UC San Diego

Executive Report on Carbon Bond Policy of Pullanta

Pullantalope[11]

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Contents

Chapter 1

Overview

This report analyzes the issue of greenhouse gas emission and explores how Pullanta can introduce a new policy for companies to effectively reduce greenhouse gas emissions, especially the carbon dioxide emissions, to 25% below 2018 by the end of the year 2030. This report provides a comprehensive proposal for a new environmental policy specifically oriented toward greenhouse gases, complete with long-term forecasts and other considerations. In the next decade with the implementation of environmental programs, Pullanta will not only be defined as an economically developed country, but it will also be defined as an environmentally developed country. This report seeks to identify all of these changes that occur during this transition and how Pullanta can design a policy that best addresses these impacts.

Over the decade, we will suggest Pullanta implement our green policy starting from January 1st, 2021. We provide a 10-year forecast of carbon emission and a revenue estimate for the bonds that we designed. A sensitivity analysis is performed to grasp which factors influence our model and how to react when the key factors, such as baseline model, expected issued bond number, interest rate, and carbon credit price, alter. We believe this report provides the most accurate solution to Pullanta given the data limitations and uncertainties. In order to bring a consensus conclusion, several assumptions are required to overcome the limitations and mitigate the uncertainties. We will give some important considerations in the report, but our main focus will be on the impacts of policy on Pullanta.

Chapter 2

Executive Summary

This report presents the opportunities for Pullanta to implement a comprehensive carbon credit program to reduce the level of carbon emission by year 2030 with great certainty. We will implement three ten-year carbon credit bonds in year 2021 that brings us revenue for our well-laid renewable investment plans. Our investments on technology will be of highest quality and meet best safety requirements.

We will create a brand new platform for companies to trade their carbon credits, a marketplace run with high technology level to promote utmost market efficiency, backed by our government, to maintain balanced supply and demand.

We conclude that by the end of year 2030, our carbon reduction goal can be achieved with ease in favorable conditions; even with unfavorable conditions, by our extended solution, there are possible measures for the Pullanta government to reach the carbon reduction goal.

Chapter 3

Assumptions

There are many complexities that drive policy making and market conditions. Here are our assumptions on our calculations.

I Interest Rates

- The interest rate of Pullanta has been and will continue to follow the US market's interest rate. With growing speculations on the Feds cutting rates again in year 2020, we expect the interest rate by year 2021 to be 1.5% and we assume it to stay constant until year 2030.

II Bond Issue

- The government will issue the bonds on 1st January, 2021 in the open market. Firms will buy the bonds according to their emissions level, and there are no profit/arbitrage opportunities for a firm to buy an excess amount of bonds and resell it in the secondary market.

III Carbon Credits

- We assume the price of carbon credits per metric tonnes issued in Pullanta to $18, equivalent to $\mathcal{P}$30, similar to the cost of carbon credits in US California with a price of $17[4]

IV Carbon Credit Allocation from United Nations

- The United Nations issued the same amount of carbon credits to Pullanta from 2021 to 2030, regardless of the price change for carbon credits.

V Secondary Market

- The secondary market functions as a medium for firms with excess carbon credits to trade with firms with a carbon credit deficit. The trade price is expected to be stabilized at $18 as the government takes the role of filling demand when there is excess supply and selling carbon credits when there is excess market demand, provided that the total carbon credits issued through the free market and the bond policy stays within our projection.

- We further assume that the Pullanta government can reliably buy and send carbon credits from their neighboring countries at a fair price, and there are no transaction and negligible administration cost for conducting these trades.

VI Trading with Neighboring Countries

- Each year, Pullanta is able to sell all the remaining carbon credits to neighboring countries at the price of $18 per carbon credit, equivalent to $\mathcal{P}$30 per carbon credit. The surplus from selling these carbon credits will be stored as reserves left for the monetary coupon payment for our bond holders.

VII Renewable Energy Investments

- We simplified the calculation by projecting a constant output in reducing carbon emissions through our renewable investments. We assume that Pullanta is a developed country with sufficient technology to utilize a portfolio of renewables, which decreases risk through diversification. Pullanta is a country that high prioritizes safety - ensuring that the technology is of finest quality with highest safety assurance, means that we assume our cost of technology is based on the highest (worst) price for each type of renewables.

Chapter 4

Baseline Forecast Model

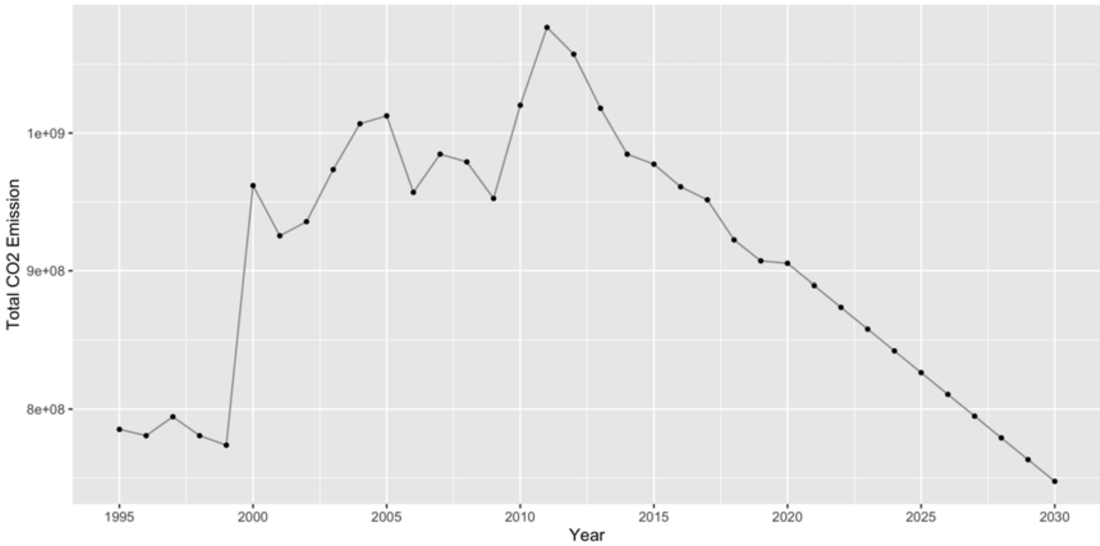
4.1 Baseline Trend

We used the ARIMA model to project the CO_2 emission from 2020 to 2030, based on the data from 2010 to 2019, since it represents the most recent and impactful data. We assume that there are no further events, which will significantly influence the trend of Pullanta's CO_2 emission, happen from 2020 to 2030. The ARIMA model was applied to each sector for prediction and we added up the forecast values for each sector to get the total CO_2 emission forecast.

CO_2 Emission Forecast from 2020 to 2030 is presented below:

Year	Lower Bound of 90% CI*	Decrease Rate	Prediction	Decrease Rate	Upper Bound of 90% CI*	Decrease Rate
2020	849,295,191		905,433,894		961,572,596	
2021	824,162,418	2.96%	889,642,687	1.74%	955,122,956	0.67%
2022	801,203,175	2.79%	873,851,480	1.78%	946,499,785	0.90%
2023	779,369,034	2.73%	858,060,273	1.81%	936,751,512	1.03%
2024	758,253,896	2.71%	842,269,067	1.84%	926,284,238	1.12%
2025	737,649,487	2.72%	826,477,860	1.87%	915,306,233	1.19%
2026	717,432,084	2.74%	810,686,653	1.91%	903,941,223	1.24%
2027	697,521,075	2.78%	794,895,447	1.95%	892,269,819	1.29%
2028	677,860,464	2.82%	779,104,240	1.99%	880,348,016	1.34%
2029	658,409,485	2.87%	763,313,033	2.03%	868,216,582	1.38%
2030	639,137,359	2.93%	747,521,827	2.07%	855,906,295	1.42%

*CI stands for confidence interval



According to the forecast model, the total CO_2 emission is 747,521,827 metric tonnes at the end of 2030, so the government policy has to reduce 55,691,029 metric tonnes more to reach 75% of 2018's CO_2 emission level. Since a decreasing trend already appears during the recent ten years, it's not surprising to see that the natural decrease, with an annual decrease rate of approximately 1.91%, takes account for 76% of the total reduction, while the government policy will take account for the remaining 24%.

