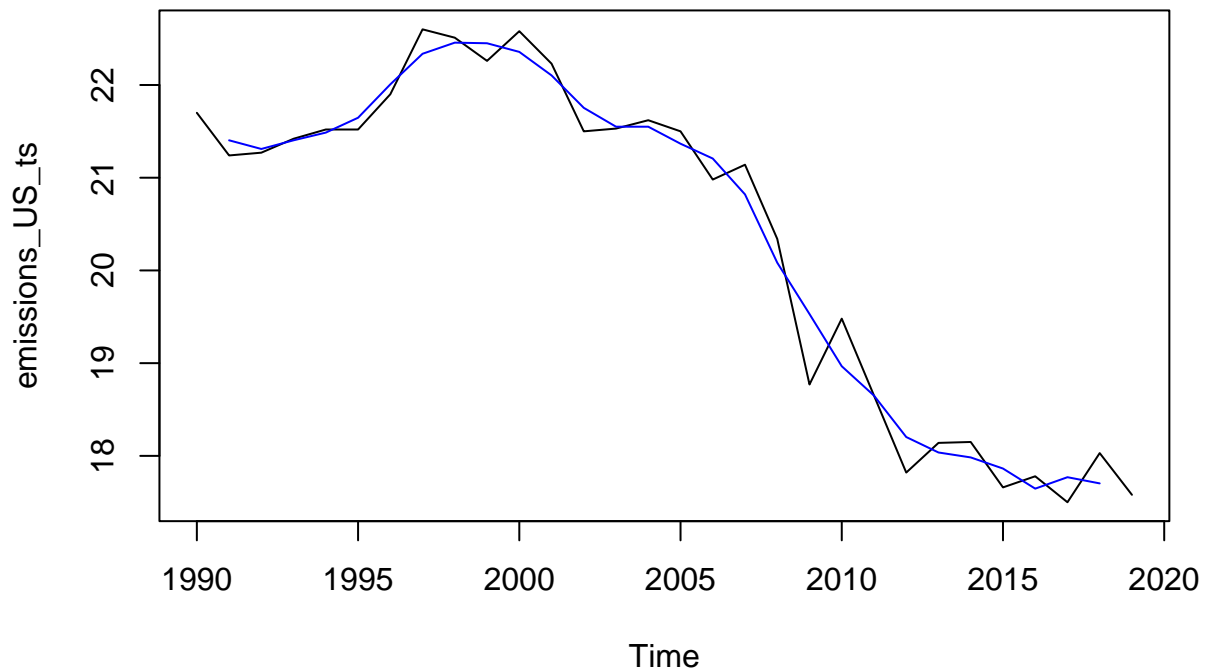
```
plot(emissions_ts)
lines(Ma_emissions, col="maroon", lwd=3)
```



```
plot(emissions_Denmark_ts)
lines(Ma_emissions_Denmark, col="orange", lwd=3)
```



```
plot(emissions_US_ts)
lines(Ma_emissions_US, col="blue")
```



The red line is the data but smoothed, so we can see the overall trend of the emissions data combined. the other two are them separated, notice how similar Denmark's is to the combined data. Interesting.

PUT RUNNING THE TIME SERIES HERE

Perceptions of Climate Change

Reading in the data:

```
survey<- read.csv(here("Data for the Code", "Corrected_Data_sets", "final_ccos_US_Denmark.csv"), stringsAsFactors=FALSE)
```

Though more people may have been interviewed in one country than the other, the survey data is in percent, as in the percentage out of the whole who chose that option. We can double check to ensure the recorded numbers equals 100 per country per survey question.

Lets check with the 'beliefs question' which is the first question we will analyzed.

```
#Parsing out just the survey answers regarding climate change beliefs
beliefs<- survey %>% filter(survey$question=="Ques__Climate_beliefs")
```

```
total<- beliefs %>% group_by(Country) %>% summarise(total=sum(Number))
total
```

```
## # A tibble: 2 x 2
##   Country      total
##   <fct>      <dbl>
## 1 Denmark    100.
## 2 United.States 100.
```

This means we can fairly compare Danes and American's perceptions of climate change.

