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THE IMPACT OF CHINA –EMISSION TRADING SYSTEM POLICY EFFECTIVENESS ON ECONOMIC AND FUTURE FORECAST: EVIDENCE FROM PILOT CITY

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ABSTRACT

China ETS is a system that is implemented in 7 regions in China which called pilot areas, including Shanghai, Beijing, Tianjin, Chongqing, Hubei, Guangdong and Shenzhen, which aiming at reducing GHG emissions or, more specifically, CO2 gas by limiting the production of carbon gas from each emitter (cap) the difference between the emission level and the value of the cap is called a trade (trade). By using panel data and Linear Regression we analyze the impact of China-ETS policy on China Economic growth (GDP) while at the same time analyze the carbon price trend which is one of the factor of the ETS system succeed. The result showing that ETS policy effectively impacts on reducing carbon emission, and there have corelation between carbon price and the carbon amount, Lastly, using ARIMA model on forecasting the carbon amount within 10 years.

KEYWORDS China-ETS; Carbon price; GDP ; Carbon Emission

INTRODUCTION

China as the world most populous country, 1.4 billion peoples in 2020 (imf.org.2020), with a fast economy growth, made it becoming the largest energy consumer and producer in the world. In the midst of Covid-19 pandemic issue, China could keep the

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growth of GDP in 2020 by 2.3% (imf.org.2020), even though this value is not as much high as the previous year. In 2020, China's carbon emission was decreased around 1.4% from the previous year (Marshall.2021) due to Covid-19 outbreak. But compared to the world data, China still become the largest carbon emitter (28%) in the world surpassing the United States (15%) due to the growing development of their industry (Friedlingstein et al.2020). Starting on 2013, China was started to implement the national ETS"Emission Trading System's to limit and reduce CO_2 emissions in a cost-effective manner, which suitable with other policies such as: energy conservation standards, air pollution standards, power market reform and capacity retirement plans. This policy will initially adopted to some cities and provinces, such as Beijing, Shanghai, Tianjin, Chongqing ,Shenzhen, Guangdong, and Hubei provinces as the top7 provinces account for two-thirds of the country's CO_2 emissions emitter from coal-fired power plants and the "big five" state owned power companies by capacity account for 50% (IEA.2020)

By this 7 years of ETS implementation in China, many researchers had study the impact of the China's ETS implementation both for environment and economic aspect. Yu et al (2017) used the data envelopment analysis model (denoted as DEA) to analyze the potential benefits of the ETS and found that it generated a 21.0% average potential environmental benefit and a 92.0% average potential economic benefit for industry. Another study from Zhu et al (2020) combined the PSM-DID model with the DEA model and discussed the impacts of the ETS on green development efficiency in China. Their conclusions show that the ETS has a significant positive impact of 4.25% on green development efficiency. While the study from Zhang et al (2020) shows the different conclusion with the two previous studies where the carbon emission in pilot ETS China is reduced by 14.5% in line with GDP fell by 4.8% using combination of PSM-DID model measurement. They analyze that the GDP reducing is comes from the declined of production in the included of industrial subsectors.

Based on these data, almost all of the studies found that the ETS had a significant inhibitory impact on carbon emissions, but the conclusions related to economic effect were different. However, the application of China's ETS will gradually checked by National Development and Reform Commission (NDRC) for the achievement goal. This program will help China to set the best strategy for reducing the negative impact on the climate while at the same time maintaining the life standard as well as supporting the growing population and avoid economic losses.

RESEARCH METHOD

The aim of this study is to measure the effect of China ETS implementation on economic growth (economic effect) and CO_2 emission (environmental effect) by assessing the trend of the effectiveness of ETS implementation in the term of carbon emission reduction, economic impact on pilot city, the impact on economic, and predicting the promising future forecasting. In this study we set ETS implementation in Shanghai, Beijing, Tianjin, Chongqing, Hubei, Guangdong, and Shenzhen as the independent variable that compared to some dependent variable such as: the carbon (CO_2) amount, carbon price, GDP, GDP per capita, and carbon amount per capita of each city. Then we assess the relation of each variable both in city scale and national scale. In city scale, we assess the trend impact of ETS implementation in carbon amount, carbon price, and GDP of each city annually. In national scale we assess the trend impact of ETS implementation in carbon amount, GDP, and forecast of ETS trend in the future annually.