Chapter 5

Bond Design

5.1 Grouping

It is a different challenge to implement our projections of the aggregate data into the company level. First, we filtered out companies that failed to report three or more emission data, and we used remaining companies as a relatively more complete set of data for finding baseline statistics. These companies are considered as reported companies, while the eliminated companies are unreported. We discovered that across the five years, omitting all 0 data for calculations, we expect a company to pollute 500,000 metric tonnes CO_2 per year. This statistics sharply contrasts with the median figure of 18,000 metric tonnes, since the histogram is heavily skewed to the left.

With the grouping of industry sectors, we found the energy and transportation sector to be much larger in their CO_2 emission size. We explored the possibility of dividing companies by their sector group, but it was not very effective. Based on the given aggregate company data, we found many similarities in each sectors' histogram of being skewed to the left. Then, we explored the possibility of sectoring companies based on their average emission quantity, and by numerous trail and errors, we came up with a distribution as such:

With our findings, we deemed most appropriate to segment the market according to the above table based on their CO_2 emission size, and we will issue three carbon credit bonds to fit the carbon credit needs of a small, medium and large sized companies. Companies with less than 10,000 metric tonnes emission per year will be granted free allocation, with further details discussed below.

Category	Overall Size among 1496 Companies	Approximate Percentile	CO_2 Emission(metric tonne)/Year
Small	1/3	0~33.33%	<10,000
	1/3	33.33~66.67%	10,000 ~ 50,000
Medium	4/15	66.67~93.33%	50,000 ~ 1,000,000
Large	1/15	93.33%~100%	>1,000,000

5.2 Free Allocation and Expected Number of Bonds Issued

I Data Preparation

We used a method called grandfathering to decide free allocation amount, which refers to the allocation of allowances based on past levels of emissions.[9] It's quite reasonable to use grandfathering here since we have company emission data for the past 5 years. Our assumption follows the key assumption of grandfathering, that the companies will emit the same percentage of total emissions as they previously emitted.[5]

As mentioned in previous section, companies with at least three non-zero data are considered as reported, while the remaining companies are unreported. For the reported companies, we use their latest valid data to project their 2021 emission by multiplying (1 - 1.91%)/year, which is an adjusting factor that is similar to the natural decrease rate based on ARIMA model forecast. For instance, if a company has valid 2019 data, the projection would be 2019 emission $\times(1-1.91\%)^2 = 2021$ emission. We choose to project each company's 2021 emission data because 2021 is the starting point of our 10-year bond program. For the unreported companies, since we don't have any additional information about them, we assume that they will only follow the nature decrease and not include them in the bond program. We also assume that the rate between unreported and reported emission is constant over the future ten years, which is approximately 20%, so that when we get the total reported emission, we could multiply it by 120% to get the total emission.

II Free Allocation

Each year, companies will receive some free allocation amount of carbon credits based on their sizes. Super small companies, which emit less than 10,000 metric tonnes per year, will receive a 100% free allocation rate, which means that the carbon credits they received could fully cover their projected 2021 emission amount. For the remaining companies, they will receive a 30% free allocation rate, which means that the will get 10,000 + (total emission - 10,000) * 0.3 carbon credits in total. While designing this policy, we notice that small companies, which is approximately 2/3 of all companies, only account for 1.4% of total emission. However, the large companies, which is approximately 1/15 of all companies, account for

85% of the total emission. Hence, it's meaningless to strictly regulate these small companies' emission, which may also seriously hurt their business. Our free allocation policy helps protect small companies and at the same time avoids giving other companies too much pressure on carbon emission reduction by 30% free allocation allowances.

III Expected Number of Bonds Issued
After calculating the projected 2021 emission and free allocation amount, finding out the expected number of bonds issued is much easier:

$$\text{Expected number of bonds} = round(\frac{\text{2021 emission} - \text{ free allocation}}{\text{2021 coupon payment}})$$

We used the round value to project the expected number of bond issued because we wanted to minimize the number of transactions on the secondary market. For instance, company with the carbon emission of 44,000 metric tonnes, then the company could purchase 4 bonds and they could satisfy extra 4,000 metric tonnes in the secondary market. It's a reasonable method, since the influence of rounding to expected value and standard deviation is almost negligible.[1]

We also calculate the expected number of bonds issued by changing round to round up/round down for future sensitivity analysis preparation.

5.3 Bond Setup

We formulate our bond similar to a federal issue bond, where the coupon rate is set close to the market interest rate and hence nearly identical to a par bond. Given the setting of Pullanta's interest rate equal that of United States' interest rate, we use the anticipated interest rate of 1.5% in year 2020 and assume the interest rate to stay constant till 2030, and use the same 1.5% as our fixed payment component for our coupons.

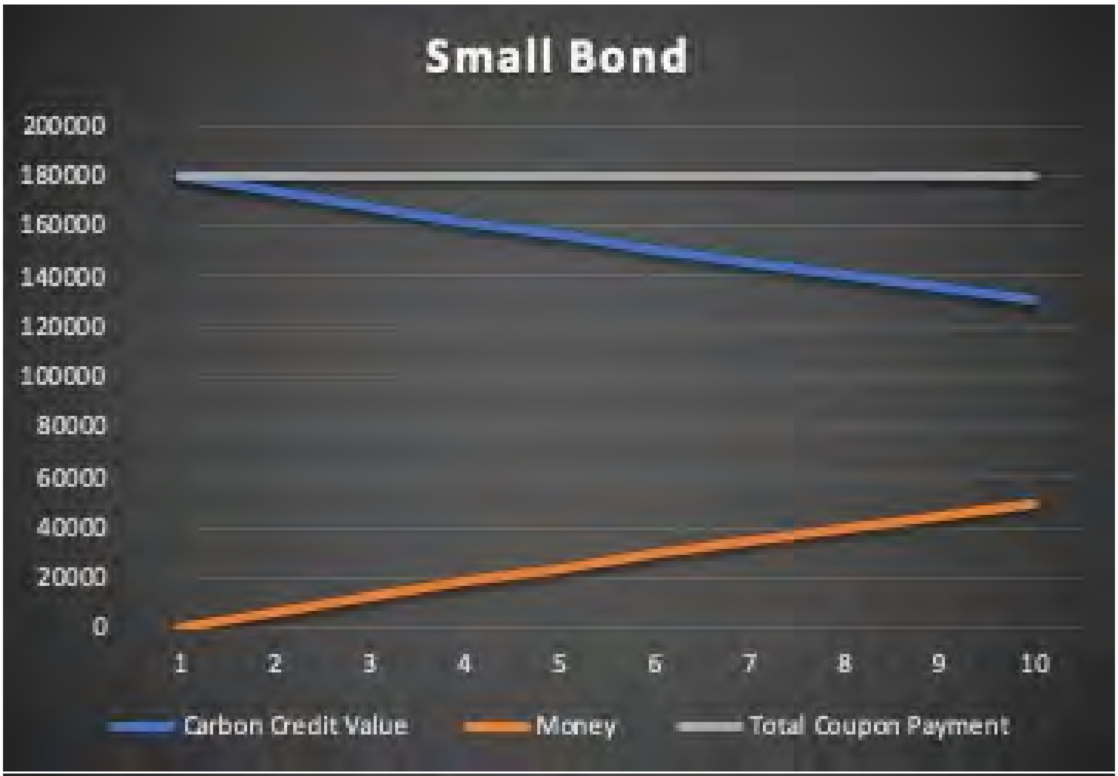
The nature of this bond is to provide carbon credits for a firm to consume for their pollution each year. We propose to issue 10-year bonds for all firms because we want to encourage firms to commit to a continuous effort in reducing carbon credit emissions. To do so, our coupon payment is specially designed with two components: per metric ton carbon credit and an equivalent cash value. We use the bond's coupon payment in the first year as the baseline, and in the subsequent years, we will be providing less carbon credits and making up for the loss portion through cash payment.