Beliefs of Climate Change Lets first see what Danes and Americans believe caused climate. The options to choose from were: caused mostly by humans, caused by natural change in the environment, caused by both, and climate change is not happening.

```
# Making the graph
ggplot(beliefs, aes(response, Number, fill=Country))+
  geom_bar(stat = 'identity', position = 'dodge') +
  labs(title="Cause of Climate Change", x="Response to Survey Question", y="Percent") + # titling and re
  #theme( axis.text.x = element_text(angle = 45, size = 13, vjust = 0.5))+ this won't work :(
  coord_flip()+
  theme_bw()

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
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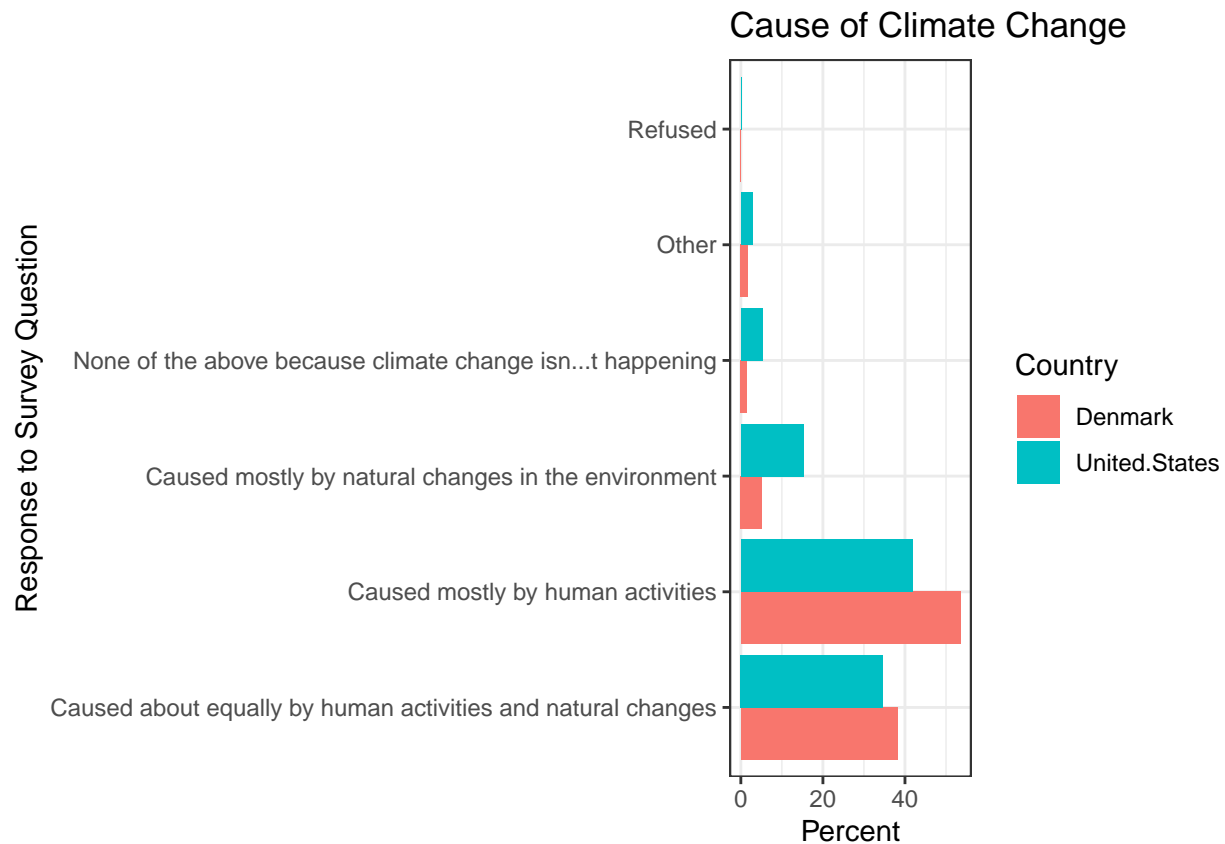


Figure 1. What Danes and Americans believe caused climate change. Responses are in percent of the total surveyed.

More Americans believe that climate change is not happening or that it is caused by natural changes than Danes. More Danes believe it is caused by human activities. However, more Danes than Americans think it is caused equally by both. Let's look at a pie chart as well.


