MASTER'S THESIS

The Relationship between Carbon Neutralization and Economic Growth —— Analysis of ANT FOREST Project and New Energy Consumption.

Master's Degree in Economics

Faculty of Economics and Business Universidad Zaragoza

Course: 2020/2021

Author: Yifan Pu

Director: Jorge Bielsa

Zaragoza, October 2021

Abstract

In this work we have presented and tested two ways of achieving carbon neutrality in China: the private project called Ant Forest (AF) and the use of new sources of energy. Regarding to AF project, this work describes this private initiative that seeks to reduce carbon emissions by modifiyng the citicen's daily low-carbon behaviors, including mobile payment, walking, taking public transportation instead of private cars to reduce travel, and paying utilities online. Moreover, this work includes an evaluation of AF's potential development power from the perspective of carbon finance, taking in account its advantages and disadvantages. In order to study the effects of the usage of new sources of energy on the carbon neutrality goal, a logarithmic VAR model was made up to demonstrate dynamic relationships between economic variables and new energy consumption (nuclear plus renewables). We check the existence and nature of long-term relationships between Per Capita Carbon Emissions, Per Capita GDP, and Total New Energy Sources. The model shows that there are positive and negative comprehensive effects between new energy consumption and carbon emissions which have negative effects on economic growth. Finally, the impact of new energy consumption on GDP has alwaysbeen positive while the emissions reduction have a clear relation with the reduction in emissions per unit of GDP. This result seems to point out some Envrironmental Kuznets Curve (EKC) behaviour in recent years for China's economy.

Key words: carbon neutralization; ANT FOREST: new energy consumption; Carbon finance

Table of contents

1.Introduction

At the UN General Assembly on September 22, 2020, China's leaders promised to achieve peak carbon dioxide emissions by 2030 and carbon neutrality by 2060. In other words, in the next 40 years, China will have a wide-ranging and profound transformation of its economic and social systems in relation to "peak carbon dioxide emissions" and "carbon neutral". Carbon emission is not only an environmental problem, but also an economic development problem. China's economy continues to grow at a high speed, and the corresponding total energy consumption is steadily increasing. Although the overall energy intensity is declining and the overall energy efficiency has gradually improved, there is still a considerable gap between China's energy efficiency and that of developed countries. Under the energy extensive economic growth mode, economic growth is supported by consuming a large amount of energy. In previous studies, researchers have found that there is a certain relationship between economy and CO2 emission in the process of social development. In the process of our vigorous economic growth, we will certainly speed up the development of industrialization, so the pollution to the environment will definitely increase. Therefore, in the process of China's vigorous economic development, it will certainly accelerate the development of industrialization, so the environmental pollution will definitely increase.

The Chinese government is trying its best to find a balance, and at the same time it promotes rapid economic development, it tries to control CO2 emissions. In this context, the private project Ant Forest (AF) has been launched. AF project is a private project that users reduce carbon emissions according to their daily low-carbon behaviors, including mobile payment, walking, taking public transportation instead of private cars to reduce travel, and paying utilities online.

Therefore, this paper aims to analyze how China’s economy is going to develop in the process of "carbon neutral" from the current situation. The research question goes as follows: Is the relationship between the two developing positively or

negatively? We analyzed it from two perspectives. First, from the perspective of consumers, we ask how to achieve the coordination between economy, and reducing carbon emissions, that is, how to use carbon emission reduction to achieve more economic benefits. Second, from the perspective of corporate government, the question is how to change the traditional energy consumption structure while vigorously developing the consumption of renewable energy. In other words, are rapid economic development and carbon dioxide emissions reduction compatible?

As for the relationship between carbon neutralization and economy, there are mainly two research directions in the literature. The first research direction is focused on the relationship between "ANT FOREST" project and CO2 emission reduction and economy. Sardonar Lee (2017) [1]analyzed the possibility of AF project developing in the field of carbon finance in the future and the problems it faces from both subjective and objective perspectives. They believed that AF project has a positive impact both on carbon dioxide emission reduction and in the economy.

The second research direction is the relationship between new energy sources (nuclear plus renewables), CO2 reduction and economy. Iwata et al. (2010) and Iwata et al. (2012)[2][3] take France as an example and use relevant measurement models to prove that nuclear power, as a renewable energy source, plays a significant role in reducing carbon emissions. Apergis et al (2010)[4]respectively established error correction models for the relationship between carbon dioxide emissions, nuclear energy consumption, renewable energy consumption and economic growth in 19 developed and developing countries.

The results based on long-term estimation method show that there is a positive relationship between new energy sources and carbon dioxide emissions. In the third chapter, we mainly analyze the relationship between China's total CO2 emissions and its economy in recent years, and the role played by the AF project. Stern et al. (2007)[5]reports on climate change from an economic perspective, assessing the possibility of changing to a low-carbon economy and adopting different adaptation