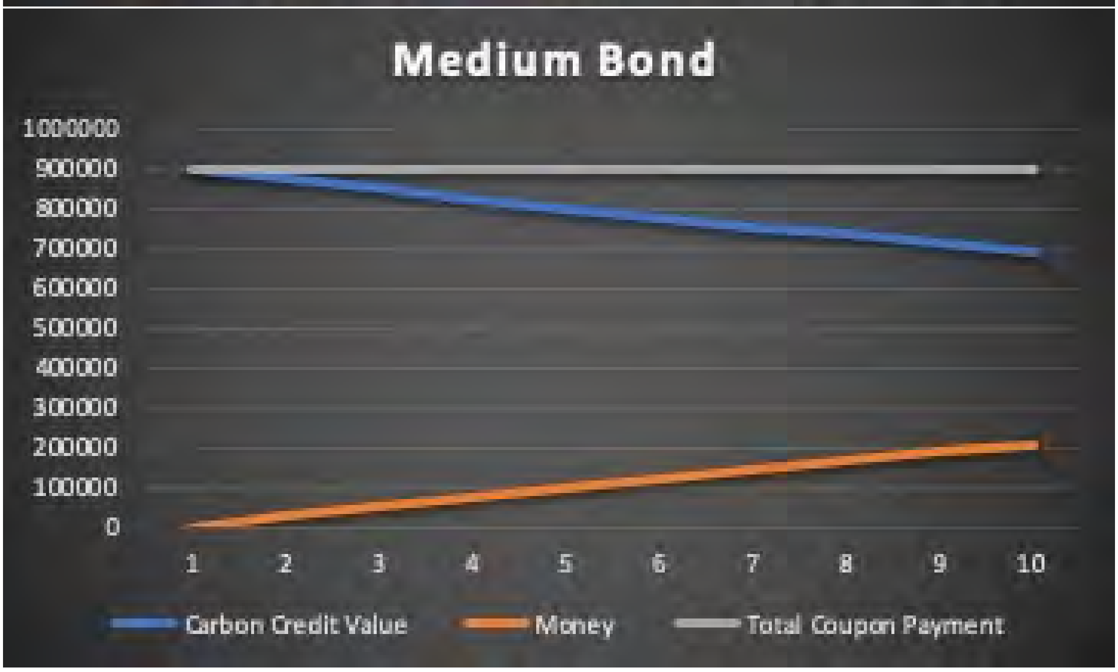
5.3.1 Carbon Credit Bond Payment Design

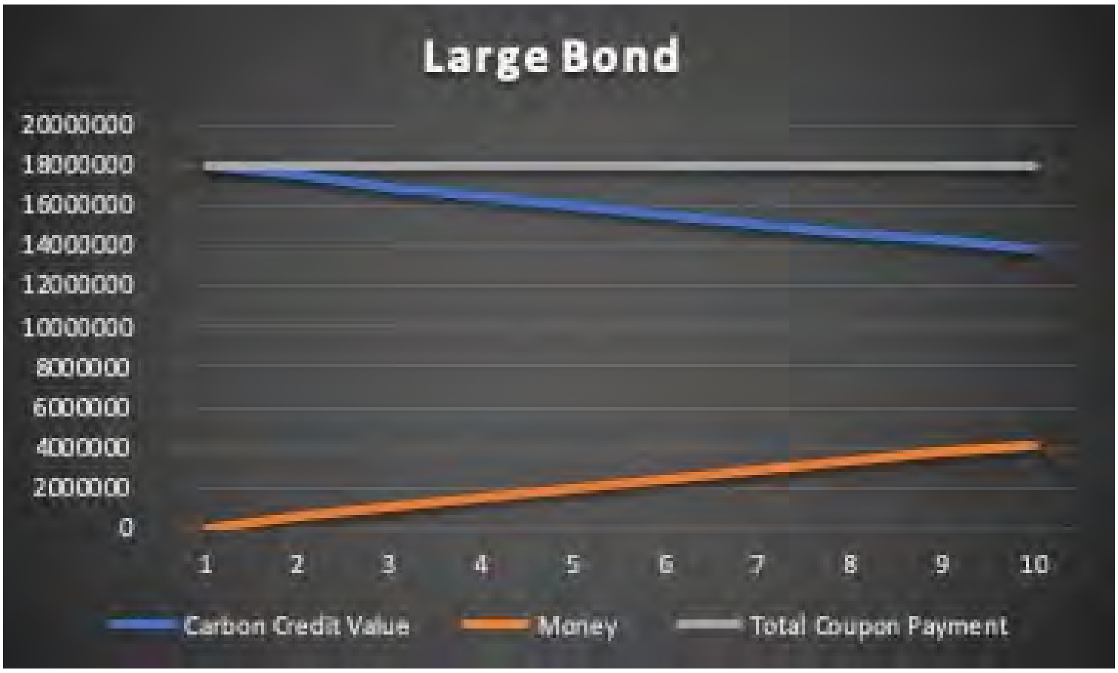
In order to effectively reduce carbon emission through our bonds, we designed our coupon payment to be a mix of carbon credits and cash. The value of total coupon payment is fixed. The cash paid each year equals the difference between total coupon payment value and carbon credit payment value. In year 1, the bond will pay only carbon credit for coupon payment(so that the cash payment is 0), then the carbon credit payment will gradually decrease at a rate of 2.86% every year. The explanation for why we chose 2.86% is in the section "Revenue and Expenses."

One of our assumptions is that the government can make profit out of selling excess carbon credit to the neighboring countries to pay off the coupon payment. However, in the case where Pullanta cannot sell excess carbon credit to the neighboring countries, the government does not have to concern about a default that it cannot pay the coupons to companies, because our profit, which has over 23 million dollars, can be saved as reserve and pay companies the annual coupon payments.

Carbon Credit Bond Payment by Year										
Small Bond										
Year	1	2	3	4	5	6	7	8	9	10
Carbon Credit	10,000	9,714	9,436	9,166	8,904	8,649	8,402	8,162	7,928	7,702
Cash(in Ᵽ)	-	42,900	84,573	125,054	164,378	202,577	239,683	275,728	310,742	344,755
Sum(in Ᵽ)	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000	300,000
Medium Bond										
Year	1	2	3	4	5	6	7	8	9	10
Carbon Credit	50,000	48,570	47,181	45,832	44,521	43,247	42,011	40,809	39,642	38,508
Cash(in Ᵽ)	-	42,900	84,573	125,054	164,378	202,577	239,683	275,728	310,742	344,755
Sum(in Ᵽ)	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000	1,500,000
Large Bond										
Year	1	2	3	4	5	6	7	8	9	10
Carbon Credit	1,000,000	971,400	943,618	916,630	890,415	864,949	840,211	816,181	792,839	770,163
Cash(in Ᵽ)	-	858,000	1,691,461	2,501,085	3,287,554	4,051,530	4,793,657	5,514,558	6,214,842	6,895,097
Sum(in Ᵽ)	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000	30,000,000


Small Bond
200000
180000
160000
140000
120000
100000
80000
60000
40000
20000
0
1 2 3 4 5 6 7 8 9 10
Carbon Credit Value
Money
Total Coupon Payment