```

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## conversion failure on 'None of the above because climate change isn't happening'
## in 'mbcsToSbcs': dot substituted for <e2>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on 'None of the above because climate change isn't happening'
## in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on 'None of the above because climate change isn't happening'
## in 'mbcsToSbcs': dot substituted for <99>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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## conversion failure on 'None of the above because climate change isn't happening'
## in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on 'None of the above because climate change isn't happening'
## in 'mbcsToSbcs': dot substituted for <99>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on 'None of the above because climate change isn't happening'
```

[illegible]


```
## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on 'None of the above because climate change isn't happening'
## in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call.graphics(C_text, as.graphicsAnnot(x$label), x$x, x$y, :
## conversion failure on 'None of the above because climate change isn't happening'
## in 'mbcsToSbcs': dot substituted for <99>
```

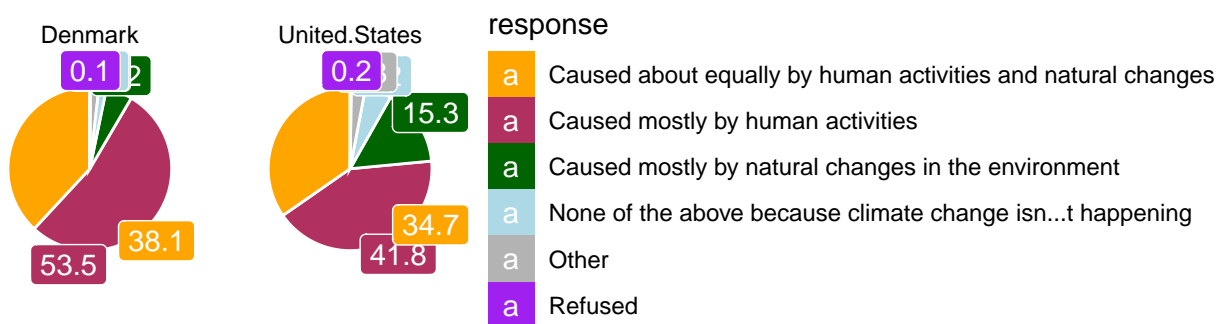


Figure 2. Pie chart of what Danes and Americans believe caused climate change. Responses are in percent of the total surveyed.

The pie chart shows that most of the Danes surveyed believe climate change is human caused, whereas more Americans thought it was a mix of human and natural causes or that climate change is not happening.

Lets run a statistical test to see if Danes believe climate change is human caused significantly more than Americans.

We have multiple categorical predictor variables with the response variable being ratio data that bounded between 0 and 100%, so we will run a _____

INSERT ### Running the Statistical Test

Level of worriedness about Climate Changed In this survey question people were asked how worried they are about climate change. There are three options for

