Modeling and Forecasting for the Growth of Carbon dioxide emission in India

A report submitted in the partial fulfillment of the requirement for the Award of the degree of

Master of Technology

Industrial and Systems Engineering

Submitted By

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CERTIFICATE

This is to certify that the project titled "**Modeling and Forecasting for the Growth of Carbon dioxide emission in India**" is a bonafide work carried out by ***Piyush Anand***, Roll no. 17QE30002, under my supervision and guidance. This report, in my opinion, is worthy of consideration for partial fulfillment of requirements for the degree of Master of Technology in Industrial and Systems Engineering in accordance to the regulations of this institute.

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1. Introduction

Harmful activities of human beings have increased the level of carbon dioxide in the atmosphere, thereby accelerating Earth's greenhouse effect. Despite global pandemic, average amount of carbon dioxide globally hit a new record high. The annual rate of increase in atmospheric carbon dioxide over the past 60 years is 100 times faster than previous natural increase. The oceans have absorbed enough carbon dioxide to increase their acidity by 30%.

Although India's percentage carbon dioxide emissions rose slower in years 2016-19 than in years 2011-15 but was much above the world average of 0.7%.

In 2020, when the Covid-19 pandemic shook economic growth of many countries, India's emissions fell 9.7%, a little more than the world average of 9.6%.
In 2020, lockdowns to tackle the COVID-19 pandemic cut global emissions of carbon dioxide by 2.6 billion tonnes.
However, few analysts believe 2020 was a special case when the emission of carbon dioxide actually came down that realistically it cannot continue for long as the world overwhelmingly relied on fossil fuels, and lockdowns as such are neither a sustainable nor desirable solution to the climate crisis.
Some of the chief sources of carbon dioxide emission are power generating plants, iron and steel industry, petrochemical industry, cement production, and transport

2. Research Objectives

Study the growth of CO_2 emission of India and forecast India's future CO_2 emissions. Suggest ways to reduce CO_2 emission in India.

3. Methodology Framework

In this project we compared two different forecasting techniques namely ARIMA and SeriesNet. ARIMA is a forecasting technique that explains a given time series based on its own past values, i.e, its own lagged values and the forecast errors of previously predicted values, so that equation can be used to forecast future values. The SeriesNet on the other hand consists of two networks. The LSTM network aims to learn connected features and reduces the dimensionality of multi-conditional data, and the dilated causal convolution network learns information from different time intervals. SeriesNet can learn multi-range and multi-level features from time series data, and has higher predictive accuracy compared to those models using fixed time intervals. Moreover, this model adopts residual learning and batch normalization to improve generalization.

4. Literature Review

In China, Sun found out that by 2010 CO2 emission in China would be approximately 1990 mega metric ton(s) by analyzed emission patterns for all 30 provinces using ARIMA models.

Lotfalipour predicted that the amount of carbon dioxide emissions will reach up to 925.68 million tons in 2020 in Iran by using ARIMA models over the period 1965 to 2010.

Basak & Nandi, analyzed the dynamics of CO2 emissions in India using a data set ranging over the period 1980 – 2000 by employing a Differential Model and revealed that CO2 emissions will increase in India over the period 2015 – 2020.

Rahman & Hasan, used time series data of from 1972 to 2015, based on and revealed that the ARIMA (0, 2, 1) model is the most suitable model for modeling and forecasting carbon dioxide emission in Bangladesh.

This project will compare SeriesNet and ARIMA models and ultimately make use of the ARIMA approach in modeling and forecasting CO2 emissions in India..

5. Materials and Methods

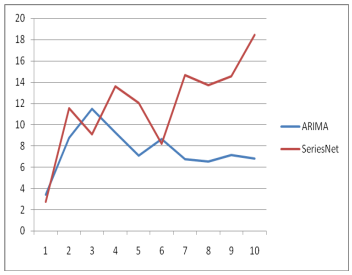
As mentioned above in this project two algorithms namely, ARIMA and SeriesNet were compared. They were compared using MAPE, SMAPE, AMAPE, MAE, RMSE measurement techniques. Both the algorithms were trained on similar training data and values were forecasted for different horizons. Values predicted by both the algorithms were compared and hence both the algorithms were evaluated. Ultimately, from the best performing algorithm future values of carbon dioxide emission of India were predicted.