Medium Bond
1000000
900000
800000
700000
600000
500000
400000
300000
200000
100000
0
1 2 3 4 5 6 7 8 9 10
Carbon Credit Value
Money
Total Coupon Payment



5.3.2 Pricing of Carbon Credits Bonds

Our policy will have a total of three bonds that are distinguished by the size of emission mentioned in the grouping. Bonds will be having the following characteristics:

I Small bonds
First Year Coupon Payment: 10,000 Carbon Credits
Face value: $18(10,000)/0.015 = $12,000,000 = ₱ 20,000,000

II Medium bonds
First Year Coupon Payment: 50,000 Carbon Credits
Face Value: $18(50,000)/0.015 = $60,000,000 = ₱100,000,000

III Large Bonds
First Year Coupon Payment: 1,000,000 Carbon Credits
Face Value: $18(1,000,000)/0.015 = $1,200,000,000 = ₱200,000,000

5.3.3 Implementation Example

T : Total Amount required by company
S : First Year Coupon Payment(in carbon credit)
Small : 10,000
Medium : 50,000
Large : 1,000,000
Z : Free Allocation Amount
Z = 0.3(T - 10,000) + 10,000
N: Expected Number of Bonds
N = Round value of (T - Z)/S
Y: The excess/deficit of carbon credit after buying bonds
Y = T - Z - N * S

Suppose that company X emits 25,000 metric tonnes of CO_2.

$$
\begin{aligned}
T &= 25,000 \\
Z &= 10,000 + 0.3 * (25,000 - 10,000) \\
&= 14,500 \\
N &= \text{Round Value of } \frac{25,000 - 14,500}{10,000} \\
&= 1 \\
Y &= 25,000 - 14,500 - 1 * 10,000 = 500
\end{aligned}
$$

So the company X needs additional 500 carbon credits. It is expected to buy them from the secondary market during the given buffer period.

Chapter 6

Revenue and Expenses

We want our bond holders to feel secure about their investments in our bond not defaulting. Our most challenging payout will be in the last year paying the face value, hence we will take no risk on that by matching the face value of the cash flows from buying a zero-coupon bond from the US treasury. For our base case, we are expected to earn 587,304 million USD (978,843 million $\mathcal{P}$) from our bond, and we need to invest in $587,304 \times (1.015)^{-10} \approx 506,061$ million USD (843,435 million $\mathcal{P}$). This makes up for the largest part (86%) of our revenue.

6.1 Aggregate Emission

Under the assumption that all of the reported companies buy the carbon credit bond, we projected Pullanta's carbon credit within bond decreases by 2.86% each year. This 2.86% came from the combination of 10-year projection of natural decrease of carbon emission , which is 1.91% each year, and 0.95% of decrease of carbon emission to successfully reach our goal of total of 25% decrease. Thus, we calculate the actual decrease, following this calculation , is 2%. To explain further, we only reduced 70% of the carbon credit and remained the 30% of free allocation. Now, when we calculate this equation, we can achieve less than 82% of 2018 total carbon emission. The remaining 7% will be decreased by the green technology that we will be implemented through the revenue of the bond. We originally did not intend to vary the available carbon credits by industry sector, because carbon emissions are widely dispersed within the same sector. Therefore, we chose to use the number of available carbon credits based on the size of carbon emission, not on the industry sector. Since we will distribute free allocation, which is 30% of total carbon dioxide of 2018, Pullanta will allow a single entity to emit 30% of 2018 carbon emission.

6.2 Frequency and Limits (expiration of Carbon Credit)

Each company is capped to buy the round-up expected number of bonds. We assume that they buy carbon credit bonds that best meets their carbon emission needs. Any company that attempts to cheat the system and only buy carbon credits off the secondary market will be penalized.

We propose a model similar to US tax reporting for carbon credits. Companies will receive their coupon at the end of each year and there is a 6-month buffer period for them to make a payment proof to the government after they sell/buy carbon credits on the secondary market. For instance, a company received payment on Dec 31, 2022. The company must have proof of owning that much carbon credits to match their corresponding year 2022 emission level, before June 30, 2023. During this 6-month period, companies could buy and sell carbon credits on the secondary market if there is a deficit or a surplus.

6.3 Social Cost of Carbon

In 2017, the U.S. government estimated that the social cost of one ton of carbon dioxide is $46 in 2017 dollars. It is to say that the social cost of one metric ton of carbon dioxide is about $41.73 in 2017 dollars.[8]

6.4 Secondary Market

As we mentioned above, there will always be extra supply of carbon credit and extra demand of carbon credit, who purchased more and less bonds. Moreover, Pullanta will set the price for the secondary market to have full control over the greenhouse gas reduction policy. In this setting, the government will not receive any revenue from the carbon credit sales on the secondary market. Our purpose of having the secondary market is to satisfy those in need of carbon credit and those in need of selling excess carbon credit.

Following table is the estimated transaction will occur:

Demand	Excess Supply
13,033,669	28,055,489

6.5 Legal Consequences

Please refer to Chapter implementation plan, section legal framework.

6.6 Neighbor Carbon Credit Trade

Assuming Pullanta is under the UNCC (United Nations Climate Change), Pullanta will involve in the transaction with other countries. UNCC stated that “emissions trading, as set out in Article 17 of the Kyoto Protocol, allows countries that have emission units to spare - emissions permitted them but not "used" - to sell this excess capacity to countries that are over their targets.[10] When Pullanta successfully reduce their carbon emission below their target, then Pullanta can sell their excess carbon credit to other neighbor countries to produce profit.

Chapter 7

Government Renewable Technology Investment

7.1 Interpreting the Biocapacity and Ecological Footprint

By definition, the biocapacity is the supply of goods from environmental landscapes and ecological footprint is the demand for goods from those landscapes. A balanced biocapacity and ecological footprint could promote sustainable development and should be targeted.

Considering the fact that the real world overload, on average, 80% of the biocapacity, it is surprising that Pullanta has a larger biocapacity of forests than its ecological footprint. For other environmental landscapes, not surprisingly, Pullanta has a larger ecological footprint than its biocapacity.

This suggests that Pullanta produces forest products more than it needs. This might suggest that growing trees to absorb carbon dioxide is not a preferred strategy, considering the sustainable development of Pullanta's economy based on its biocapacity and ecological footprint. Therefore, among all ways the revenue could be used, investing on forest seems to not be one of the effective ways.

7.2 Profit Amount

Our revenue comes from selling carbon credit bonds to companies and selling the remaining carbon credits of the government to neighboring countries.

The revenue generated from selling carbon credit bonds is 646 billion. Since the government need to pay back the face value to companies, the present value of the profit is

$$\begin{aligned}\text{Profit} &= \text{Revenue} - \text{ PV of Cost of paying back Face Value} \\ &= 646 \text{ billion} - 556,375 \text{ million} \\ &= 89,321 \text{ million}\end{aligned}$$

One additional thing to address here is the money contained in the carbon credit bond' coupon. Although each year the government needs to pay companies a certain amount of money, the government makes up by selling remaining carbon credit to neighboring countries, the amount of which is equal to the money that the government payout to companies. Such balance assures that we don't need to deduct anything else from the profit anymore, so the actual money that the government can use to reduce CO2 emission is 81,243 million.

7.3 Investment in Renewable Technology and Effects

Assuming that Pullanta is a developed country and have 2 million people predicted in 2019, it should have similar cost per MWh for each renewable technology as the US.

In order to calculate the effect of investment on carbon dioxide emission, we need to first find the total energy of pullanta in MWh. By using our total revenue to divide cost per MWh for each renewable technology, we can get how much energy use in pullanta can be changed to Green energy. Then the same portion of total carbon dioxide emission can be reduced assuming that green energy does not produce carbon dioxide. Thus, we will get how much carbon dioxide emission can be reduced by a certain amount of revenue. In the following parts, I will show how we achieve it step by step.

