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Going Climate neutral in South Korea: A Sentiment analysis study on the announcement of Climate neutrality

Term paper

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List of Abbreviations

GHG	Greenhouse Gas
EU	European Union
IPCC	Intergovernmental Panel on Climate Change
RoBERTa	Robustly Optimised BERT Pretraining Approach
NLP	Natural Language Processing
ML	Machine Learning
AI	Artificial Intelligence

1 Introduction

In recent decades South Korea has become a renowned name in manufacturing technology. Companies like Hyundai in the automobile manufacturing sector and Companies like Samsung in the semiconductor and communications technologies sectors have succeeded in becoming exceptionally successful companies which have helped contribute a lot to the South Korean economy and have helped uplift the country through financial hardships (Le et al., 2016, p. 2). Undoubtedly, this unprecedented industry progress in the past few decades has helped South Korea become one of the prominent economic powerhouses on Earth (Le et al., 2016, p. 1). However, with enormous amounts of growth also comes various consequences which can hamper countries' upwards economic trajectory, such as environmental issues, namely pollution. South Korea's earliest economic movements date back to the 1950-1960s after the end of the Korean war (Le et al., 2016, p. 2). Therefore, the earliest environmental concerns also date back around the same period and have been from people who have been direct victims of pollution due to Industrial parks in their near vicinity (Jonghoe Yang, 2012, p. 2). Since then, Korean environmental concerns have been recurring news in mainstream media and have also become one of the topics parliament has discussed in recent decades (Jonghoe Yang, 2012, p. 2).

In recent years, environmental concerns have become headlines in almost every country worldwide. Major organisations like the United Nations have also categorised environmental issues like climate change and global warming as one of the most pressing challenges of recent times (United Nations, n.d.). As raised in an article by The World Bank (World Bank, 2022), "Climate change poses major challenges to environmental stability, economic growth and human development in the East Asia and Pacific region. The region includes 13 of the 30 countries most vulnerable to the impacts of climate change, and without concerted action, the region could see an additional 7.5 million people fall into poverty due to climate impacts by 2030."

In response to the imminent threat of Climate Change, several countries worldwide and in East Asia have been trying to construct policies and movements that can offset,

reverse, or positively improve upon the dire climate change situation. In recent years, Carbon Neutrality has become a prominent keyword in climate summits and symposiums worldwide. As stated in the news section of the European Parliament's website (2019), "Carbon neutrality means having a balance between emitting carbon and absorbing carbon from the atmosphere in carbon sinks. Removing carbon oxide from the atmosphere and then storing it is known as carbon sequestration. In order to achieve net zero emissions, all worldwide greenhouse gas (GHG) emissions will have to be counterbalanced by carbon sequestration." Therefore, the paper can raise that for a country to be carbon neutral; it must absorb the same amount of carbon it releases into the earth's atmosphere to offset its effect. In recent years, several countries have implemented their versions of Carbon Neutrality Policies. These include countries, for example, Austria (which is currently in the Policy stage), Canada (with a law mandating Net zero emission by 2050), Denmark (with law for net zero emission by 2050), France (with a net zero emissions mandate till 2050), and Germany (with the law for net zero emission target till 2045) and more (Darby & Gerretsen, 2019).

Korea also, in 2020, declared its willingness to reduce Carbon related emissions and to strive to achieve net zero emissions or Carbon neutrality by 2050 (McCurry, 2020). According to an article by McCurry (2020), "He [Moon Jae-In] vowed to end its [South Korea's] dependence on coal and replace it with renewables as part of its Green New Deal, a multibillion-dollar plan to invest in green infrastructure, clean energy and electric vehicles."

However, more than 1/3rd of South Korea's energy demands are met by Coal, with less than 10% being met by renewable energy at the moment (McCurry, 2020).To summarise, while South Korea looks to reduce its use of carbon-based fuels and move on to renewables, the ground-zero situation is not favourable. It is also important to note that while South Korea declared itself to be Carbon Neutral, the amount of fiscal is very low compared to other more giant economic blocs in the world like the EU (Oh et al., 2021, p. 45).