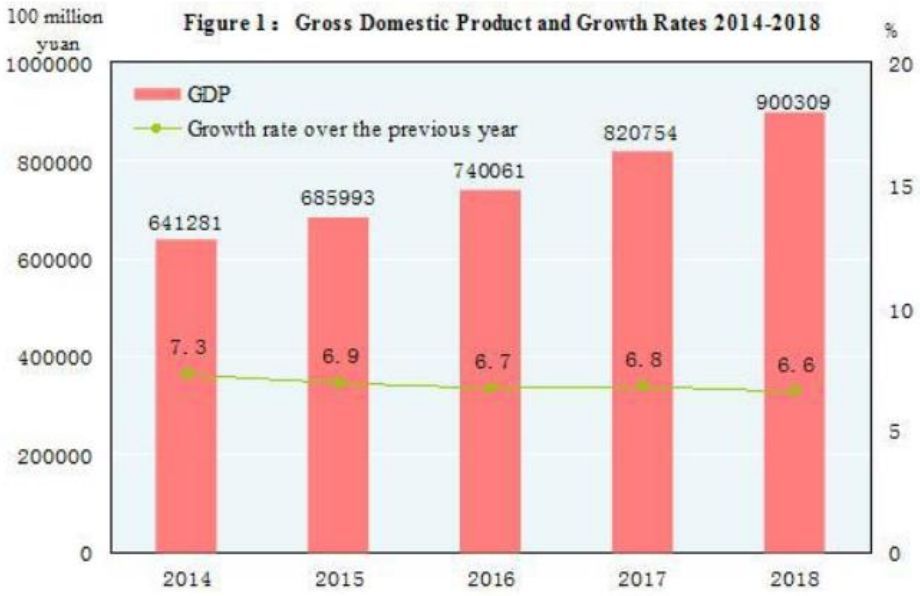
methods in the context of climate change, and analyzing the impact of climate change on the British economy. It is predicted that 5%~20% of GDP will be lost due to climate warming by the beginning of the 21st century. The report strongly urges all countries in the world to take rapid and effective measures to slow down the further global warming (Xue, 2014) [6]

Thus the paper is organized as follows: The next chapter analyses AF project, the relationship between carbon dioxide emissions and the economy; and an evaluation of AF's potential development power from the perspective of carbon finance, taking into account its advantages and disadvantages. The third chapter introduces the relationship between new energy sources (nuclear plus renewables), carbon dioxide emissions and economy based on VAR model. The fourth section is the conclusions and recommendations.

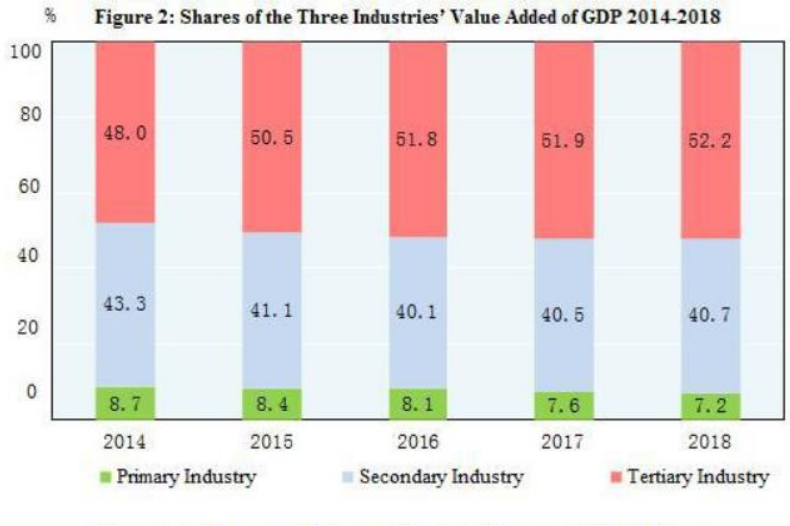
2. The relationship between ANT FOREST, total CO2 emissions and economy

2.1 The relationship between China's GDP and carbon emissions

In the statistical bulletin of the People's Republic of China on national economic and social development in 2018 (Figure 1 and Figure 2), it can be seen that from 2014 to 2018, China's GDP is showing an increasing trend, and the growth rates of the three major industries are also between 3.5% and 6.6% compared with the previous year. In addition, China's energy consumption per 10,000 yuan of GDP in 2018 decreased by 3.1% compared with 2017, while the overall labor productivity reached 107,327 yuan per person in 2018, an increase of 6.6% over the previous year.

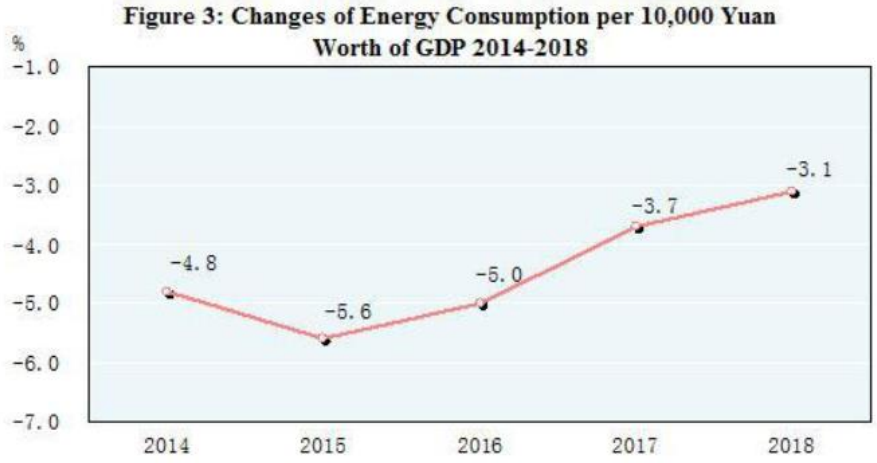


Source: China Statistical Bulletin on National Economic and Social Development in 2018. [7]



Source: China Statistical Bulletin on National Economic and Social Development in 2018

The energy consumption per 10,000 yuan of GDP refers to the total energy consumed per 10,000 yuan of GDP in a region. The lower the energy consumption per 10,000 yuan of GDP, the more remarkable the effect of energy saving and emission reduction. It can be seen from Figure 3 that China's energy consumption per 10,000 yuan of GDP is decreasing year by year, indicating that China has achieved remarkable results in energy conservation and emission reduction although the speed of this reduction is getting lower as the times goes by.