7.3.1 Calculate the total energy emission of Pullanta

In the given table, we have data of the population of Pullanta in 2019 which is 200 million and we have the energy per capita in equivalent of oil in 2019 which is 23303 kg. By multiplying these two factors, we can get the total energy of Pullanta in oil equivalent: $4.6606 \times 10^1 1$ oil kg. Then we need to translate energy in oil kg to MWh. We know that one barrel of oil can produce 1700 KWh energy, one barrel of oil equals 136.4 kg of oil and one MWh is 1000 KWh. Through following calculation:

$$4.6606 \times 10^{11} kg \times \frac{1 \text{ barrel}}{136.4 \text{ kg}} \times \frac{1700 \text{ KWh}}{1 \text{ barrel}} \times \frac{1 \text{ MWh}}{1000 \text{ KWh}}$$

We get the total energy of Pullanta in 2019 is 5,808,005,689 MWh.

7.3.2 Calculate the total energy that can be produced by investing all the revenue to a certain type of renewable energy

By doing research, we have the cost for each renewable technology as follows:

Method of Renewable Energy	Cost per KWh in Dollar
Solar PV	143
Wind Offshore	212.9
Geothermal	53.4
Wind Onshore	75.6
Hydro	69.8
Nuclear	104.3

This cost is calculated based on the total cost of installation and maintenance across its lifespan. The formula is from the following website.[6]

$$\mathrm{LCOE} = \frac{\text{sum of costs over lifetime}}{\text{sum of electrical energy produced over lifetime}} = \frac{\sum_{t=1}^{n} \frac{I_t + M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}}$$

I_t : investment expenditures in the year t

M_t : operations and maintenance expenditures in the year t

F_t : fuel expenditures in the year t

E_t : electrical energy generated in the year t

r : discount rate

n : expected lifetime of system or power station

However, it is the average cost across its lifespan. We need to find out the average cost within ten years. In order to do so, we need to figure out the average lifespan of each green energy power plant. Then, by using total revenue dividing the average cost of each different Green energy per MWh, we can get the total energy that can be produced by investing all the money to Green energy i. The following is formula.

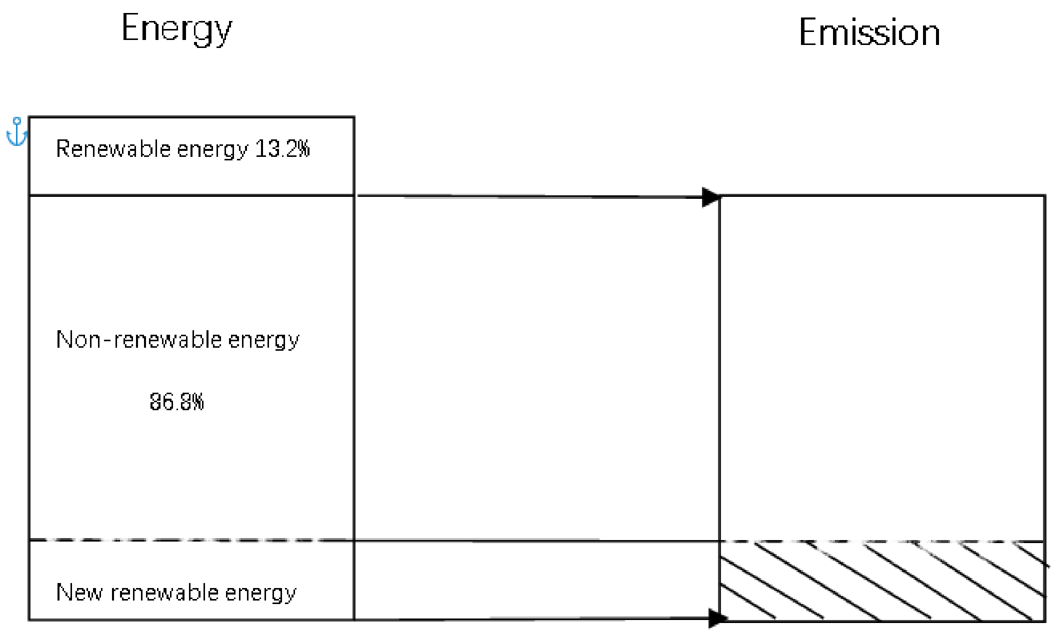
$$\frac{\text{Total Revenue}}{\text{cost per MWh}_i \times \frac{\text{Average Lifespan}_i}{10}} = \text{Total energy in WMh}$$

Then, we get the total energy that can be produced by investing all the money to a certain type of Green energy.

Method of Renewable Energy	Energy Produced Using Revenue
Solar PV	206,594,757
Wind Offshore	169,601,562
Geothermal	507,137,254
Wind Onshore	477,621,329
Hydro	116,394,539
Nuclear	222,554,138

7.3.3 Build a relationship between energy produced and carbon dioxide emission

Assume that all the carbon dioxide emissions are produced by non renewable energys and there is a linear relationship between the total amount of carbon dioxide produced and the amount of total non-renewable energy. Also, from the given data, we know that in Pullanta, the non-renewable energy takes 86.8% of total energy. The following graphs illustrate the relationships.



As a result, the following is the amount of carbon dioxide emission by investing all the money to a certain type of Green energy.

Method of Renewable Energy	CO_2 Reduction
Solar PV	37,172,205
Wind Offshore	30,516,090
Geothermal	91,248,251
Wind Onshore	85,937,506
Hydro	20,942,650
Nuclear	40,043,747

7.3.4 Create an investment portfolio

Since not every country has a coastline, we assume that the investment to wind onshore should be a small amount which is 10%. Also, the Geothermal, Hydro, and Nuclear have limitations too. So, we allocate different proportions to them separately as follows.

Method of Renewable Energy	Percent Usage	Total CO_2 Reduction
Solar PV	0.35	13,010,272
Wind Offshore	0.2	6,103,218
Geothermal	0.1	9,124,825
Wind Onshore	0.1	8,593,751
Hydro	0.1	2,094,265
Nuclear	0.15	6,006,562

The total CO_2 emissions that can be reduced by \$81 billions revenue, equivalent to $\mathcal{P}$135 billions, are 44,932,892. In addition, we can make reserves if we do not need to reduce as much as 45 millions CO_2.

Chapter 8

Risk Management

8.1 Sensitivity Analysis

Our above calculations are made based on thoroughly considered assumptions, but in reality their values could defer from our original estimates. Our next section consists of our sensitivity analysis to evaluate the impactfulness of our bond and investments in reducing carbon emissions, and the potential change to our surplus accounts.

We identified three main factors related to our bond offer: market interest rate, total bonds sold in the market, and carbon credit price. We will discuss each change individually.

I Interest Rate Adjustment
Since we are issuing a par bond with equal interest rates and coupon rates, our face value of the bonds will simultaneously be adjusted to reflect the same level of coupon payments. Our calculations show that there is a small change in total profit from bonds due to interest rate changes, whether it is an increase or decrease. However, this could present as a challenge for firms without sufficient cash flow to buy bonds when there are lower interest rates.

II Total Bonds Sold in Market

- Our base calculations rounded the expected number of bonds that a firm will buy based on their need after subtracting their projected free allocation. Our sensitivity analysis here attempts to understand the extreme cases.

- The case of rounding down total bonds sold: if all firms are more aggressive in estimating the cost and believe that they could reliably buy carbon credits off the secondary market, we predict their behavior to buy a rounddown amount of bonds they need. Our model shows that our carbon credit bond will be very effective in this scenario; however the expected CO2 reduction calculation here is obviously overestimated without taking into account of more emission to be compensated with carbon credits off the secondary market. With reference to our assumption on secondary market, the government effectively has more control over the reduction amount by setting the amount of carbon credits they sell in the market each year. There is more leeway in managing the investment and reserve balance.