Against this overall backdrop of South Korea's declaration to be Carbon Neutral and its real-world conditions, it could be insightful to find how the public perceives the overall announcement of South Korea aiming for Climate Neutrality as environmental issues have a sense of great concern to the public (Jonghoe Yang, 2012, p. 2).

The paper aims to understand South Korea's public perception of the announcement of Carbon Neutrality in the country and to gain insight into possible factors influencing the public's overall perception. The paper will first examine the background of environmental awareness among citizens in South Korea, followed by Policies and initiatives taken by the Korean government to mitigate climate risks in the previous years. The paper then tries to gather data (public opinion over social media channels), and run a Sentiment analysis to get the quantified value of the Korean public perception.

The paper does not look into the country's political discourse on environmental issues. However, it looks to get an insight into the public perceptions, which could help frame practical and concise environmental policies in the future.

2 Literature Review

2.1 Environment and Global Climate crises

It is common knowledge that the world is undergoing a global climate catastrophe. To name a few, Global warming and Climate have been global buzzwords which news, many publications, and everyone is discussing in the current decade. According to Shaftel (2022), "Global warming is the long-term heating of Earth's surface observed since the pre-industrial period (between 1850 and 1900) due to human activities, primarily fossil fuel burning, which increases heat-trapping greenhouse gas levels in Earth's atmosphere." While the warming trend has been going on since the 1850s, the rate of warming has significantly accelerated in the past 50 years, from the 1950s to the current 2000s (Shaftel, 2022).

As raised in the above section, Global warming is perpetrated by the burning of fossil fuels, which leads to the release of Carbon related compounds to be related in the atmosphere, mainly Carbon Dioxide, methane and fluorinated gases, which act as a component which traps the amount of heat in the atmosphere resulting in an overall increase in the world's atmosphere (MacMilan & Turrentine, 2021). Continuous warming due to this phenomenon has caused Earth's Temperature to rise by about 1℃ since pre-industrial levels in 2017 (IPCC, 2022, p. 51). The report by IPCC (2022) also states that "Temperature rise to date has already resulted in profound alterations to human and natural systems, including increases in droughts, floods, and some other types of extreme weather; sea level rise; and biodiversity loss " (IPCC, 2022, p. 53). Furthermore, global warming and induced climate change can have detrimental impacts on several regions and possibly irreversible changes on the planet, which can endanger human societies (IPCC, 2022, p. 79).

As stated in the previous segment, Greenhouse gases and Carbon related compounds are involved mainly in the deterioration of Climate and higher temperatures across the globe. Major government institutions like the European Commission have raised that Carbon Dioxide gas is the main contributor to the Global warming phenomenon, and the concentration of the gas in the atmosphere has increased by approximately 50% since pre-industrial levels (European Commission, n.d.). Fossil fuel burning to keep up with energy requirements, and almost most of the countries in the world using fossil fuels, is one of the reasons behind the gas's meteoric rise in concentration (World Nuclear Association, n.d.). Currently, the world fulfils more than half of its energy requirements through fossil fuels (World Nuclear Association, n.d.). Thus it is quite imperative to think that the world's energy requirements contribute to the phenomenon of global warming. Therefore, to offset the effects of Global warming, the first point of contact would be to solve the carbon dioxide problem in the atmosphere.

To summarise this section, the ever-increasing problem known as Global warming presents itself as an imminent threat fuelled by Carbon based compounds. Therefore, there is a need to create a solution to deal with the excess Carbon compounds in the

atmosphere. The following section investigates policies and movements introduced by world governments to tackle the ongoing problem of global warming.