```
worry<- survey %>% filter(survey$question=="Ques__climate_worry")
```

```
ggplot(worry, aes(response,Number, fill=Country))+geom_bar(stat = 'identity') +
  labs(title="Level of Concern Over Climate Change", x="Response to Survey Question", y="Percent") + th
```

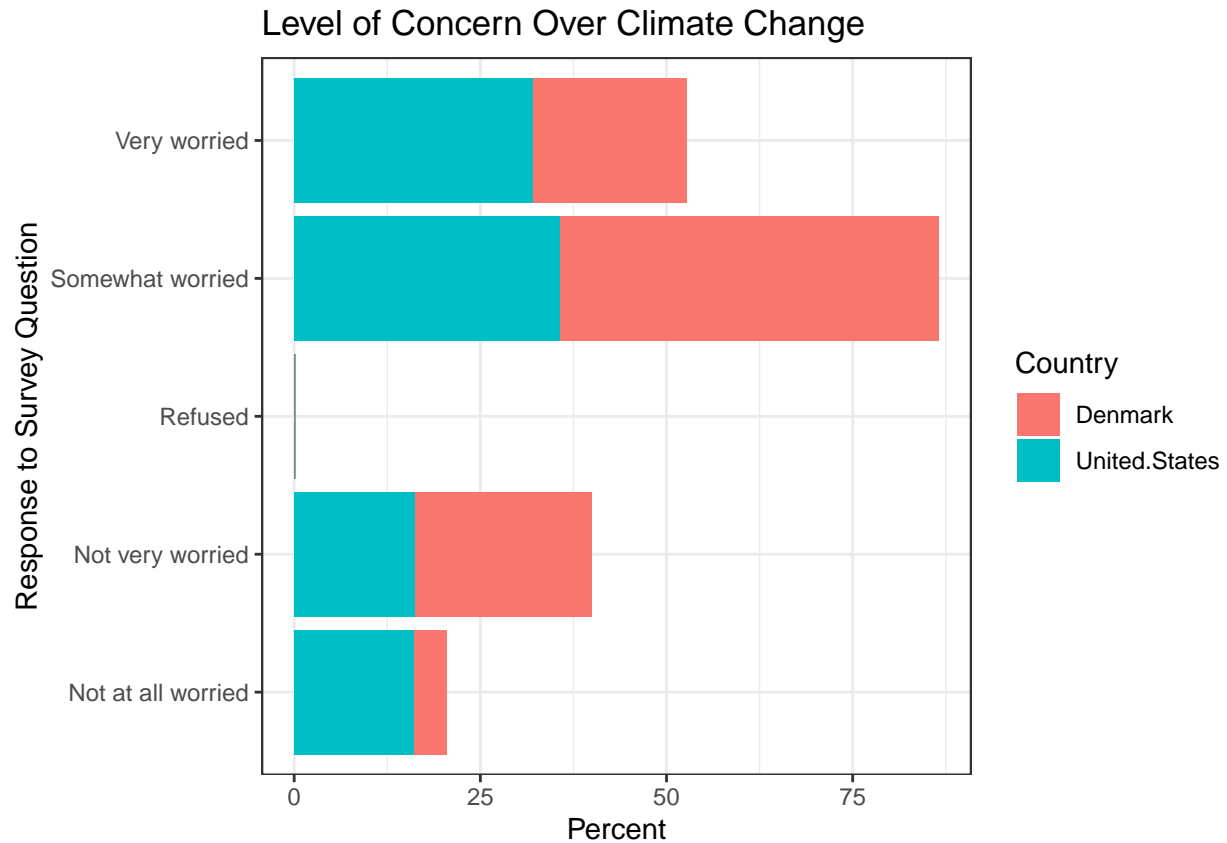


Figure 3. Bar graph of the Level of Concern over climate change of both Danes and Americans. Response is in percentage of the total surveyed.

32% of Americans are very worried about climate change, whereas only 21% of Danes are. But 52% of Danes are somewhat worried at only 36% are. To better visualize this let's try another graph.

```
ggplot(worry, aes(x="", y= Number, fill=response))+ geom_bar(stat="identity", width=1)+ coord_polar("y")
  geom_label(aes(label = round(Number, digits = 1)), nudge_x = 0.4) + # add percentages
  theme_void()+ # remove background, grid, numeric labels
  facet_wrap(~Country)
```

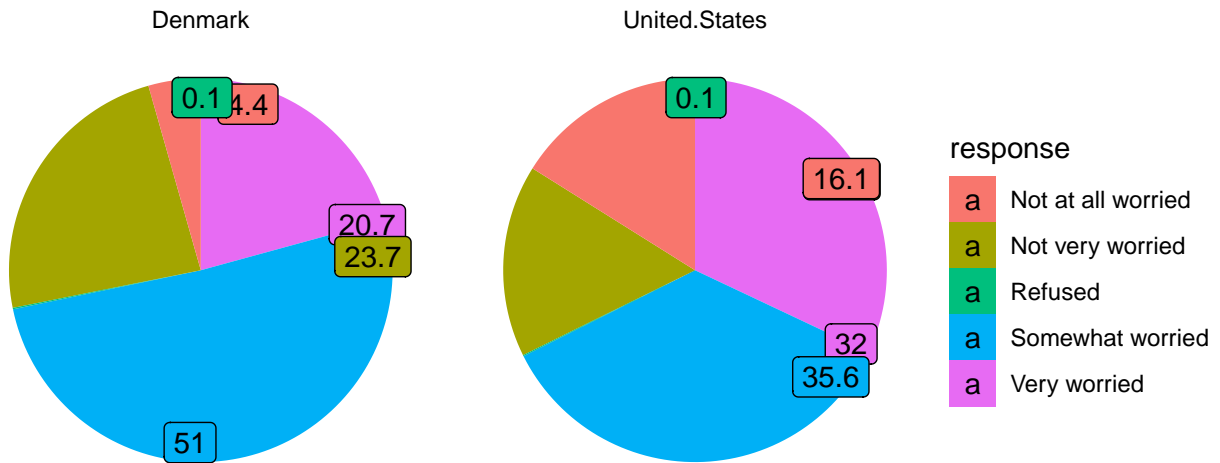


Figure 4. Pie chart of the Level of Concern over climate change of both Danes and Americans. Response is in percentage of the total surveyed.

We can see that most Danes are somewhat worried, with the smallest percentage being not worried at all. Most Americans are also somewhat worried, though the percentage is smaller compared too Denmark (51% to 35.6%). More Americans however are very worried, and more Americans are not at all worried than Danes. Interesting. A statistical test is needed to see if Americans are less worried than Danes.

Lets do a statistical test to verify. Again we will do a general linear model.

INSERT STATISTICAL TEST

Is Climate Change a Big Threat

In this survey question people were asked whether or not climate change is a big threat within the next 20 years. The options were very serious threat, somewhat serious, not a threat at all, or I do not know.

parcing the data