- The case of rounding up total bonds sold: if all firms are unconfident about their ability to reduce, or unwilling to buy carbon credits off the secondary market for cash flow reasons, we predict their behavior to buy more bonds than what they need to fully cover their required carbon credits. This situation creates more challenges than the former - our model shows that our carbon bonds are unsuccessful in directly decreasing carbon emission, hence shifting the goal of reducing emissions on renewable investments from bond profits, and with our calculations using expensive technology based on our assumptions, we will come up short.

III Carbon Credit Price

- Our research suggests that carbon credit prices fluctuate over time, and assuming that our economy in the next 10 years is stable, we expect the price to be staying within the range of the past 10 years, so we set our price to be \$ $18 \pm 10USD(30 \pm 16.67\mathcal{P})$ for our sensitivity analysis.[3]

- The bond's impact remains the same, but the bond prices would drastically change. Our bond profits will decrease when there is a decrease in carbon credit price, but our model shows that even with the decrease our goal is still attainable.

Next page contains a table that summarizes all the relevant data for sensitivity analysis.

Sensitivity Analysis for CO_2 Emission							
	Base case	Scenario 1		Scenario 2		Scenario 3	
Variable Values	N/A	Interest Rate		Number of Bonds Issued		Carbon Credit Price	
Natural Decrease Rate	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%	1.91%
Adjustment Rate	98.09%	98.09%	98.09%	98.09%	98.09%	98.09%	98.09%
Interest Rate	1.50%	1.25%	1.75%	1.50%	1.50%	1.50%	1.50%
Carbon Credit Price(₱)	₱30	₱30	₱30	₱30	₱30	₱13.33	₱46.67
Number of Bonds Issued							
Small Bond	565	565	565	457	693	565	565
Medium Bond	1456	1456	1456	1308	1625	1456	1456
Large Bond	410	410	410	377	451	410	410
Expected Bond Price(₱)							
Small Bond	20,000,000	24,000,000	17,142,857	20,000,000	20,000,000	8,888,889	31,111,111
Medium Bond	100,000,000	120,000,000	85,714,286	100,000,000	100,000,000	44,444,444	155,555,556
Large Bond	2,000,000,000	2,400,000,000	1,714,285,714	2,000,000,000	2,000,000,000	888,888,889	3,111,111,111
Expected Bond Revenue(₱)	978,840,000,000	1,174,608,000,000	839,005,714,286	893,940,000,000	1,085,100,000,000	435,040,000,000	1,522,640,000,000
Expected Bond Profit(₱)	135,405,646,901	137,216,618,692	133,629,615,566	123,661,194,874	150,104,886,858	60,180,287,512	210,631,006,291
Required Total CO_2 Reduction(metric tonne)	55,691,029	55,691,029	55,691,029	55,691,029	55,691,029	55,691,029	55,691,029
Expected CO_2 Reduction from Bond(metric tonne)	35,699,689	35,699,689	35,699,689	67,646,068	-3,370,701	35,699,689	35,699,689
Required CO_2 Reduction from Revenue(metric tonne)	19,991,340	19,991,340	19,991,340	-11,955,039	59,061,730	19,991,340	19,991,340
Expected CO_2 Reduction from Revenue(metric tonne)	44,833,739	45,443,599	44,255,650	41,035,624	49,501,281	19,930,595	69,757,082
Available Reserves	71,168,149,354	72,979,121,146	69,392,118,020	159,687,805,608	-27,878,131,128	-4,057,210,035	-4,057,210,035

Out of the three factors, we can conclude that the total bonds sold in the market is the most impactful, followed by carbon credit price, and finally interest rate adjustment. Here is a brief summary of our analysis and followed recommendations:

Factor	Risk Impact	Recommendation
Interest Rate	Low	Our bond program is quite safe against interest rate risks.
Carbon Credit Price	Medium	When carbon credit prices become very low, the total bond profit is barely enough to cover the renewable investment costs, hence in this situation, the government can impose transaction fees in the carbon credit secondary market to generate more revenue. When the carbon credit prices go up, we see a surge in the pricing of the bonds, and individual firms might be challenged to pay that price. We suggest providing financial aid that gives priority small and medium firms with a proven financial difficulty to purchase the carbon credit bonds beginning year 2021.
Total Number of Bonds Issued	High	The government should not sell carbon credit bonds to the point where it loses its effectiveness to decrease (using the roundup number). We recommend the number of each type of bonds to be issued in between the rounded and rounddown number. Within the secondary market, the government has more control in reaching the goal by slightly under providing bonds, and fill the market demands of carbon credit if necessary.

8.2 Extended Solution

In this section, we discuss three more scenarios that change fundamental variables and propose our corresponding solutions.

8.2.1 Scenario 1

In this scenario, our baseline projection will be 789 million carbon emission in year 2030, and our target decrease is 97.48 million carbon emission. If we use the same per year decrease of carbon credit of r=2.86%, the firms will have a high likelihood of missing their annual goals, so the r has to be loosened. We found that using r=2.05%, a similar amount of aggregate carbon emission decrease will occur from the contribution of bonds, meaning that this is a more achievable goal by the firms. What that leaves, however, is that there is more to be completed by the renewable investment component. The budget is impossible with our original assumptions.

8.2.2 Scenario 2

This is the situation where we need to relax our constraint on renewable energy costs - we expect that the government will take more aggressive measures on investments, hence managing to lower their renewable investment costs to the average level. With the improved costs, the renewable investments can cover enough carbon reduction to reach the goal of decreasing 97 million carbon emission.

8.2.3 Scenario 3

We provide another possibility to have a safe amount for reserves as well. If we set our carbon credit decrease rate to r=2.3%, not only will we manage to reach our goal of carbon reduction, but we can maintain a net positive of available reserves in case we need to fall back on the safety net of cash coupon payouts as well.

Next page contains a table that summarizes all the relevant data for these three scenarios.

Extended Solution			
Scenario	1	2	3
r (Carbon Credit Decrease Rate)	0.0205	0.0205	0.023
Interest Rate	0.015	0.015	0.015
Number of Bonds Issued	0		
Small	659	659	659
Medium	1,479	1,479	1,479
Large	415	415	415
Carbon Emission Model Natural Decrease	0.0124	0.0124	0.0124
Adjustment Rate	0.9876	0.9876	0.9876
Carbon Credit Price	30	30	30
Expected Bond Price			
Small	20,000,000	20,000,000	20,000,000
Medium	100,000,000	100,000,000	100,000,000
Large	2,000,000,000	2,000,000,000	2,000,000,000
Expected Bond Revenue	991,080,000,000	991,080,000,000	991,080,000,000
Expected Bond Profit (deduct FV)	137,098,839,985	137,098,839,985	137,098,839,985
Expected CO_2 Reduction from Bond	56,330,945	56,330,945	71,916,256
Expected CO_2 Reduction from Bond Profits	75,824,600	108,332,497	108,332,497
Required CO_2 Reduction from Bond Profits	106,137,531	106,137,531	90,552,221
Total Required CO_2 Reduction	162,468,477	162,468,477	162,468,477
Available Reserves	(54,808,962,133)	2,777,811,484	22,501,606,558
Cash Coupon Payout Needed	12,990,612,150	12,990,612,150	14,479,766,274

8.3 Data Limitations

Although a large data set was given, there are still many limitations that prevent us from generating more accurate decisions. Here is a table that summarizes data limitations and our corresponding assumptions.