2.2 Efforts to tackle the problem of global warming

In order to tackle the ever-looming threat of global warming, it is imperative that countries must come up with viable solutions that could necessarily prevent the further deterioration of the Climate and offset any adverse effects on the environment. The Paris Agreement is one of the landmark agreements in climate and global warming action plans and agreements (United Nations Framework Convention on Climate Change, 2022). As raised in the Agreement, "[i]ts goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels." (United Nations Framework Convention on Climate Change, 2022). In Order to achieve the goal of limiting the temperature rise, the Agreement urges its signatory states to limit their greenhouse emissions and to create policies limiting greenhouse gas emissions (United Nations Climate Change, 2016). Since the United Nations announced the Agreement, several countries have implemented their very Climate-related policies and have given assurance that they will reach their climate goals, especially Climate neutrality, by 2050 (more in section 2.5) (Cornwall, 2020). Moreover, the new policies and enacted laws have created visible effects around many industries that work in the renewable sector, with technologies like solar power becoming cheaper than before (Cornwall, 2020).

More prominent organisations like the EU have created legislations and laws which aim at reducing greenhouse gas emissions by more than 50% by the end of 2030 and also aim to create an industrial platform which can help in sustainable economic growth and also create a platform for 'climate financing' encouraging other countries around the world to work in the direction of reducing the impact of global warming (Council of the EU and the European Council, 2022).

This paper can imply that countries and organisations worldwide are taking reasonable actions to tackle the problems of global warming and collaborating to create platforms which help achieve the goal.

In recent years, the concept of Climate neutrality has taken centre stage. The following section focuses on the concept of Carbon neutrality and looks at how Asia and South Korea have focused on Carbon Neutrality.

2.3 Carbon Neutrality

As raised in the introduction, carbon neutrality can be summarised as a state where the amount of Carbon emitted by a country is offset by the amount of Carbon it consumes; thus, in theory, it no longer pollutes the environment, i.e., having net zero emissions in the environment. Achieving Carbon neutrality is not just a governmental task but an initiative aimed at the individual as well as on company levels; as raised by United Nations Framework Convention on Climate Change (2021), "Climate neutrality means that you bring your emissions down to zero; something that applies both to individuals and to organisations."

Countries around the world have pitched it with their own version of climate neutrality policies; for example, Countries in Europe such as Germany, France, Ireland, Hungary and more (Darby & Gerretsen, 2019). As mentioned in the introduction, several countries around the world have either announced their policies, put up a resolution, enacted laws and are trying to bring in the initiative of carbon neutrality in their respective neighbourhoods. Carbon neutrality is also an agenda that is nowadays a crucial point in politics. Several regions around along with their political parties put them into their manifestos as a chance to connect more with the current Climate conscious public (Waisman et al., 2020). Countries in Asia also look at Carbon Neutrality as influential agenda to achieve their goals and achieve a Carbon neutral society. The following section looks into the background of Carbon Neutrality in Asia and the policies and movements which have taken place in Asia

2.4 Carbon Neutrality in Asia

Several countries from Asia signed the Paris Agreement in 2015, and as of 2022, A total of 192 Countries have joined the Agreement. Although almost all the countries in Asia have also participated in the Agreement (United Nations, 2016), major countries like China and India also joined the Agreement (BBC News, 2016; Sidharth

Pandey, 2016) which gives positive hope that Paris agreement will encourage and also promote the region to pursue and enact major environmental policies.

Asian Countries have implemented policies for Carbon Neutrality in recent years include, including Japan, with its net zero emissions target by 2050, has been trying to bring down the levels of emissions caused by Coal electric power generation, which approximately occupies more than 30% of their respective country's electricity generation capacity (Darby & Gerretsen, 2019). On the other hand, a country like Maldives is extremely ambitious with its net zero greenhouse gas emissions target resolved by 2030, far earlier than most countries aiming for Carbon neutrality (Darby & Gerretsen, 2019). Furthermore, extremely smaller countries like Singapore face challenges in implementing a transition to renewable energy due to space constraints in the island state; however, the country raised that their final goal is to achieve decarbonisation (Darby & Gerretsen, 2019).

Tachev (2022) raises in an article about Asia's journey to Carbon Neutrality that "Asia has little choice but to pledge to carbon-neutral goals. Pressure to boost Asia's ambitions comes from the public, investors and the corporate world." Southeast Asia is one of the most vulnerable areas in the world, which can get severely hit by rising global temperatures due to global warming (Tachev, 2022). East Asia consisting of China, Japan and Korea, contributed to over 1/3rd of the world's total carbon emissions in 2018 (Greenpeace East Asia, 2020). However, each has declared its Carbon Neutrality Policies, which aim to achieve a net zero emissions target by the year 2050 to somewhere around 2060 (Darby & Gerretsen, 2019).