```
threat<- survey %>% filter(survey$question=="Ques__threat_20_years")
```

```
ggplot(threat, aes(response,Number, fill=Country))+geom_bar(stat = 'identity', position = 'dodge') +
  labs(title="Perceieved Threat of Climate Change", x="Response to Survey Question", y="Percent") + the
```

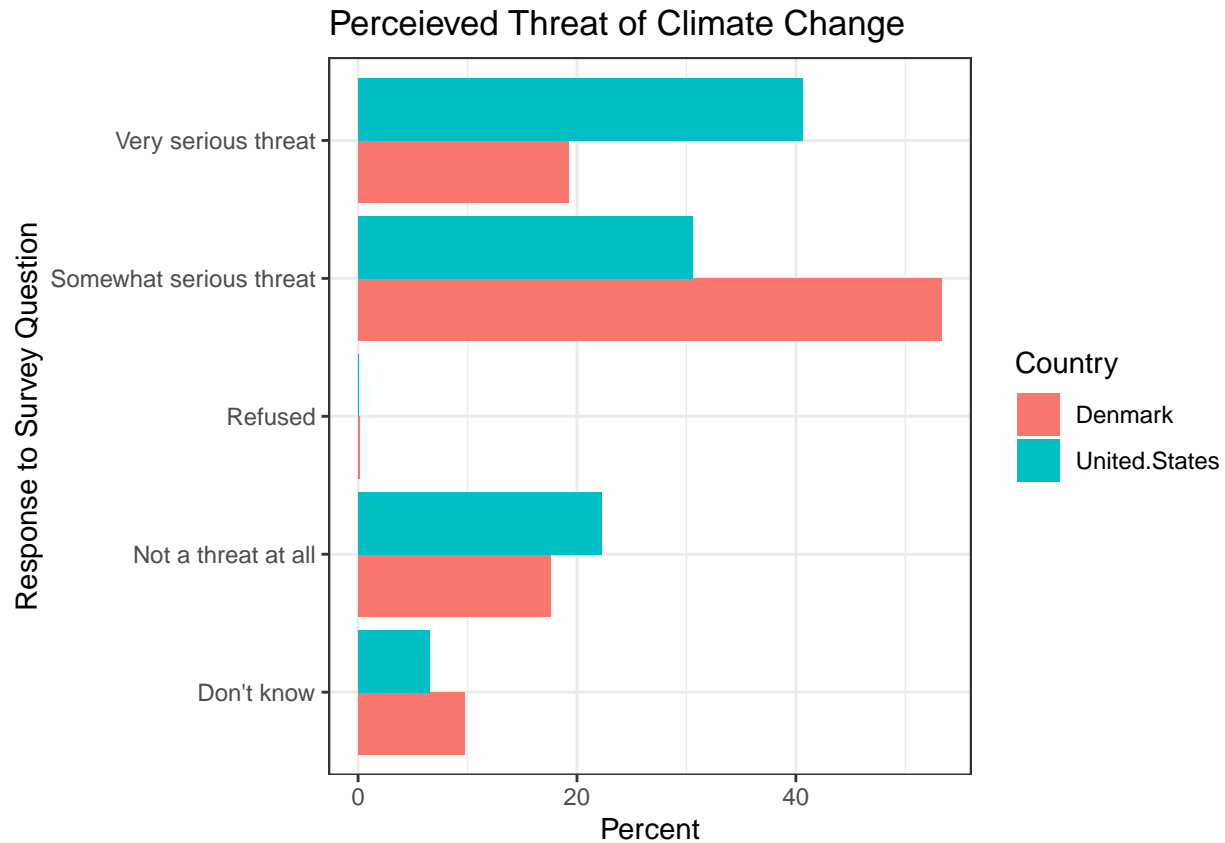


Figure 5. Bar graph of the perceieved threat of climate change of Danes and Americans. Response is in percentage of the total surveyed.

More Americans than Danes think that climate change is a very serious threat, but Danes think it is a somewhat serious threat than Americans. More Americans also think that climate change is not a threat at all than Danes. Lets view a pie chart.