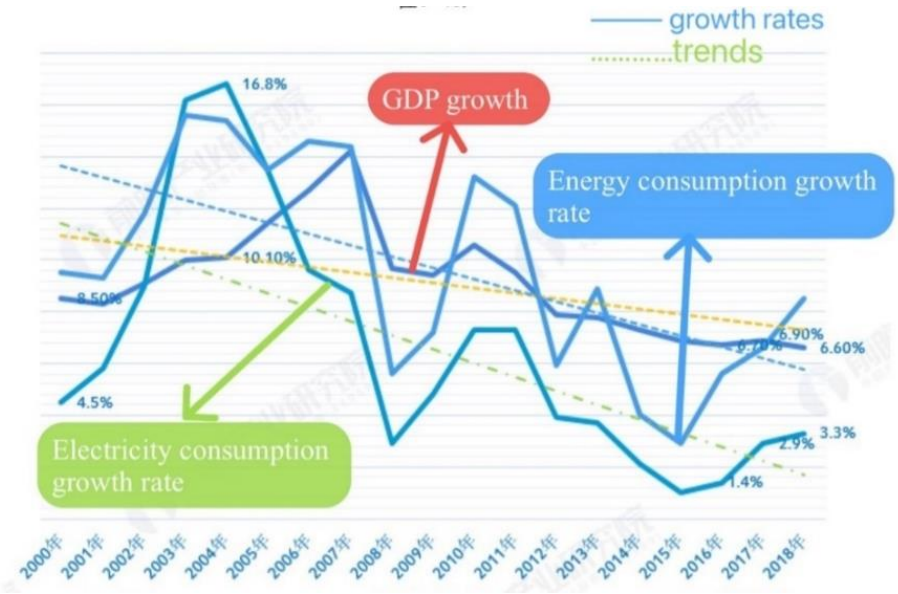


Source: China Statistical Bulletin on National Economic and Social Development in 2018.

Besides, when we compare the growth rate of GDP with the growth rate of energy and electricity, it can be found that the growth rate of China's GDP in recent years is obviously higher than the growth rate of energy consumption and power consumption, which means that China's rapid economic growth has somehow got rid of the previous extensive growth. There are great differences in energy consumption among different industries. Heavy industry consumes more energy than light industry, while the tertiary industry (service industry) consumes less energy than industry.

The decline of energy consumption coefficient shows that China's national economic structure has changed. In addition, the rapid development of China's low energy consumption industries is also one of the possible reasons for the decline of energy consumption coefficient. On the whole, China's energy consumption and economic development show a trend of continuous optimization. While the industrial structure is continuously optimized, the energy application efficiency is continuously improved.

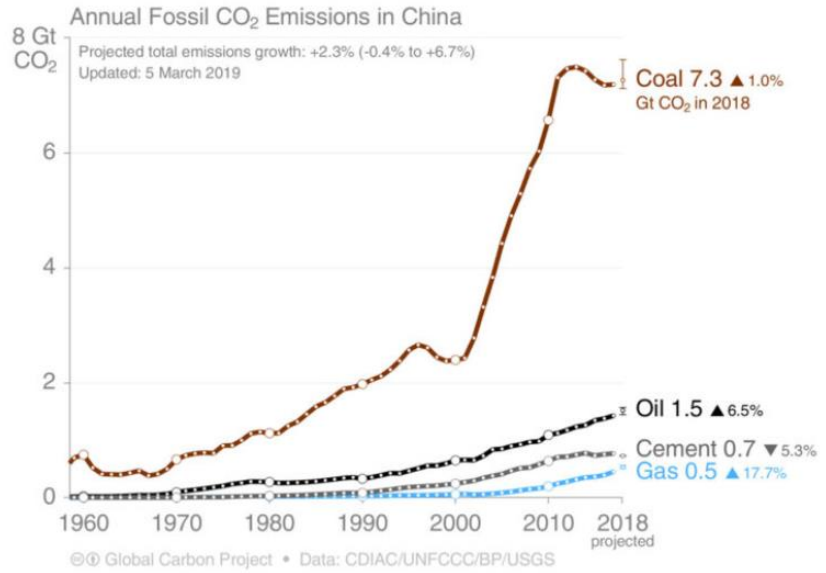
Figure 4 Comparison of China's GDP growth rate, energy growth rate and power growth rate from 2000 to 2018.



Source; China Statistical Yearbook Prospective Industry Research Institute.

The figure 4 shows how, in 2018, China's carbon dioxide emissions increased faster than in 2010. It increased by 7% in 2017. This indicates that China's emissions increased in the second year after being suspended or slightly decreased from 2014 to 2016. The figure 5 shows how a strong growth of CO2 Emissions in 2018 and that China's carbon dioxide emissions are mainly coal.

Figure 5 Annual Fossil CO2 Emissions in China 1960-2018



Chinese CO2 emissions by source, 1960-2018, billions of tonnes of CO2 (GtCO2). Note the upward biased uncertainty on the growth in coal-related CO2 emission. Source: Global Carbon Project.

It can be seen from the figure 5 that, in fact, the biggest factor determining China's carbon dioxide emissions in 2018 is coal consumption, which has accounted for 59% of the total energy consumption and more than 70% of the energy-related carbon dioxide emissions.

According to the statistics of global carbon projects, compared with 2017, it can be known that coal consumption, like 2017, decreased from 2014 to 2016 and then increased again. Like 2017, the biggest single contribution of coal consumption growth is the increase of power generation. In 2018, power generation increased by 7.7%, accounting for about half of China's coal consumption. In 2018, China's oil (up

6.5%) and natural gas consumption (up 17.7%) increased rapidly, continuing the recent trend.[8]. Although their proportion in China's carbon dioxide emissions is far lower than that of coal, this rapid growth promotes the growth of total carbon dioxide emissions, which is far higher than that of coal.

Meanwhile, according to BP statistics, China's carbon emissions per unit GDP (CO2 emissions/USD, that is, CO2 emissions per USD GDP) reached its peak from 1984 to 1992, with the highest emission of about 0.006 tons/USD. However, after China's entry into WTO, the growth rate of GDP has obviously increased, while the unit carbon emissions have decreased rapidly since 2004, and still maintain a certain rate of decline. It is estimated that the carbon emissions per unit GDP in China in 2019 were 0.00069 tons/USD [9].