The selection of 7 pilot region as the variable in this study was related to the China strategy of ETS implementation that using these 7 pilot region samples as the representation of the highest emission contributor city around the country (35% of the total amount). The

other consideration was come from some aspects such as: the geographical locations of each city (spread over China), the carbon emissions of each city (energy production from industry activities), and gross economies (advance industrialization) that make different value representation, and the fact that all pilot cities were follow the principle of "invigorating the large ones while relaxing the small one" which can cover sectors that possibly strong development endowments and great emission reduction potential (Zhang et al, 2014; Wang et al, 2018).

The data used in this study were collected from the year of 2000 until 2019 by taking on the Carbon Emission Accounts & Datasets for emerging economies (CEADs) database for the carbon amount of each city; World Bank Dashboard for the carbon pricing of each city; GDP each city; Our World in Database for the carbon amount per capita of national China; World Bank Data for GDP per capita of national China. The collected data then statistically processed using a mathematical software (Minitab, Origin, Microsoft Excel) to measure the trend of each variable relation. Here we used some statistical method that suitable to the function needed of each method and the goal set of each study variable.

RESULT AND DISCUSSION

1. Effectiveness of ETS Implementation

The ETS implementation in China was initially started at the end of 2013 in 7 pilot areas. This scheme be expected to reduce the carbon (CO_2) emission in China as the largest country of carbon contributor in the world. The effectiveness of ETS implementation could be seen by the decreasing of carbon emission amount per capita.

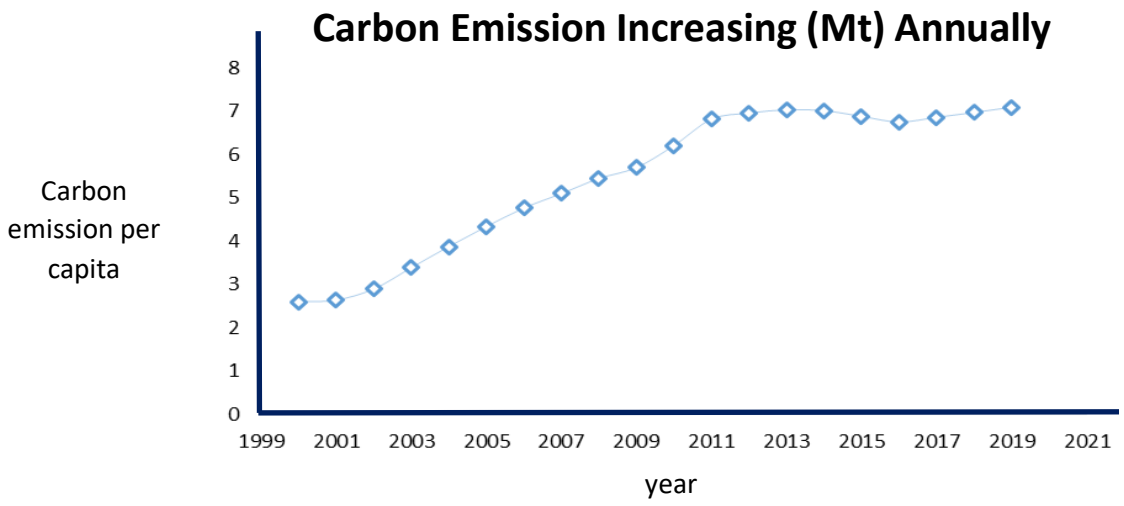

Figure 1. Annual China Carbon Emission

Breaking down to city scale, the trend of decreasing carbon emission after ETS implementation also captured in each city carbon amount, especially for the 7 pilot cities as a treatment city. The scatterplot diagram in figure 2 shows a negative effect between carbon emission amount by the year after ETS implementation.