The paper focuses on the policies taken by South Korea during global warming and its policies to combat its effect inside the country and globally. As raised in the introduction, South Korea declared its intent to be Carbon Neutral in 2020 (McCurry, 2020). South Korea, just like other countries, implemented several policies regarding Climate challenges. However, the following section investigates the cultural and public background of how South Korea's environmental concerns have come up to be.

3 Korean Environmental Awareness

South Korean Public's environmental concern has been increasing in the last couple of decades, with Environmental topics becoming an important topic among citizens which needs to get solved (Jonghoe Yang, 2012, p. 2). South Korea's exceptional economic growth has had its consequences in the past few decades due to industrialisation, which started in the 1960s (Ku, 2011, p. 208). As raised by Ku (2011), "The Korean environmental movement developed rapidly with the opening of the political opportunity structure, and has grown into a political force capable of changing that structure after securing its own resource mobilisation capabilities. Korean society continues to experiment with green politics through social movements via such interplays of structure and action"(Ku, 2011, p. 208).

As raised earlier, the Korean environmental concern started very early in the 1960s – 1970s. During those times, few environmental organisations had an environmental ideology; however, the Korean Environmental movement started with the joint actions of victims of environmental exacerbation (Jonghoe Yang, 2012, p. 2; Ku, 2011, p. 208). The unorganised actions by these organisations did not bear any result in the process; however, they set up a foundation for current environmental movements and a sense of environmental concern in the country (Ku, 2011, p. 208).

The 1980s followed up with anti-pollution protests (Ku, 2011, p. 208), which could be due to the country's rapid industrialisation based on heavy and chemical industries (Le et al., 2016, p. 256). The anti-pollution movements took action alongside the democratisation movement, which followed in the 1980s, and mostly consisted of College students and graduates. (Ku, 2011, p. 209). However, the government looked considered these anti-pollution movements as Anti-governmental and prevented and discouraged residents from participating in these professional environmental organisations (Ku, 2011, p. 209).

The 1990s till the present follow the era of "new environmental movements", which replaced the anti-pollution movements in the previous decade (Ku, 2011, pp. 209–210). Ku (2011) also said, "The Korean movement has not strictly confined itself to the issue of the environment. It has positioned itself as a leading force of green

politics, pursuing goals positive to preservation of the environment, life and democracy."(Ku, 2011, p. 211).

Along with the movements, environmental concern has been very high since the 1980s, with approximately ¾ of the population of South Korea expressing concern over environmental issues (Jonghoe Yang, 2012, p. 24). Furthermore, the environment is very relevant even after the democratisation, economic development, and value shift. In summary, the Korean population has always been concerned about the environment and cares about the policies and actions put forward by the government to create an environment. The trend is only going upward.

3.1 South Korea's Carbon Neutrality announcement

As raised in the previous sections, South Korea announced its goals and intention to achieve Carbon Neutrality by 2050 (McCurry, 2020) to prevent a Climate emergency. In perspective, South Korea was the seventh biggest emitter of carbon dioxide in 2017 and produced and provided approximately half of its energy requirements through Coal (McCurry, 2020). However, on 31st August 2021, South Korea became the 14th country to legislate a carbon neutrality act (Hyeong-woo, 2021). The legislation mandates the country's government to cut on greenhouse gas emissions by 35% of 2018 levels by the year 2030, and there is also an article which proposes a national vision where the country achieves its goal of carbon neutrality for the economy and the harmony of the country (Hyeong-woo, 2021). To summarise, the country has a policy which compels the it to put a limit of on its carbon compound/greenhouse gas emissions.

4 Research Question

The literature review summarises that the global climate scenario is a global threat, and it has been urgent for most of the world to create countermeasures that reset or offset the effects of Global warming. Countries worldwide have implemented policies aiming to achieve net-zero emissions of carbon-based compounds, or in other words, achieve carbon neutrality.