Data Limitations	Corresponding Assumptions	Justification
Incomplete information for company data	Use data with at least 3 years of emission data	This provides a relative large dataset where companies included have reliably reported their data
Companies with zero emission data	We assume that companies with missing data will report, and companies that have misreported to follow regulations and report the accurate emissions level	Strict law enforcement, harsh punishments and random inspections by government officials will disincentivize unethical behaviors.
There is no data or explanation about why carbon emissions in Pullanta historically has sharp increases or decreases	We use past ten years of data (2010~2019) for our baseline model projection	They are the most relevant information for making future projections.

Chapter 9

Implementation Plan

We advise the government authority to issue this complete policy change in a public press at the earliest time possible in 2020. Between year 2020 and the beginning of year 2021, we have four main goals, as discussed below in detail.

9.1 More Concise Data Collection

We need to collect unreported, missing data from firms and the Department of Environmental Concerns database, confirm closed firms, and punish firms that are reporting false data. Data offer means for the government to understand situations and make appropriate policies. Currently, We choose to use company data where firms have reported at least 3 out of 5 years on their emission.

9.2 Promote Renewable Energy Sources

The government will go all out on promoting sustainability and encouraging firms to switch into renewable energy. There are two schemes that we plan to launch from the beginning of year 2021 to strengthen the social mission of reducing carbon emissions:

- Sustainable Free Carbon Credit Programme

- In order to achieve CO2 emissions reduction goal by 2030, the government will promote renewable energy usage. This strategy was founded by the Japanese government. Tokyo Cap-and-Trade program implemented this strategy in 2008. So, for the companies, which implement renewable energy to produce electricity that sustains their company to be functionable, the government will deduct companies' carbon emission. To give a simple illustration, if a company's building could produce electricity through solar panels, then by 1000 kWh x CO_2 emission factor for electric power(0.489kgCO_2/KWh) x 1.5 will be deducted from the company's carbon emission. By using this strategy, the government could expect the rapid growth of the green policy, which will lead the government to successfully achieve the goal by 2030.

9.3 Set up Carbon Credit Trading Secondary Market

Our goal is to set up a platform for firms to trade carbon credits. The platform will be secured by implementing blockchain technology for trading. Under the Department of Environmental Concerns, the government will form the Carbon Credit Secondary Market(CCSM) to monitor, regulate, and promote the Carbon Credit trading among companies. Moreover, the government will have professionals monitoring the trading platform to prevent any fraudulent trades.

9.4 Establish Legal Framework

9.4.1 Regulation

During this one year period, Pullanta's government will let companies do self-audit on violation of environmental laws, offering owners the opportunity to find, correct and self-disclose any existing violations.[7] Starting from 2021, more strict regulations would be implemented to further prevent violations. For unintendedly violations, the Department of Environmental Concerns will take civil administrative actions such as sending notice of violation letter, an order directing a business to take actions to come into compliance, as well as properly fining companies based on the severity of violation. For intendedly violations, civil judicial actions, or even criminal actions will be taken, which may lead to both fines and imprisonment.

9.4.2 Raising public awareness

The Pullanta's Department of Environmental Concerns will try to raise public's awareness of complying existing environmental laws through different ways, such as regular advertisement and promotion on business conferences. By doing so, the government wishes to reduce the amount of violations such that the actual CO_2 emission could stay within the target amount.

Chapter 10

Conclusion

We recommend that Pullanta implements a carbon reduction policy by 2021 to achieve a goal of 25% carbon reduction by year 2030 to make Pullanta greener than before. Our analysis has illustrated the possibility of successful carbon reduction utilizing 3 bonds and green technology investestment. Furthermore, the policy has shown that Pullanta can go beyond green after 2030 using all the instruments that Pullanta has built over the decade. After 2030, Pullanta will be more than just an economically developed country, it will become a front-running world example of thriving with sustainability.