From the above data and charts, we can conclude that in the process of economic development, the growth of China's carbon dioxide emissions of coal are decreasing, while energy consumption is increasing (oil, cement, and gas). The aim is to reduce CO2 emissions as much as possible but achieving a stable growth rate of GDP too.

2.3. ANT FOREST：CO2 emission reduction and economic outcomes

"ANT FOREST" is a private project (AF) that intends to incentive users to reduce carbon emissions by way of their daily low-carbon behaviors, including mobile payment, walking, taking public transportation instead of private cars to reduce travel, and paying utilities online. At the same time, it is also the first project that make users create personal "carbon accounts". The "carbon account" mentioned here is also the carbon emission trading account (hereinafter referred to as the carbon account), which is opened by the carbon emission trading exchange in the carbon emission trading system and is used for bidding to purchase carbon emission quotas paid by the government in the primary market and trading carbon emission rights in

the secondary market. Each trading account of the control enterprise shall designate one person in charge of carbon emission trading, who shall be responsible for account management and trading operation of the trading system. The main participants are countries and large enterprises. AF project is a personal "carbon account" launched by Alipay, a subsidiary of Ant Financial. Break through the traditional mode, not limited to enterprises, so that everyone can have their own "carbon account", and truly any people can participate in emission reduction activities.

In this project, when users achieve low-carbon emission reduction every day, they can get some green energy. When the green energy is accumulated to 179kg, the staff of public welfare organizations will plant a Haloxylon ammodendron tree in the desert areas such as Alashan, Jiuquan and Bayannaoersha.

As everyone lives with low carbon, thus reducing their own carbon emissions, green energy is accumulating, and Haloxylon ammodendron trees are planted in the desert. According to statistics, since the launch of AF project, the total number of users has reached 550 million in more than five years, that is, more than 204,000.01 hectares of desert have been "covered" with green "coat". And by the middle of 2020, the cumulative emission reduction of AF project users has reached 12 million tons.

In recent years, the Report on Chinese Low-carbon Life released by the Research Group of the Research Center of Environment and Economic Policy of the Ministry of Ecology and Environment shows that there are more and more green low-carbon life scenes based on the Internet, and many new platforms and modes of public participation have emerged. In AF alone, its users insist on "planting trees with mobile phones" to achieve carbon emission reduction of 12 million tons. AF users has planted 223 million real trees for the earth, with an area equivalent, it has become a typical example of research by the Ministry of Environment [10].

Planting trees not only changed the local environment, but also promoted the development of local economy. In China's development process, it is a great goal to

get rid of poverty in an all-round way. In short, get rid of poverty means promoting economic development. According to the results of the Report, after years of growth, when the management and maintenance are in place, the ability of the ecosystem to provide services will continue to improve, until all the plots reach the mature state of the vegetation in their respective regions, and the estimated gross value of the ecosystem based on the constant price in 2020 is 11.306 billion yuan (TechWeb, 2021).[11]

In addition to generating income in the ecosystem, it also provides more labor income. According to statistics, in 2018, AF provided more than 400,000 green jobs to the poor by planting trees and patrolling protected areas. At the same time, from planting ecological forest to on-line protected land and expanding economic tree species, for example, by planting seabuckthorn as an economic tree species, it can not only improve the local environment, but also bring more green jobs and income; In 2019, it is hoped that 6,666.667 hectares of economic forest will be planted, and more economic forest varieties will be expanded besides seabuckthorn. In addition, in the mode of protected areas, through the development of cultural products, more local cultural traditions are revived, and economic value is brought. For example, embroidery, a non-legacy product in Heshun, Shanxi Province, increases the income of local embroidered mothers by 2,000 yuan per month. According to the report, AF has created more than 400,000 green jobs in total and realized labor income increase of more than 60.59 million yuan. Therefore, consumers, the largest group in the whole society, should be driven, and consumers must become active participants in carbon neutrality.

2.4 ANT FOREST and carbon finance.

2.4.1 What is carbon finance?

The so-called carbon finance refers to various financial institutional arrangements and financial transactions aimed at reducing greenhouse gas emissions, including trading and investment of carbon emission rights and their derivatives,

investment and financing of low-carbon project development and other related financial intermediary activities. Generally speaking, carbon emission is regarded as a valuable commodity, and then spot, futures and so on can be bought and sold. With the concept of carbon finance, the corresponding carbon trading market will be extended. The basic principle of carbon trading is that one party to a contract obtains the greenhouse gas emission reduction amount by paying the other party and buying a house can use the purchased emission reduction amount to slow down the greenhouse effect and achieve its emission reduction target (ChinairnZSM, 2013). [12]

In order to transform the low-carbon economy into people's practical actions under the market economy, it is necessary to utilize the carbon trading market mechanism and drive it with the help of green interests. In order to achieve the ultimate goal of global greenhouse gas reduction under the United Nations Framework Convention on Climate Change, the aforementioned legal framework stipulates three emission reduction mechanisms:

1. Clean Development Mechanism (CDM).
2. Joint Implementation (JI).
3. Emissions Trade (ET).

According to the three mechanisms of carbon trading, carbon trading can be divided into two forms: quota trading and project trading. Carbon trading is quota-based trading, where buyers purchase emission reduction quotas formulated, allocated (or auctioned) by managers under the "cap and trade system", such as AAUs under Kyoto Protocol and EUAs); under EU-ETS. Project-type transaction is a project-based transaction, in which the buyer buys emission reduction from a project that can prove to reduce greenhouse gas emissions. The most typical transactions are CERs and ERUs generated under the Clean Development Mechanism (CDM) and the Joint Implementation Mechanism (JI), respectively. China's carbon trading is more of a project-based trading, relying on the clean development mechanism. In summary, this mechanism is a cooperative project between developed countries and developing

countries, and developed countries exchange for the right to reduce emissions under the project by providing technically sound funds, thus enabling the country to fulfill its emission reduction commitments under the Kyoto Protocol [13].