As per the previous sections, Korea also has announced and put into legislation its policies to achieve Carbon neutrality and looks to achieve them as per their decided time limits. Korea's public has also had great concern over environmental and Climate issues in the past and present.

Compiling all the literature raised above regarding climate policies, the background of South Korea's environmental concern and the recent announcements of Carbon Neutrality policies, the paper raises the following research question:

R1: How has the Korean public reacted to the announcement of the Carbon Neutrality goal 2050?

By Referring to the literature on the environmental concern of the Korean public towards environmental issues, the paper raises the following hypotheses to the research question (R1):

For R1:

H1: There is a positive reaction from Korean with respect to the announcement of the Carbon Neutrality goal 2050

The paper uses the data analysis method of Sentiment analysis to figure out and quantify the public perception regarding the research question.

5 Method

Sentiment Analysis is one method the paper uses to answer the above-raised Question. As raised in an article by Tech Target (2021), "Sentiment analysis, also referred to as opinion mining, is an approach to natural language processing (NLP) that identifies the emotional tone behind a body of text. This is a popular way for organisations to determine and categorise opinions about a product, service, or idea. It involves the use of data mining, machine learning (ML) and artificial intelligence (AI) to mine text for sentiment and subjective information."

Sentiment analysis in the context of our research can be used to gather opinions or data regarding 'Carbon Neutrality 2050' in Korea and then use a Natural Language

Processing (NLP) model to process the opinions into numerical positive, negative, and neutral sentiments scores.

Companies and institutions apply sentiment analysis in several fields in market research, social media monitoring, product analysis and more (Roldós, 2020).

For the research question raised above, the paper will use Twitter as a platform to gather or mine a dataset for the research and use the Natural language Processing model known as 'RoBERTa' (to compute the sentiment of the dataset obtained (Barbieri et al., 2020; Hugging Face, n.d.; Liu et al., 2019; Rotulo, 2022). For the scope of the paper, the method uses 'Twitter' social media platform to gather data due to the ease of gathering public opinions. Furthermore, since every post, in this case 'tweet', is limited to approximately 280 characters and is predominantly in the text format, it is easier to compile and process them in comparison to photos or videos or a combination of those (Gil, 2021).

The order of the steps followed for the sentiment analysis is as follows (Refer to Table 1):

Table 1 Sentiment Analysis for Carbon Neutrality 2050 for Korea

Step no.	Action
1	Data Mine Tweets which have '2050 탄소중립' in them.
2	Compile all the tweets and convert them into a dataset file (.csv)
3	Use the dataset file and run it through an NLP model (in the case of this research, 'RoBERTa' sentiment analysis model
4	Create Sentiment Probability scores for the whole dataset into (Positive, Neutral, and Negative)

In step one, the paper tries to mine tweets using a Python programming language code, which has keywords '2050 탄소중립' (translated to be 2050 Carbon Neutral) in them through the Twitter advanced search query. In step two, the paper compiles the collected data into a dataset file with all the tweets containing the keyword '2050

탄소중립'. For this paper, the search query exclusively looks for tweets in the Korean Language to minimise any chances of tweets done by a non-Korean foreign entity (for example, including English-language tweets). Furthermore, the search query ranges from the date of the announcement of Carbon Neutrality in Korea, i.e., from 28th October 2020 to the present day of 8th August 2022. The code for this paper is a modified version of AI Spectrum's (2022) Tweet Scraping tutorial code. The code for the data collection and compilation of the dataset for the query is as follows (The code is titled *Climate_tweets.py)*:

```
import snscrape.modules.twitter as sntwitter
import pandas as pd

query = "2050 탄소중립 until:2022-08-10 since:2020-10-28"
tweets = []
limit = 25000

for tweet in sntwitter.TwitterSearchScraper(query).get_items():

    #print(vars(tweet))
    #break

    if len(tweets) == limit:
        break
    else:
        tweets.append([tweet.date, tweet.user.username, tweet.content])

df = pd.DataFrame(tweets, columns=['Date', 'User', 'Tweet'])
df.to_csv('Climate_SouthKorea_tweets_Korean_New.csv')
```

The python code (named *Climate_tweets.py)* raised above collects all the tweets on the Twitter database with the keywords '2050 탄소중립' and compiles them into a dataset file known as '*Climate_SouthKorea_tweets_Korean_New.csv*'.