```
ggplot(threat, aes(x="", y= Number, fill=response))+ geom_bar(stat="identity", width=1)+ coord_polar("r")
  geom_label(aes(label = round(Number, digits = 1)), nudge_x = 0.5, nudge_y = 2 ) + # add percentages
  theme_void()+ # remove background, grid, numeric labels
  facet_wrap(~Country)
```

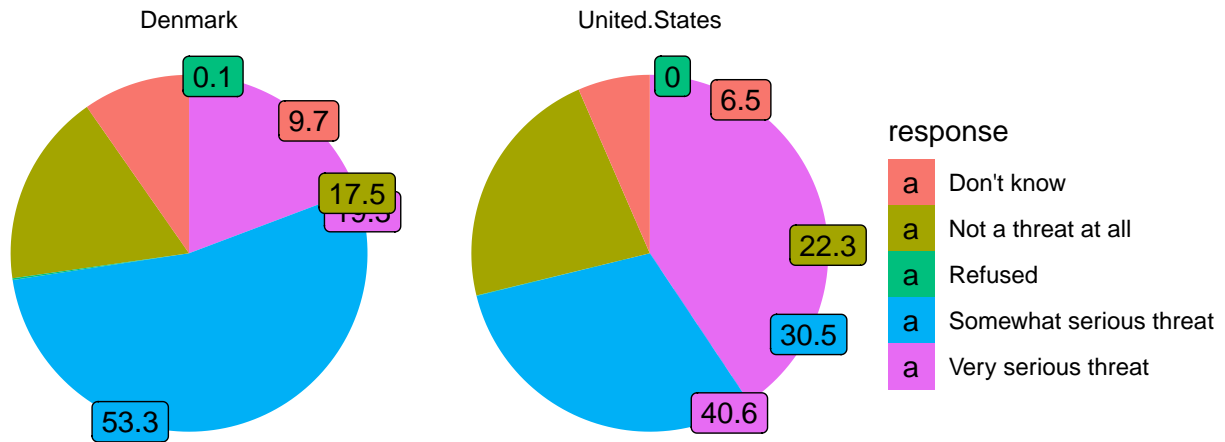


Figure 6. Pie char of the perceieved threat of climate change of Danes and Americans. Response is in percentage of the total surveyed.

We can see that most Danes, %53 think climate change is a somewhat serious threat, whereas most Americans, %40.6, think it is a very serious threat. Only 17.5% of Danes think that it is not a threat at all, compared to the 22.3% of Americans that think that. Lets test with a statistical test.

Lets do a statistical test to verify. *###INSERT STATISTICAL TEST*

More or less Fossil Fuels

Now that we know what Danes and Americans think about climate change and how worried they are, lets see how they are reacting. This next survey question asked people if their region should use more or less fossil fuels with the options being much more, somewhat more, same as today (same amount), somewhat less, or much less.

Lets check with the 'beilefs question' which is the first we will anaylzed.