Chapter 11

Appendix

11.1 R Code to Produce Ten-Year Forecast

```
setwd("/Users/zhaoruidi/Desktop/SOA Case Study Competition")
library(readxl)
library(forecast)
library(ggplot2)


#Load data
my_data <- read_excel("pullanta.xlsx", sheet = "R")

#####Building & Land Use#####
BL_emission <- my_data$‘Buildings & Land Use‘[c(16:25)]
BL_ts <- ts(BL_emission, start = 2010, end = 2019, frequency = 1)
#ARIMA prediction
BL_model <- auto.arima(BL_ts, trace = TRUE)
BL_forecast <- forecast(BL_model, level = c(90), h=11)

#####Energym, Manufacturing & Construction######
EMC_emission <- my_data$‘Energy, Manufacturing & Construction‘[c(16:25)]
EMC_ts <- ts(EMC_emission, start = 2010, end = 2019, frequency = 1)
#ARIMA prediction
EMC_model <- auto.arima(EMC_ts, trace = TRUE)
EMC_forecast <- forecast(EMC_model, level = c(90), h=11)

#####Industrial Process & Producti Use######
IPU_emission <- my_data$‘Industrial Processes & Product Use‘[c(16:25)]
IPU_ts <- ts(IPU_emission, start = 2010, end = 2019, frequency = 1)
```

```
#ARIMA prediction
IPU_model <- auto.arima(IPU_ts, trace = TRUE)
IPU_forecast <- forecast(IPU_model, level = c(90), h=11)

#####Other######
Other_emission <- my_data$`Other`[c(16:25)]
Other_ts <- ts(Other_emission, start = 2010, end = 2019, frequency = 1)
#ARIMA prediction
Other_model <- auto.arima(Other_ts, trace = TRUE)
Other_forecast <- forecast(Other_model, level = c(90), h=11)

#####Transport######
Transport_emission <- my_data$Transport[c(16:25)]
Transport_ts <- ts(Transport_emission, start = 2010, end = 2019,
    ↪ frequency = 1)
#ARIMA prediction
Transport_model <- auto.arima(Transport_ts, trace = TRUE)
Transport_forecast <- forecast(Transport_model, level = c(90), h=11)

#####Waste######
Waste_emission <- my_data$`Waste`[c(16:25)]
Waste_ts <- ts(Waste_emission, start = 2010, end = 2019, frequency = 1)
#ARIMA prediction
Waste_model <- auto.arima(Waste_ts, trace = TRUE)
Waste_forecast <- forecast(Waste_model, level = c(90), h=11)

#Calculate the total CO2 emission
Total_2030 <- Waste_forecast$mean[11] + IPU_forecast$mean[11] +
    ↪ Transport_forecast$mean[11] + Other_forecast$mean[11] +
    ↪ BL_forecast$mean[11] + EMC_forecast$mean[11]
Total_2029 <- Waste_forecast$mean[10] + IPU_forecast$mean[10] +
    ↪ Transport_forecast$mean[10] + Other_forecast$mean[10] +
    ↪ BL_forecast$mean[10] + EMC_forecast$mean[10]
Total_2028 <- Waste_forecast$mean[9] + IPU_forecast$mean[9] +
    ↪ Transport_forecast$mean[9] + Other_forecast$mean[9] +
    ↪ BL_forecast$mean[9] + EMC_forecast$mean[9]
Total_2027 <- Waste_forecast$mean[8] + IPU_forecast$mean[8] +
    ↪ Transport_forecast$mean[8] + Other_forecast$mean[8] +
    ↪ BL_forecast$mean[8] + EMC_forecast$mean[8]
Total_2026 <- Waste_forecast$mean[7] + IPU_forecast$mean[7] +
    ↪ Transport_forecast$mean[7] + Other_forecast$mean[7] +
    ↪ BL_forecast$mean[7] + EMC_forecast$mean[7]
```

```
Total_2025 <- Waste_forecast$mean[6] + IPU_forecast$mean[6] +
    ↪ Transport_forecast$mean[6] + Other_forecast$mean[6] +
    ↪ BL_forecast$mean[6] + EMC_forecast$mean[6]
Total_2024 <- Waste_forecast$mean[5] + IPU_forecast$mean[5] +
    ↪ Transport_forecast$mean[5] + Other_forecast$mean[5] +
    ↪ BL_forecast$mean[5] + EMC_forecast$mean[5]
Total_2023 <- Waste_forecast$mean[4] + IPU_forecast$mean[4] +
    ↪ Transport_forecast$mean[4] + Other_forecast$mean[4] +
    ↪ BL_forecast$mean[4] + EMC_forecast$mean[4]
Total_2022 <- Waste_forecast$mean[3] + IPU_forecast$mean[3] +
    ↪ Transport_forecast$mean[3] + Other_forecast$mean[3] +
    ↪ BL_forecast$mean[3] + EMC_forecast$mean[3]
Total_2021 <- Waste_forecast$mean[2] + IPU_forecast$mean[2] +
    ↪ Transport_forecast$mean[2] + Other_forecast$mean[2] +
    ↪ BL_forecast$mean[2] + EMC_forecast$mean[2]
Total_2020 <- Waste_forecast$mean[1] + IPU_forecast$mean[1] +
    ↪ Transport_forecast$mean[1] + Other_forecast$mean[1] +
    ↪ BL_forecast$mean[1] + EMC_forecast$mean[1]

Total_2030_upper <- Waste_forecast$upper[11] + IPU_forecast$upper[11] +
    ↪ Transport_forecast$upper[11] + Other_forecast$upper[11] +
    ↪ BL_forecast$upper[11] + EMC_forecast$upper[11]
Total_2029_upper <- Waste_forecast$upper[10] + IPU_forecast$upper[10] +
    ↪ Transport_forecast$upper[10] + Other_forecast$upper[10] +
    ↪ BL_forecast$upper[10] + EMC_forecast$upper[10]
Total_2028_upper <- Waste_forecast$upper[9] + IPU_forecast$upper[9] +
    ↪ Transport_forecast$upper[9] + Other_forecast$upper[9] +
    ↪ BL_forecast$upper[9] + EMC_forecast$upper[9]
Total_2027_upper <- Waste_forecast$upper[8] + IPU_forecast$upper[8] +
    ↪ Transport_forecast$upper[8] + Other_forecast$upper[8] +
    ↪ BL_forecast$upper[8] + EMC_forecast$upper[8]
Total_2026_upper <- Waste_forecast$upper[7] + IPU_forecast$upper[7] +
    ↪ Transport_forecast$upper[7] + Other_forecast$upper[7] +
    ↪ BL_forecast$upper[7] + EMC_forecast$upper[7]
Total_2025_upper <- Waste_forecast$upper[6] + IPU_forecast$upper[6] +
    ↪ Transport_forecast$upper[6] + Other_forecast$upper[6] +
    ↪ BL_forecast$upper[6] + EMC_forecast$upper[6]
Total_2024_upper <- Waste_forecast$upper[5] + IPU_forecast$upper[5] +
    ↪ Transport_forecast$upper[5] + Other_forecast$upper[5] +
    ↪ BL_forecast$upper[5] + EMC_forecast$upper[5]
Total_2023_upper <- Waste_forecast$upper[4] + IPU_forecast$upper[4] +
    ↪ Transport_forecast$upper[4] + Other_forecast$upper[4] +
    ↪ BL_forecast$upper[4] + EMC_forecast$upper[4]
```

```
Total_2022_upper <- Waste_forecast$upper[3] + IPU_forecast$upper[3] +
    ↪ Transport_forecast$upper[3] + Other_forecast$upper[3] +
    ↪ BL_forecast$upper[3] + EMC_forecast$upper[3]
Total_2021_upper <- Waste_forecast$upper[2] + IPU_forecast$upper[2] +
    ↪ Transport_forecast$upper[2] + Other_forecast$upper[2] +
    ↪ BL_forecast$upper[2] + EMC_forecast$upper[2]
Total_2020_upper <- Waste_forecast$upper[1] + IPU_forecast$upper[1] +
    ↪ Transport_forecast$upper[1] + Other_forecast$upper[1] +
    ↪ BL_forecast$upper[1] + EMC_forecast$upper[1]

Total_2030_Lower <- Waste_forecast$lower[11] + IPU_forecast$lower[11] +
    ↪ Transport_forecast$lower[11] + Other_forecast$lower[11] +
    ↪ BL_forecast$lower[11] + EMC_forecast$lower[11]
Total_2029_Lower <- Waste_forecast$lower[10] + IPU_forecast$lower[10] +
    ↪ Transport_forecast$lower[10] + Other_forecast$lower[10] +
    ↪ BL_forecast$lower[10] + EMC_forecast$lower[10]
Total_2028_Lower <- Waste_forecast$lower[9] + IPU_forecast$lower[9] +
    ↪ Transport_forecast$lower[9] + Other_forecast$lower[9] +
    ↪ BL_forecast$lower[9] + EMC_forecast$lower[9]
Total_2027_Lower <- Waste_forecast$lower[8] + IPU_forecast$lower[8] +
    ↪ Transport_forecast$lower[8] + Other_forecast$lower[8] +
    ↪ BL_forecast$lower[8] + EMC_forecast$lower[8]
Total_2026_Lower <- Waste_forecast$lower[7] + IPU_forecast$lower[7] +
    ↪ Transport_forecast$lower[7] + Other_forecast$lower[7] +
    ↪ BL_forecast$lower[7] + EMC_forecast$lower[7]
Total_2025_Lower <- Waste_forecast$lower[6] + IPU_forecast$lower[6] +
    ↪ Transport_forecast$lower[6] + Other_forecast$lower[6] +
    ↪ BL_forecast$lower[6] + EMC_forecast$lower[6]
Total_2024_Lower <- Waste_forecast$lower[5] + IPU_forecast$lower[5] +
    ↪ Transport_forecast$lower[5] + Other_forecast$lower[5] +
    ↪ BL_forecast$lower[5] + EMC_forecast$lower[5]
Total_2023_Lower <- Waste_forecast$lower[4] + IPU_forecast$lower[4] +
    ↪ Transport_forecast$lower[4] + Other_forecast$lower[4] +
    ↪ BL_forecast$lower[4] + EMC_forecast$lower[4]
Total_2022_Lower <- Waste_forecast$lower[3] + IPU_forecast$lower[3] +
    ↪ Transport_forecast$lower[3] + Other_forecast$lower[3] +
    ↪ BL_forecast$lower[3] + EMC_forecast$lower[3]
Total_2021_Lower <- Waste_forecast$lower[2] + IPU_forecast$lower[2] +
    ↪ Transport_forecast$lower[2] + Other_forecast$lower[2] +
    ↪ BL_forecast$lower[2] + EMC_forecast$lower[2]
Total_2020_Lower <- Waste_forecast$lower[1] + IPU_forecast$lower[1] +
    ↪ Transport_forecast$lower[1] + Other_forecast$lower[1] +
    ↪ BL_forecast$lower[1] + EMC_forecast$lower[1]
```

```
#Combine previous given data and prediction data
forecast <- c(Total_2020, Total_2021, Total_2022, Total_2023, Total_2024,
    ↪  Total_2025, Total_2026, Total_2027, Total_2028, Total_2029,
    ↪ Total_2030)
previous <- c(my_data$Total)
combine <- c(previous, forecast)
combine_ts <- ts(combine, start = 1995, end = 2030, frequency = 1)

#Plot it and save
df <- data.frame(year = c(1995:2030), emission = combine_ts)
tiff("baseline.tiff", units="in", width=10, height=5, res=300)
ggplot(data = df, aes(x = year, y = emission, group = 1)) +
  geom_line(color = "grey61", linetype = "solid") + geom_point(size = 1) +
  xlab("Year") + ylab("Total CO2 Emission") +
  scale_x_continuous(breaks = seq(1995,2030,5))
dev.off()
```

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