The paper then uses the obtained dataset file *Climate_SouthKorea_tweets_Korean_New.csv* and processes it through the Natural Language processing code of 'RoBERTa' to process a Sentiment analysis score for all the entries in the dataset. However, for this paper, RoBERTa NLP model can only process English tweets, and since *Climate_tweets.py* obtains Korean tweets through

its search query, the paper translates all the available Korean tweets in the dataset file into English using Google Sheets (Google LLC, n.d.) and creates a new dataset file '*Google_Climate_SouthKorea_tweets_Korean_New.csv*'

The paper then uses *Google_Climate_SouthKorea_tweets_Korean_New.csv*, runs it through the RoBERTa Sentiment Analysis python code, and obtains sentiment scores for every tweet in the data; the paper converts all the sentiment scores obtained into a new dataset file and compiles an overall score for the whole of the dataset. This Overall score will denote the sentiment of the Korean Public on Twitter towards the concept of Carbon Neutrality 2050.

The code to process the *Google_Climate_SouthKorea_tweets_Korean_New.csv* and run it through the RoBERTa Sentiment analysis, named '*Climate_sentiment_Korean.py*', is as follows:

```
from cgitb import text
import csv
import pandas as pd
import nltk
import numpy as np
from transformers import AutoTokenizer
from transformers import AutoModelForSequenceClassification
from scipy.special import softmax
from tqdm.notebook import tqdm
from nltk.sentiment import SentimentIntensityAnalyzer
import urllib.request

def preprocess(example):
    new_example = []
    for t in text.split(" "):
        t = '@user' if t.startswith('@') and len(t) > 1 else t
        t = 'http' if t.startswith('http') else t
        new_example.append(t)
    return " ".join(new_example)

df = pd.read_csv("Google_Climate_SouthKorea_tweets_Korean_New.csv")
example = df['Tweet'][16]


MODEL = f"cardiffnlp/twitter-roberta-base-sentiment-latest"
tokenizer = AutoTokenizer.from_pretrained(MODEL)
```

```
model = AutoModelForSequenceClassification.from_pretrained(MODEL)

#Running example on ROBERTA
encoded_text = tokenizer(example, return_tensors='pt')
output = model(**encoded_text)
scores = output[0][0].detach().numpy()
scores = softmax(scores)
scores_dict = {
    'Roberta_Neg' : scores[0],
    'Roberta_Neu' : scores[1],
    'Roberta_Pos' : scores[2]
}

def offensive_score_roberta(example):
    encoded_text = tokenizer(example, return_tensors='pt')
    output = model(**encoded_text)
    scores = output[0][0].detach().numpy()
    scores = softmax(scores)
    scores_dict = {
        'roberta_neg' : scores[0],
        'roberta_neu' : scores[1],
        'roberta_pos' : scores[2]
    }
    return scores_dict

print(scores_dict)


#Whole Data set on ROBERTA
res = {}
for i, row in tqdm(df.iterrows(), total=len(df)):
    text = row['Translation']
    myid = row['User']
    #roberta_result = hatespeech_scores_roberta(text)
    res[myid] = offensive_score_roberta(text)

print(pd.DataFrame(res).T)
pd.DataFrame(res).T.to_csv('Climate_NEW_Result_sentiment_korean.csv')
```

The Python code above, *Climate_sentiment_Korean.py*, is based upon a sample sentiment analysis code from Medallion Data Science's Code (2022) but is modified to process the dataset '*Google_Climate_SouthKorea_tweets_Korean_New.csv*' and

then output the results obtained through the code into a new dataset file filled with sentiment scores.

Running this code will give the paper a final dataset file, '*Climate_NEW_Result_sentiment_korean.csv*'. The paper will then use the obtained sentiment scores to sum and average approximate sentiment probability scores into 'Negative' 'neutral' 'positive' towards Carbon Neutrality 2050 (specifically 2050 탄소중립).