```
#Parcing out just the survey answers regarding climate change beliefs
fuels<- survey %>% filter(survey$question=="Ques__Fossil_moreorless")
```

```
# Making the graph
```

```
ggplot(fuels, aes(response,Number, fill=Country))+geom_bar(stat = 'identity', position = 'dodge') +
  labs(title="Fossil Fuel Use", x="Response to Survey Question", y="Percent") + # renaming x and y axis
  theme_bw() +
  coord_flip() # switching x and y axis to read the suvey questions
```

```
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :  
## conversion failure on 'Don't know' in 'mbsToSbs': dot substituted for <e2>  
  
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :  
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## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :  
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## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :  
## conversion failure on 'Don't know' in 'mbsToSbs': dot substituted for <e2>  
  
## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :  
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## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :  
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## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :  
## conversion failure on 'Don't know' in 'mbsToSbs': dot substituted for <80>
```

[illegible]

```
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## conversion failure on 'Don't know' in 'mbcsToSbcs': dot substituted for <80>

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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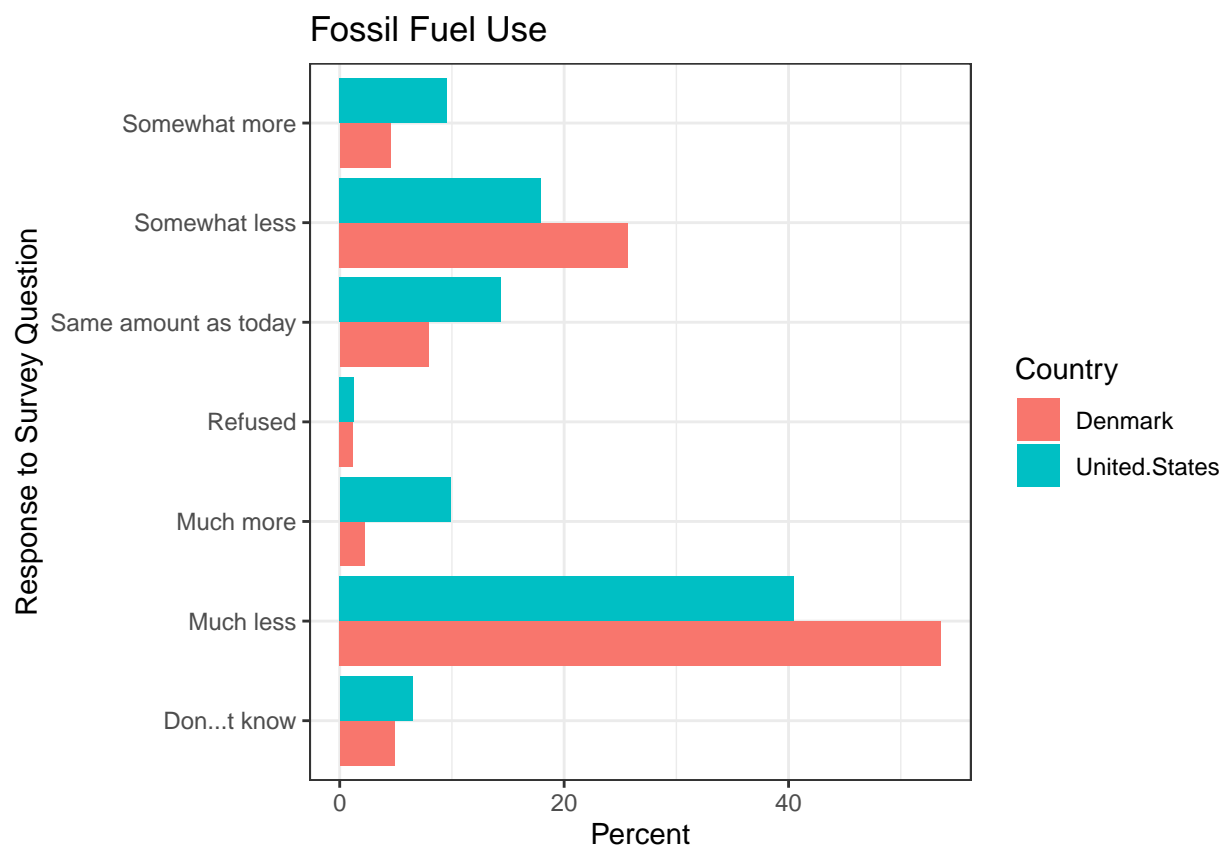


Figure 7. The fossil fuel usage Danes and Americans think their area should use. Response is in percentage of the total surveyed.