2.4.2 Data of China's carbon trading market.

According to relevant information provided from Leng Xue (2019) [14], we know that the market value of the global carbon market reached 144 billion US dollars in 2009, and people in the industry predict that the global carbon market will grow to 3.5 trillion US dollars by 2020, which will become the largest trading market in the world alongside the oil trading market. Other data show that since 2005, the global carbon trading market has grown at a high speed with an annual growth rate of 100%. In 2008, there were nearly 5 billion carbon dioxide transactions in the world, with the transaction volume reaching 126 billion US dollars, of which the carbon emission quota market was 93 billion US dollars, and the carbon transactions of CDM and other projects were 5.4 billion US dollars. For China's market, China's GDP accounted for 7% of the world in 2009, but its emissions accounted for more than 20% [14]. According to the forecast, the total amount of carbon dioxide emissions in China in the future is likely to rise from the current nearly 7 billion tons to 10-12 billion tons. At present, China's clean production mechanism (CDM) projects have reached 36.37 million tons, which has become the largest CCM carbon trading country in the world.

However, whether from the international market or the Chinese market, the main participants in the current carbon trading market are mainly the government, enterprises, banks, and such collective institutions, and have not transitioned to the individual level. Especially in the Chinese market, the development of carbon finance is still in its infancy, which is relatively backward compared with the international carbon finance market. As a developing country, China is now in a critical period of accelerated economic development and upgrading, which determines that China's

carbon finance development must explore a development path with Chinese characteristics in line with China's special national conditions.

2.4.3 Evaluation of ANT FOREST's potential development power from the perspective of carbon finance.

China's per capita carbon dioxide emissions have exceeded the world average, which is 6.4 tons. We are now 7 tons per capita of carbon dioxide, so we are facing unprecedented pressure in reducing greenhouse gas emissions anyway. ANT FOREST is also the first step to contact with carbon finance.

Therefore, if the carbon market breaks out in the future, the biggest broker in this market will not be a company or a traditional broker but a consolidated project involving hundreds of small investors. Nowadays, most stock transactions are conducted on mobile phones, and the high-traffic portal on mobile phones may become the biggest player in the carbon market.

(A) ANT FOREST development evaluation index.

(B) Analysis of the advantages and disadvantages of ANT FOREST's potential development based on the perspective of carbon finance.

(A) From the perspective of carbon finance as for the evaluation index of enterprise potential competitiveness, Qi Xuan and Kong Xiaoxi (2020) [15]mentioned that there are many studies based on enterprise resource potential competitiveness, on enterprise capability competitiveness, on enterprise financial competitiveness, on enterprise environmental competitiveness and on enterprise scale competitiveness. The potential competitiveness of an enterprise mainly reflects its future development ability and prospects through some existing data. The evaluation of the potential competitiveness of an enterprise is mainly divided into the following aspects: First, the research and development capability, which is the core of an enterprise's development, requires constant research and development of new technologies and products to shorten the product update cycle, so as to meet the needs of customers and

enable the enterprise to keep up with the pace of the times. Second, the enterprise's strategic decision-making ability, which can make the enterprise personnel at all levels clearly know the future development direction, enhance the cohesion and centripetal force of the enterprise, and at the same time help to optimize the resources, and then realize the maximum value of the resources, so that the enterprise can face all kinds of opportunities and challenges more calmly. Third, corporate culture plays an inestimable role in the development of enterprises. Although this influence may not appear in a short time, its influence will become more and more important as time goes by. To a certain extent, the culture of an enterprise determines how far an enterprise can go in the market. Fourth, the ability of market development, which also has a far-reaching impact on the development of enterprises, determines the future customer scale of enterprises and other aspects of development. The fifth is the low-carbon management structure, which mainly shows the management system of enterprises in terms of carbon emissions. Sixth, enterprise low-carbon brand equity, which can show the public familiarity and evaluation of the enterprise in carbon finance, and reflect the public's recognition of the enterprise. Based on the above analysis and comparison, drawing lessons from other scholars' relevant research, and according to Qi Xuan and Kong Xiaoxi's (2020) [15]principles of scientific, representative, and accessible index system design, 13 three-level indicators were specifically selected. The connotation of the index system is as follows: First, the research and development capability is the potential competitiveness and fundamental driving force of ANT FOREST. This paper mainly selects two indicators: the proportion of research and development funds and the number of annual award-winning products. Second, the strategic decision-making ability is the guarantee of the potential competitiveness of the enterprise, which mainly selects two indicators: the comprehensive quality score of the decision-making team and the complete rate of the management system. Thirdly, corporate culture is the fundamental driving force to enhance the potential competitiveness of enterprises, which mainly selects three indicators: corporate image level, cultural activity status and corporate low-carbon

culture. Fourthly, the ability of market development determines the degree of exploring potential competitiveness, and mainly selects two indicators: the average annual advertising investment and the satisfaction rate of after-sales service. The last two points, low-carbon management structure and low-carbon brand assets of enterprises, are more specifically selected from the perspective of carbon finance to evaluate the competitiveness of enterprises in this respect, including enterprise system, low-carbon strategic alliance, low-carbon brand awareness and low-carbon brand reputation.

Table 1 is the score of ANT FOREST's potential competitiveness based on relevant data from Qi Xuan et al. (2020) [15] with a grade of 0-100. The author qualifies the positive and negative points of all the items of the project, subtracting points according to his review and comparison methodology with national or industrial regulations. It shows a modified table with the most important results:

(B) Table 1 Evaluation Table of Potential Development Ability of ANT FOREST Based on Carbon Finance Perspective.