The paper edited and ran the codes in Microsoft Visual studio code V1.69.2. Moreover, the paper used GOOGLE SHEETS and Microsoft Excel 2019 to translate text and basic calculations.

6 Results and Observation

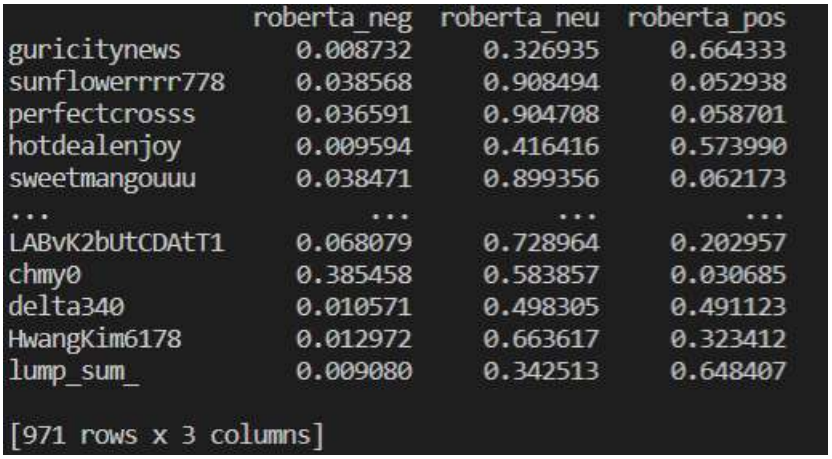
Running the code *Climate_tweets.py* mines and collects all the tweets which had '2050 탄소중립' in them. The result of running the code led to an output file/dataset file named '*Climate_SouthKorea_tweets_Korean_New.csv*', which obtained 2662 tweet messages from the Twitter search query[1].

The tweet messages inside the dataset are then translated using the translation function in GOOGLE SHEET and exported with a new file named *Google_Climate_SouthKorea_tweets_Korean_New.csv.* Next, the paper ran the Translated data file into the sentiment analysis code *Climate_sentiment_Korean.py*, which then created an output *Climate_NEW_Result_sentiment_korean.csv* which had a sentiment analysis score for all the tweets present in the *Google_Climate_SouthKorea_tweets_Korean_New.csv* dataset file. The result of the analysis leads to an outcome of a total of 971 results. It is to note that out of the 2662 results found in the initial data mining, only 971 results were in the final sentiment analysis. The duplication of texts could explain by a user who posted the same content repeatedly through their accounts which the 'RoBERTa' model ignored to reduce redundancy.

[1] All the Code Files and dataset files (CSV files) are available on GitHub for reference at:

The output in the Microsoft Visual Studio is as follows (Refer to Figure 1):

Figure 1 Output for Sentiment Analysis on the Dataset for Carbon Neutrality 2050 Tweets in Microsoft Visual Studio Code



	roberta_neg	roberta_neu	roberta_pos
guricitynews	0.008732	0.326935	0.664333
sunflowerrrrr778	0.038568	0.908494	0.052938
perfectcrosss	0.036591	0.904708	0.058701
hotdealenjoy	0.009594	0.416416	0.573990
sweetmangouuu	0.038471	0.899356	0.062173
...	...	...	...
LABvK2bUtCDAtT1	0.068079	0.728964	0.202957
chmy0	0.385458	0.583857	0.030685
delta340	0.010571	0.498305	0.491123
HwangKim6178	0.012972	0.663617	0.323412
lump_sum_	0.009080	0.342513	0.648407

[971 rows x 3 columns]

Referring to figure 1, the column contains the usernames of the people who typed the tweet. Column two with '*roberta_neg*' indicates the sentiment probability score of the tweet to be negative. Column three with '*roberta_neu*' indicates the sentiment probability score of the tweet to be neutral. Finally, column four with 'roberta_pos' indicates the sentiment probability score of the tweet to be positive. The python code of '*Climate_sentiment_Korean.py*' runs these sentiment probability scores on all the 971 cases and thus processes probability scores for all the tweets in the dataset.