More Americans think there should be much more or or somewhat more fossil fuels used than Danes. More Danes thinks there should be somewhat less or much less fossil fuels used. This appears to clearly show that Danes think fossil fuel usage should be decreased, where Americans think that less. Let's see in pie chart form.

```
ggplot(fuels, aes(x="", y= Number, fill=response))+ geom_bar(stat="identity", width=1)+ coord_polar("y")
  geom_label(aes(label = round(Number, digits = 1)), nudge_x = 0.4) + # add percentages
  theme_void()+ # remove background, grid, numeric labels
  facet_wrap(~Country)
```


[illegible]

[illegible]

[illegible]

```

## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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## Warning in grid.Call(C_textBounds, as.graphicsAnnot(x$label), x$x, x$y, :
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```

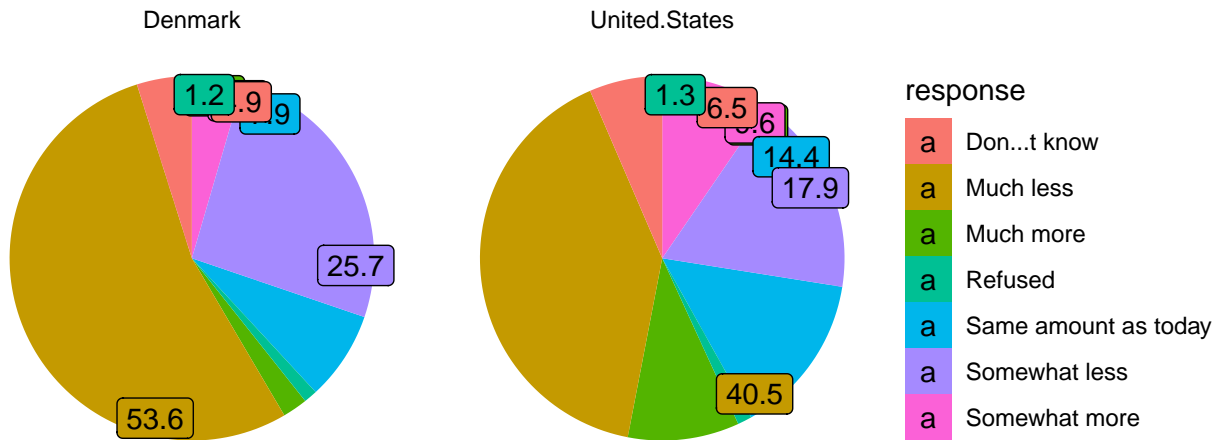


Figure 8. The fossil fuel usage Danes and Americans think their area should use. Response is in percentage of the total surveyed.

The pie chart shows that most of the Danes surveyed, %53.6, believed much less fossil fuels should be used, with the second largest percentage of 25.7% believed somewhat less should be used. These percentages are larger than results in the United states, though the largest percentage of Americans also believed there should be much less fossil fuel usage at 40.5%, with the second most thinking somewhat less fossil fuel usage, 17.9%. More Americans believed there should be much more or somewhat more than Danes. Lets verify with a statistical test.

we will run another generalized linear model.

Running the Statistical Test ### *INSERT STATISTICAL TEST*

Survey data Impacting Emissions

Summary Discussion

Limitations

The data used is from a survey conducted on Facebook, so all respondents are Facebook users. This adds a confounding variable, when utilizing this study.

Challenges

Prior to this project how to conduct a time series analysis, work with survey data, or make pie charts was not discussed nor taught. External research and problem solving had to be conducted in order to achieve this data analysis.

When constructing graphs the pie charts proved to be particularly cumbersome as the percentages were not align on the pie chart in the correct spot, nor all be visible. Research into `geom_label` and `geom_text` yeilded a the most succesful outcome. However, the pie charts still need work and any feedback regarding how to would be greatly appreciated.

Research into how to make a likert graph was also conducted. The responses to the four survey questions would have to be the same however, in order to produce a likert graph. I could change the answers to create a made up response scale of pro or anti climate action. Would that be professional or no? Let me know your thoughts so I can include it in the final.