Level I index	**Secondary index**	**Three-level index**	**Grade**
Potential competitiveness of enterprises.	Research and development ability.	Proportion of research and development funds.	97
		Number of annual award-winning product grades.	90
	Strategic decision-making ability	Comprehensive quality score of decision-making teams.	95
		Complete rate of management system.	91
	Corporate culture	Grade of corporate image	95
		Cultural activities.	95
		Enterprise low carbon culture.	96
	Market development ability.	Average annual advertising investment.	92
		Satisfaction rate of after-sales service.	96
	Low carbon management structure	Enterprise system	96
		Low carbon strategic alliance.	96

	Enterprise low carbon brand equity.	Low carbon brand awareness.	90
		Low carbon brand reputation.	97

Note: The meanings of the following elements shall be implemented according to the national or industrial regulations.

Source: Qi Xuan et al. (2020) "Study on the Evaluation of ANT FOREST's Potential Competitiveness from the Perspective of Carbon Finance." Market Weekly: Theoretical Research 000.003(2020) :P.8-11.

Table 1 has three different level indexes to clarify and to synthesize the research of Qi Xuan et al. (2020) [15] demonstrating a great potential development capacity of ANT FOREST based on the perspective of carbon finance. Level I index is the title of what is being evaluated, the AF's potential competitiveness as a real sustainable enterprise, despite it's currently considered just as a project. Secondary index shows the compact categories that best evaluate AF's performance, the categories are result from a proposed methodology taking into account the points highlighted by other authors such as Maneejuk (2020)[18] Apergis (2010) [18] and Jiaqi (2019) [18] to evaluate AF's performance. Then, Three-level index is a compilation between the categories studied by Qi Xuan (2020) [15] with their grades but considering the proposed methodology, which means a most complete, integral, and easiest way to realize AF's potential. So all the categories are not related to Secondary index, they are not including in table 1. Overall table 1 demonstrates AF's sustainability and success in all the categories, because all of them are above 90 grades, but especially in corporate culture, low carbon management structure and market development ability. While enterprise low carbon brand equity and research and development ability are still strong but less than the former. Finally, among AF's strong skills, its strategic decision-making ability can improve.

On the whole ANT FOREST's potential development advantage is mainly reflected in its "carbon account", which is used to measure the carbon emissions of users' daily activities, exactly as table 1 shown. As the third largest account after

capital account and credit account, it is undoubtedly another brand-new attempt of Ant Financial. Establishing a "carbon account" means building the world's largest platform for measuring, trading, and sharing low-carbon life, which can not only record users' green footprints, but also provide users with trading accounts for carbon emissions saved by green and low-carbon emission reduction activities, paving the way for future investment and trading of carbon assets (Qi Xuan et al., 2020) [15]. If the "carbon account" can be used properly and put into operation, it will make a great contribution to the future financial market. Of course, AF also has some disadvantages in its development. First, the whole project lacks internal incentive mechanism and external supervision mechanism. Energy collection depends entirely on users' interests, even on a whim, so how to make users live a low-carbon life for a long time and continuously still needs a good mechanism to promote it. Secondly, the profit model of this matter is not clear enough. Although collecting energy can promote more users to use Alipay, it is only unilateral. The trees planted in AF have to be paid by foundations in various places all the time. However, there is no free lunch in the world, and this transaction may not bring clear benefits to the other party. In the long run, the capital chain will definitely break, so the future development plan will be difficult to realize. Thirdly, the tree planting link is too abstract for users. After users exchange energy for saplings, they will only get a certificate, and they cannot see their own sapling planting process or specific planting position in real time. Finally, the number of saplings is in short supply, and users often have enough energy, but there will be a shortage of saplings, which will also hurt the enthusiasm of users.

2.5. Future Development Direction of "ANT FOREST" under the Carbon Neutralization Strategy

Since April 22, 2016, more than 100 countries have jointly signed the Paris agreement to limit each country's carbon emissions, CO2 emissions are not only an environmental issue, but also a reflection of a country's economic development. It is

not only to reduce carbon emissions, but also to create a market for carbon and make the concept of carbon relevant to life. As the first individual-based carbon trading account project established by China, "ANT FOREST" is very important in the carbon finance field. Therefore, after putting forward the "carbon neutral" strategy, how can the project be better developed?

(1) Increase the number of users, let more and more people create more "green energy" through low-carbon behavior in their lives, and plant as many trees as possible in deserts and border areas. This will not only directly reduce carbon emissions, but also create more jobs and economic benefits.

(2) Establish the whole system of carbon finance. After China established its first carbon exchange in 2013, it has so far launched carbon trading trials in seven key cities. China is gradually improving the carbon finance market. Therefore, "ANT FOREST" should not only focus on planting trees to reduce carbon dioxide but should also enter the carbon finance market as soon as possible. Moreover, it is necessary to extend the "internet plus Public Welfare" model currently in operation to the "internet plus Public Welfare+Carbon Finance" model, so that public welfare and carbon dioxide emission reduction can interact well with the logic of real business and operate fully and effectively. Only in this way can low-carbon behavior truly generate value that can be traded in the market. Truly, the rapid economic development can also take into account the emission reduction of carbon dioxide. Integrating carbon dioxide emission reduction with carbon finance and changing the traditional environmental protection model will also enable the carbon finance industry to embark on a new stage and drive the overall economic development from another aspect.