The paper collected the scores and averaged the results of the final probability scores into Microsoft Excel 2019. The results are as follows (Refer to Table 2):

Table 2 Overall Sentiment score for All the tweets present in the Sentiment analysis Dataset

	'roberta_neg' Indicates the negative sentiment probability of the tweets towards Carbon Neutrality 2050	*'roberta_neu'* Indicates the neutral sentiment probability of the tweets Carbon Neutrality 2050	*'roberta_pos'* Indicates the positive sentiment of the tweets toward Carbon Neutrality 2050
Overall sentiment of the tweets	0.100432 (10.04%)	0.661987 (66.19%)	0.237581 (23.75%)
Total number of tweets: 971			

The paper summarises that 10.04% of all the tweets in the dataset are showing a probability of being negative towards ‘Carbon Neutrality 2050’. 66.19% of the tweets in the dataset show a probability of being neutral towards ‘Carbon Neutrality 2050’ and 23.75% of the tweets are positive towards ‘Carbon Neutrality 2050’.

7 Conclusion and discussion

Looking through the results, the paper can raise that most of the tweets obtained throughout the analysis are not negative towards the ‘2050 탄소중립’ or the Carbon Neutrality 2050 initiative or the announcement. Approximately 90% of the dataset shows positive or neutral sentiment towards the concept; however, the analysis also infers that while there is no positive majority sentiment towards Carbon Neutrality 2050 for the Korean tweets. The 90% neutral-positive probability score shows an optimistic stance that the South Korean public is concerned about the environment and that there is a positive leaning possibility of the population supporting environmental protection/improvement policies. In conclusion, the paper raises that the hypothesis proposed is inconclusive given that the majority of the tweets have a neutral sentiment probability score, but, given the Positive sentiment probability score is higher than the negative score, it is hopeful that sentiment may lean more towards positive sentiment than negative sentiment.

For policy implications, the paper suggests policymakers use the sentiment analysis data and design policies aimed at positive environmental actions. Policies which can accelerate the progress of South Korea toward Carbon Neutrality have a higher chance of support than being rejected by the public, and thus sentiment analysis gives an insight into the shade of the South Korean Public’s opinion towards Carbon Neutrality (at least on the Twitter Social media)

8 Limitations

The paper aimed to get an initial insight into how Koreans perceive the news of the Carbon Neutrality 2050 announcement and to introduce the possibility of sentiment analysis to track how Korean Public’s political stance could be understood in the digital age.

The sentiment analysis in this paper allowed technologies like Machine Learning Models and Data Mining to compute posts on the internet to understand the sentiments of people towards a topic. The paper used Twitter as a platform to analyse the sentiment of the Twitter user towards the topic of Carbon Neutrality 2050. It is to note that since the topic only uses Twitter as the platform for the analysis, the results might not necessarily be representative of the whole population. With South Korea's Twitter penetration rate at around 7% (Inquivix, 2022), the study does not represent the whole population. Future research is recommended with more sophisticated codes or models, or methods which can encompass a higher percentage of the population with their opinions included.

Another limitation is the consideration of language and region. The paper uses Korean Language Tweets to analyse sentiment. However, that does not necessarily restrict the paper to South Korea only. There could be chances where the foreign users or a foreign publication can publish in Korean Language and post their opinion. Thus, in order to focus the data mining results on a specific region, future research is recommended to improve the search algorithm to filter tweets according to their region.

Another thing to note is that the paper translated the Korean language tweets into English for the sentiment analysis model to process using GOOGLE TRANSLATE. However, the accuracy of Google Translate is not perfect (Wetsman, 2021). For future research, the paper recommends using Translator with higher accuracy or using a sentiment analysis model made specifically to process Korean texts.

Another limitation is that the Sentiment analysis model RoBERTa does not have a complete 100% accuracy in its analysis (Jose Camacho-Collados, 2020/2022). Therefore, the paper recommends using or implementing more accurate models to get a better depth of the sentiment and better accuracy during the analysis.

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