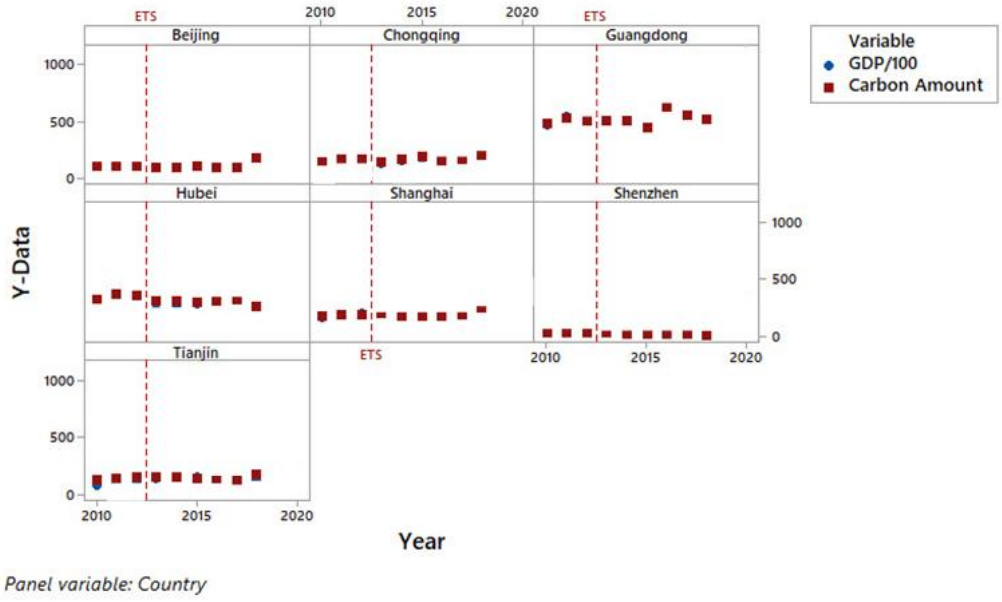

Figure 2. Carbon emission of 7 pilot areas in China before - after ETS implementation

The graph shows that almost all of areas are undergoing a decreasing of carbon emission amount at the first year of ETS implementation (in 2013), but only Guangdong didn't following this trend. This anomaly is happened because as we know that Guangdong is the largest industrial city in China which much industry activity is supported from a high energy source from non-renewable energy. To fulfil its industrial needs, Guangdong keep built a power generation where the total installed power capacity is keep increase from 71 GW in 2010 to 103 GW in 2013. The emissions from power sectors are the largest and relatively concentrated, which accounted for 54% because the power sector in Guangdong still use coal, crude oil and fossil-fueled energy. But after ETS policy implemented, the power sector in Guangdong is started to change their strategy by develop some renewable and nuclear energy uses. Besides that, they implement the environmentally friendly technology to mitigate carbon emission by installing a carbon capture and storage (CCS) technology in the machine (Zhao et al, 2013).

Then to making sure the effectiveness of ETS implementation in China, then we compared carbon amount value of 7 pilot areas (treatment) with other city (controlled) spanning from 2000 – 2020. We use t-test: "paired two sample for means" method to analyse the result, as below:

Table 1. t-test carbon amount emission of pilot city vs other city

	Pilot city	*Other city*
Mean	157.7786435	298.2098446
Variance	1993.661513	15155.25143
Observations	20	20

Pearson Correlation	0.966559311
Hypothesized Mean Difference	0
df	19
t Stat	-7.775969377
P(T<=t) one-tail	1.27443E-07
t Critical one-tail	1.729132792
P(T<=t) two-tail	2.54886E-07
t Critical two-tail	2.09302405

Based on t-test result, there is a deviation of mean carbon emission between pilot and other cities. It could be seen from the p-value which is lower than alpha (5%). The deviation value is about 47.1% (as shown in figure 5.3), where the carbon emission mean of pilot city is 157.77, while for other cities is 298.21. The deviation value is showing a significant deviation between the carbon emission in pilot city and other cities, means that the ETS effectiveness is satisfying to implement in China.

2. Impact on Economy

Generally on implementing a new ploicy in some are will bring impact to those area, especially the economic sector of those area, since economy is one of the main sources that regulate the cycle of life. Likewise, the implementation of ETS has also had a significant impact on the economic system in 7 pilot cities. To analyze the effect of ETS implementation in the economic aspect of each city, we process the data of GDP (gross domestic product) as one of indicator of the economic succession that compared to carbon emission produced.