3. Empirical analysis of the effects on emissions of new energy sources

3.1 Introduction

In the previous chapter 2, we analyzed the relationship between individuals, carbon emissions and economy. In this chapter, we analyze the relationship between new energy sources, carbon emissions and economic growth in China from a global perspective. As we all know, China surpassed Japan to become the world's second largest economy in 2010. Moreover, China still mainly consumes coal, which makes the consumption level of major other energy sources such as nuclear energy and renewable energy more necessary. In 2020, China proposed to achieve "peak carbon dioxide emissions" in 2030 and "carbon neutrality" in 2060. In this context, it is of great practical significance to study the dynamic relationship among new energy consumption (nuclear plus renewable), carbon emissions and economic growth. Thus, to analyze the relationship of these variables, it was collected some scholars' research on the relationship between energy consumption and economic growth, and the relationship between environmental pollution and economic growth with carbon emission as the main index.

(1) the relationship between energy consumption and economic growth. Chen Zheng (2011)[16] established a second-order error correction model from GDP to energy consumption on the basis of demonstrating the one-way causal relationship between energy consumption and economic growth, predicted the total energy consumption in China, showed the changing trend of energy consumption, and pointed out that energy consumption and economic growth brought about environmental pollution, especially the increase of carbon emissions.

(2) The relationship between carbon emissions and economic growth. Han Xu (2010)[17]made an empirical analysis of China's EKC (environmental Kuznets curve) by using the research method of time series and used VAR model to study the dynamic relationship between environmental pollution and economic growth

including carbon emission index. The EKC shows how in its early stages, economic growth will be environmentally prejudicial due to the growth economic, but later, when the economy develops to a proper level, the previous environmental quality will be restored, indicating that the nexus of growth and the environment has a turning point. (Maneejuk, 2020) [18]

(3) Relationship between economic growth, energy consumption and carbon emissions Apergis (2010)[18]has established error correction models for the relationship between carbon dioxide emissions, nuclear energy consumption, renewable energy consumption and economic growth in 19 developed and developing countries. The results based on long-term estimation method show that there is a significant negative correlation between nuclear energy consumption and carbon emissions, while there is a positive correlation between renewable energy and greenhouse gas emissions. Generally speaking, the conclusions of each scholar using different analytical methods are not the same. On the basis of domestic and foreign scholars' research, this chapter focuses on the dynamic relationship among multiple variables and takes new energy sources consumption as the research object, establishes autoregressive model and impulse response function, and studies the long-term and short-term relationship among renewable energy consumption, carbon emissions and economic growth.

3.2 Data processing and model building.

The model made is shown in the expression below, $(\boldsymbol{CO_2})_{\boldsymbol{t}}$it indicates per capita carbon emissions, and $\boldsymbol{GDP_t}$its statistical data comes from the World Resources Institute. Said per capita GDP, calculated at constant price (1978 =100), and the statistical data came from China Statistical Yearbook (1985-2019); $\boldsymbol{NC_t}$ it indicates the proportion of the power generation of “new energy sources”, which it contains for this work mainly wind energy, water energy and nuclear energy, to the total energy consumption, and reflects the consumption status of new energy sources. Its statistical data comes from China Energy Statistics Yearbook (2020).

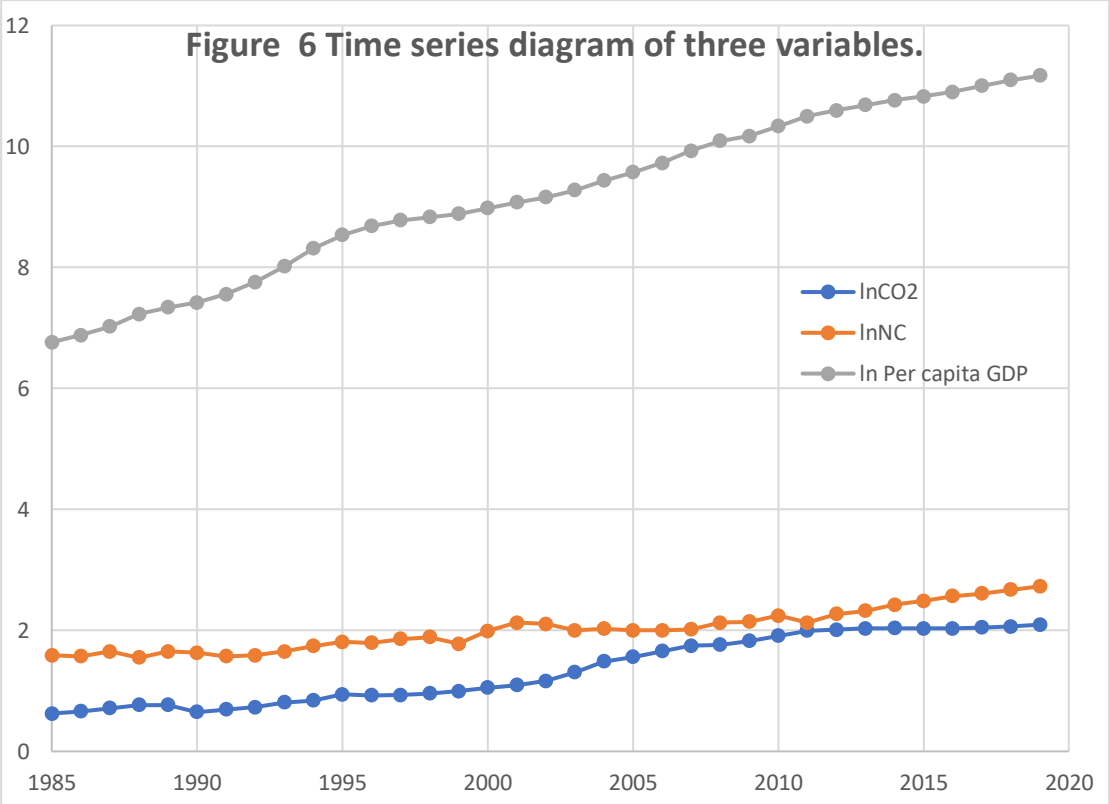
- .$(\boldsymbol{CO_2})_t$ = Per capita carbon emissions
- .$(\boldsymbol{GDP_t})$ = Per capita GDP
- .$(\boldsymbol{NC_t})$ = Total new energy sources consumption