6. The Data Collection

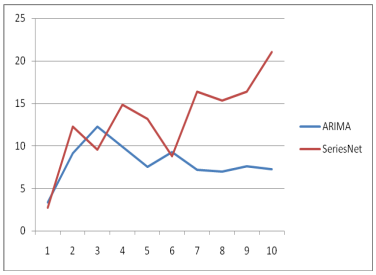
The data was collected from United Nation's website. The original dataset contained information about GDP, Crude Oil consumption, capital, labour, FDI, and Carbon dioxide emission of India from 1980 to 2019. We are interested only in information about Carbon dioxide emission.

7. Results and Discussion

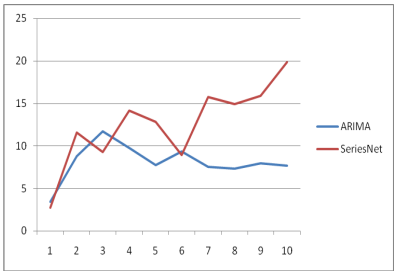
The predicted values from both the algorithms for different horizon(s) were compared with actual values and various forecasting error analyzing methods namely Mean Absolute Percentage Error (MAPE), Symmetric Mean Absolute Percentage Error (sMAPE), Adaptive Mean Absolute Percentage Error (AMAPE), Mean Absolute Error (MAE), Root Mean Squared Error (RMSE).
It was found that ARIMA performed better than SeriesNet for both small as well as big horizon. Therefore, we chose ARIMA over SeriesNet to predict future values of Carbon dioxide emission of India.



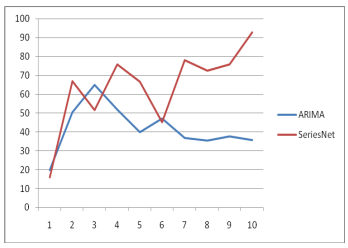
MAPE



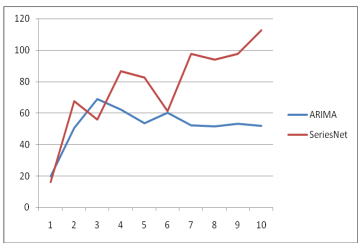
sMAPE



AMAPE



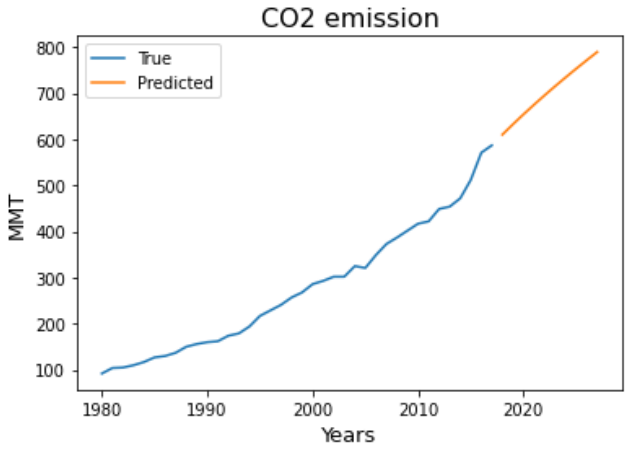
MAE



RMSE

8. Conclusions

After choosing ARIMA as the forecasting technique we predicted the future values of carbon dioxide emission of India for the next ten years. We observed that India's CO_2 emission will only go up which is a worrisome news. Our predicted values for the next 10 years in MMT are 610.19321918, 632.55312205, 654.15931252, 675.08379019, 695.39167681, 715.14187324, 734.38765376, 753.17720352, 771.55410472, 789.55777629 . A graph showing actual values and predicted values is shown below.



Hence, we urge strong action to be taken by the government to curb carbon dioxide emission.

Some of the steps government can take are as follows:-

1. It can switch to clean energy by reducing consumption of coal and investing heavily in solar energy to generate electricity.
2. It can run advertisements urging people to make their houses energy efficient and cutting upon unnecessary travels.
3. It can educate people about deforestation and its ecological damages and urge people to plant and look after trees.

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