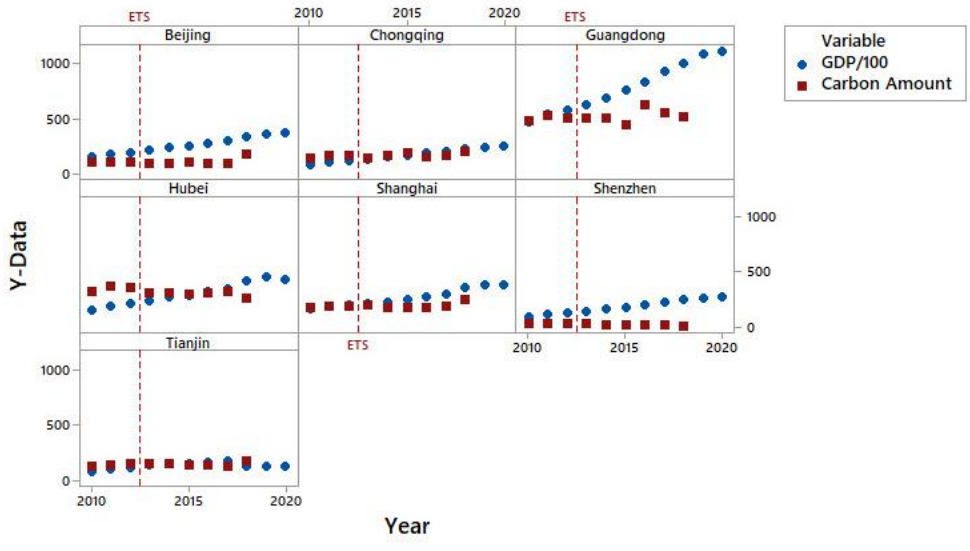

Figure 4. GDP value of 7 pilot areas compared to carbon emission in China before - after ETS implementation

Based on the scatter plot in figure 5.4 above, it can be seen that there is an opposite relationship between GDP value with the carbon emission amount, where the decreasing of carbon emission amount after ETS implementation mainly effected on increasing GDP value in almost all areas. It shows that the ETS implementation not only positively impact in environmental aspect, but also in economical aspect. Based on economy growth theory - Schumpeter Theory (Langroodi, 2017), innovation becoming an important thing should be upgraded continually to make an economy country keep growth in other to be survive and win the economic goal. Here, ETS becoming a strategy implemented by China to strengthen the country economic by look deeper on untouched factor yet like environment issue. ETS not only can cut the amount of carbon emission off, but further more, it will earn more money from saving energy by the limitation carbon emission producing implementation. It's legalistic with the other economic growth theory from Harrod Domer (Thong et al, 2019) saying that a country should backing up its income to replace, or, even add the fund for the next business, so the economy cycle could keep rotating, further more to broaden up the coverage area business.

From the scatter plot in figure 5.4 too, it can be seen that from the 7 pilot cities that being treated for ETS Implementation, Guangdong became a city that produced the largest carbon amount, while the least one was Shenzhen, in the same trend with GDP achievement. It because……...

To looking more detail, here is the descriptive statistics of the variables are given in the following table:

Table 2. Research variable descriptive statistics

Pilot	Variable	ETS	N*	Mean	StDev	Minimum	Median	Maximum
Shanghai	Carbon Amount	-	-	194	6,58	187	195	200
		1	2	202	27,40	188	190	257
	GDP	-	-	18.848	1.538,00	17.166	19.196	20.182
		1	-	30.274	6.693,00	21.818	29.406	38.701
Beijing	CarbonAmount	-	-	98	4,39	94	97	103
		1	2	104	32,00	85	93	169
	GDP	-	-	17.059	2.033,00	14.964	17.189	19.025
		1	-	28.793	5.716,00	21.135	28.462	36.103
Tianjin	Carbon Amount	-	-	149	11,04	137	152	158
		1	2	155	13,42	141	154	180
	GDP	-	-	11.142	1.840,00	9.224	11.307	12.894
		1	-	15.580	1.921,00	13.363	15.084	18.549
Chongqing	Carbon Amount	-	-	156	12,36	142	160	165
		1	2	163	18,87	140	157	192
	GDP	-	-	9.941	1.775,00	8.065	10.161	11.595
		1	-	18.997	4.303,00	13.028	19.045	25.003
Hubei	Carbon Amount	-	-	355	26,90	324	368	374
		1	2	306	17,57	272	310	325
	GDP	-	-	19.283	3.156,00	15.968	19.632	22.250
		1	-	35.145	7.886,00	24.792	34.072	45.828

		1	2	520	57,70	444	508	618
	GDP	-	-	52.008	5.608,00	45.945	53.073	57.008
		1	-	87.239	18.214,00	62.503	86.906	110.761
Shenzhen	Carbon Amount	-	2	39	*	39	39	39
		1	7	21	*	21	21	21
	GDP	-	-	11.829	1.716,00	10.069	11.923	13.496
		1	-	21.795	4.726,00	15.234	21.983	27.670

N* : missing value

Based on the above table, in the column * there are 2 data for the carbon amount variable in the ETS period from each pilot area data are not available, due to constraints from the data sources obtained on 2019 and 2020. Then there is a carbon amount data emptiness for Shenzhen as much as 9 out of a total of 11 data resulting in no statistical significance for this row, so that the characteristics of the Shenzhen data cannot be interpreted.

Based on the mean column for the carbon amount variable, it can be seen that between the mean before the implementation of ETS and afterwards almost all increased, except for Hubei which fell from 355 to 306. However, based on the median carbon amount column, almost all countries decreased, except for Tianjin and Guangdong with a decrease of 2 and 3 units. Meanwhile, for the GDP column, all countries experienced an increase in the mean and median between before the implementation of ETS and after. Simple analysis like this cannot be used as a benchmark for whether these two variables have increased or decreased during the implementation of ETS because only few data is used. Then it is necessary to do further research.

Because there are several missing values, the mean imputation method will be used to overcome them. Of the 7 countries, only 6 will be used in this study because the carbon amount of Shenzhen has a missing value of> 50%, it will be removed from this study to avoid irrelevant results. Imputation is done by entering the average carbon amount of each pilot area in the period after the implementation of ETS, which can be seen in the table above.

The purpose of this study was to determine how the effect of ETS policy implementation on environmental and economic conditions in China. Since there are two main response variables, carbon emissions and GDP, this effect is measured by the carbon amount per unit of GDP. The method used to see the effect of ETS policies on environmental and economic conditions is simple linear regression. The following is the process carried out in linear regression analysis.

3 Regression equation model

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Regression Equation

ETS
0    Carbon/GDP = 0,009316 - 0,000000 GDP + 0,000028 Carbon Amount

1    Carbon/GDP = 0,007819 - 0,000000 GDP + 0,000028 Carbon Amount
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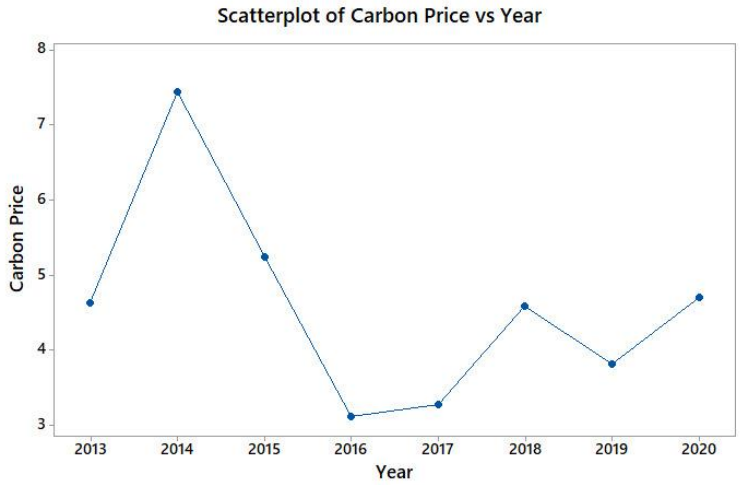
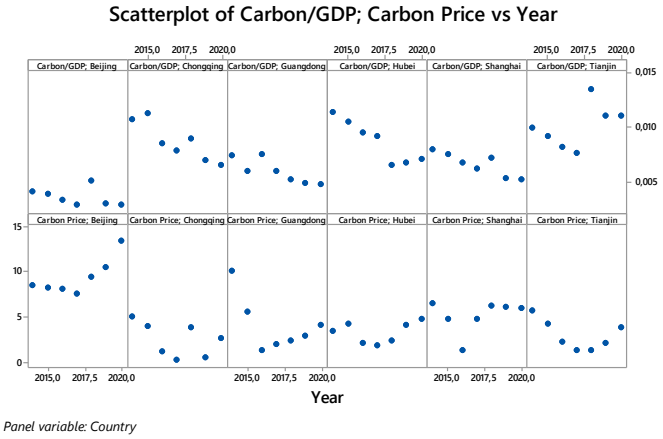
It can be seen that the coefficient after the ETS implementation is smaller, although only slightly different. So indeed the implementation of this ETS has a good impact on the environment and improves the economy in China.

4 Economical Impact in Pilot City



Graph 5.xx Carbon price

Carbon prices are determined by supply and demand, this can be seen in the fluctuations shown in Figure 6. Currently China's carbon market is starting to be interactive like other commodities such as oil, gas, and gold. Several other things that affect China's market price, of course various global economic events and the entity's expectations of future environmental regulations whether to be more stringent or not will affect the entity's decision. In addition, carbon prices can also stimulate the industry to commit to reducing emissions in practice the industry will switch or replace to the renewable / environmentally friendly energy rather than buy the carbon with the high price.

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Pearson correlation of Carbon/GDP and Carbon Price = -0,536
P-Value = 0,000
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Graph 6.xx

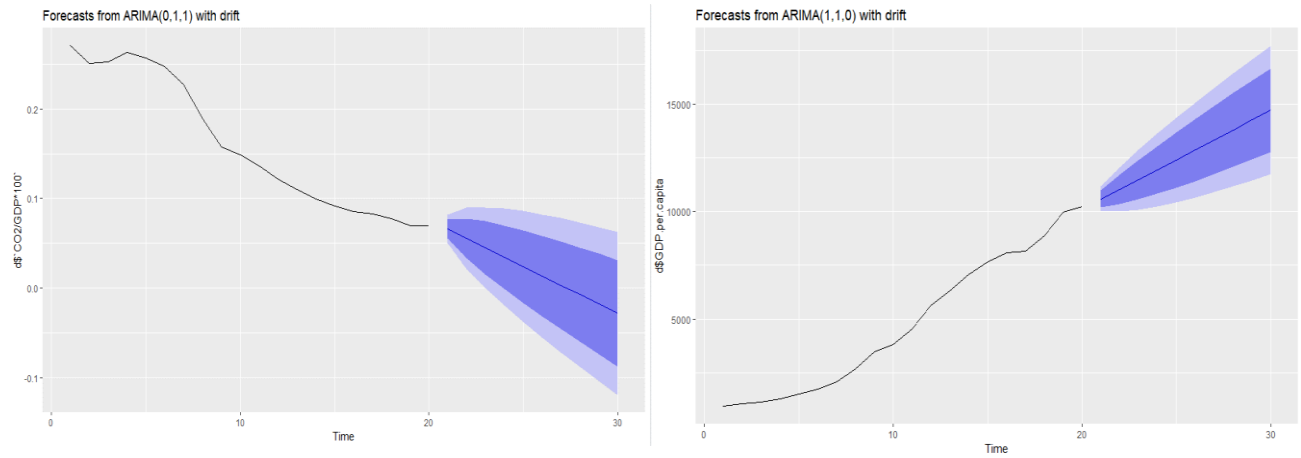
Based on the results of the Pearson correlation test, it states that the p-value is 0,000 which is less than 0.05 and the correlation coefficient value is more than 0.5. So it can be

concluded that there is a strong correlation between carbon prices and environmental and economic conditions in China, which in this study is shown by the value of the amount of carbon per unit of GDP. The correlation given is negative, which mean that the greater the price of carbon, the lower the carbon amount per GDP

4.5 The Future CO2 Emission in China

For forecasting we use data from 2000-2019. We process this data using the ARIMA method. Based on the graph, there will be a reduction in CO_2 / GDP emissions in the future. Starting in 2020 there will be more ground for reducing CO_2 emissions in entities that have been involved in ETS and the number of entities involved in ETS is also increasing with ETS coverage that has begun to enter the public sector such as transportation, residential buildings, airlines and offices. So that CO_2 emissions are decreasing.

In addition, there will also be many innovations to reduce CO_2 emissions such as the waste power plant in Shenzhen, photovoltaics on the roof of residential buildings, CCS technology (carbon capture storage). The entity is also expected to invest in modernizing their obsolete power plant. Because the investment value of a new power plant will make more sense than having to buy carbon.



GDP for the next year will increase. Because the ETS market will continue to grow, along with the number of entities involved, the volume of money exchange in the carobon market will continue to increase so that it will have an effect on GDP.

CONCLUSION

China's energy demand is predicted to keep rising year by year accomplishing with the economic growth. Coal as the biggest fuel combustion sources still couldn't be replaced by any other alternative sources due to the cost and simplicity access to fetch it, making China as the largest and the youngest coal power fleet. This paper with panel data and linier method analyze ETS effectiveness on the pilot city: Beijing, Shanghai, Tianjin, Chongqing, Shenzhen, Guangdong, and Hubei provinces. Generally, the effectiveness of ETS policy in China is significantly decrease the carbon emission amount. It proved by the deviation of area with the ETS treatment and not is around 47.1%. The economy impact of ETS implementation shows the increasing of GDP. The trend of carbon amount emission will decreased in the future by

ETS implementation. However, due the limited data obtained in this study it will be necessary to continue this study in the future.

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