In order to eliminate the heteroscedasticity in time series, the variable data should be logarithmic processed first. This can not only reflect the change of elastic coefficient among variables, but also not change the cointegration relationship between the original time series. The following equation is set in this paper:

$$\ln(\boldsymbol{CO_2})_t = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} \ln \boldsymbol{GDP_t} + \cdots + \boldsymbol{\beta_4} \ln(\boldsymbol{GDP_t})^3 + \boldsymbol{\alpha_1} \ln \boldsymbol{NC_t} + \cdots + \boldsymbol{\alpha_3} \ln(\boldsymbol{NC_t})^3$$

3.2.1 Unit root test.

In this section, we use the time series data:$\ln(\boldsymbol{GDP_t})$、$\ln \boldsymbol{NC_t}$、$\ln(\boldsymbol{CO_2})_t$ to make the variable timing diagram (Figure 6).



From Figure 6, we can see that the trends of the three variables are gradually rising, and the changing trends are basically the same. Therefore, it is preliminarily shown that there is a certain correlation among the three variables. At the same time, it can be preliminarily judged that the time series of the three variables are non-stationary. Scatter chart shows that there are strong dependencies among the three variables, but if they are directly regressed, it may lead to problems such as "pseudo-regression", and the statistical distribution of many parameters is no longer the standard distribution, so it is necessary to carry out unit root test on the time series of the three variables first.

In this paper, ADF method is used to test the stationarity of the time series of carbon emissions per capita, GDP per capita and the proportion of new energy consumption in China from 1985 to 2019. The results of unit inspection are shown in Table 2. It can be seen from Table 2 that the original time series is basically stable after the first-order difference sequence, so it can be concluded that the time series $\ln NC_t$ and $\ln(CO_2)_t$ is first-order unitary.

Table 2 Unit root test results.

variable	Type of inspection	T value	5% significant level.	probability;likelihood	conclusion
$\ln(CO_2)_t$	（c,t,0）	-2.647	-3.603	0.259	Not smooth
$\Delta\ln(CO_2)_t$	（c,t,0）	-3.421	-3.553	0.049	stable
$\ln NC_t$	（c,t,1）	-2.333	-3.549	0.8049	Not smooth
$\Delta \ln NC_t$	（c,t,0）	-7.089	-3.553	0.0003	stable
$\ln GDP_t$	（c,t,1）	0.405	-3.710482	0.997	Not smooth
$\Delta\ln GDP_t$	（c,t,0）	-3.210	-3.710482	0.083	stable

Note: Among the inspection types (c,t,k), c and t respectively indicate that there are constant items and time trends in ADF inspection, and k indicates lag order. The lag period is selected according to AIC criterion and SC criterion. δ denotes the difference order.

3.2.2 Cointegration test.

If the linear combination of time series of multiple variables is stable, it is said that there is a cointegration relationship between the series. Aeg two-step method can be used to test whether there is cointegration relationship among multiple variables. In this paper, AEG two-step method is used to test whether there is a cointegration relationship among per capita carbon emissions, per capita GDP and new energy sources consumption. The AEG two-step method is chosen because it can be used to test whether there is a cointegration relationship among multiple variables. In the first step, the linear regression of a variable to other variables is performed by using the general least square method, and the residual sequence is obtained. Secondly, the stationarity test is carried out on the residual sequence obtained in the first step; If the residual sequence is non-stationary, there is no cointegration relationship among the

multivariate, and if the residual sequence is stationary, there is a cointegration relationship among the multivariate.

Through quantitative analysis, we get R^2=0.931, and adjusted R^2=0.926. The T value of each explanatory variable parameter is greater than 5%, which has passed the significance test. The unit root test results of residual sequences are shown in Table 3. As can be seen from Table 3, the residual series is stable, so we can say that there is a cointegration relationship between per capita carbon emissions, per capita GDP and new energy consumption. It can be seen that, affected by the impact of rapid economic growth, the per capita carbon emissions do fluctuate drastically in the short term, but there is a long-term equilibrium relationship between the two, that is, the fluctuation range of per capita carbon emissions will gradually decrease until it is balanced; In contrast, the relationship between carbon emissions and new energy consumption has a long adjustment period.

Table 3 ADF test results of residual sequence.

inspection item	**T value**	**probability;likelihood**
ADF inspection statistics.	-3.951552	0.0029
Critical value of 1%.	-3.65322	
Critical value of 5%.	-2.86776	
A critical value of 10%.	-2.522989	

3.3. Establishment of VAR model.

VAR model is an unstructured model containing many equations, which is usually used to describe the influence of random disturbances on variable systems. The modeling idea of VAR model is that every endogenous variable in the system is regarded as the function of the lag term of every endogenous variable in the system to construct the model, determine the lag order and estimate the parameters. For non-stationary time series, VAR model can be established as long as there is a cointegration relationship among the time series of variables.

In this paper, the dynamic VAR is established to analyze and predict the degree of mutual impact among the three factors. The output results of Eviews based on econometric software are shown in Table 4. It can be seen from Table 4 that the adjusted R^2 of the autoregressive equations of new energy consumption, carbon emissions and economic growth are 0.903410, 0.963927 and 0.999084, respectively, indicating that the VAR model has a strong fitting degree; The regression coefficients of the three variables have passed the t statistical test, so the model is theoretically valid. The results show that the reciprocal of the modulus of all characteristic roots is less than 1, that is, they are all in the unit circle curve, which shows that the model is stable and has good statistical properties, which can ensure the validity of impulse response analysis and variance decomposition and the rationality of data interpretation.

Table 4 Estimated results of VAR model.

Explanatory variable	$\ln(CO_2)_t$	$\ln NC_t$	$\ln GDP_t$
$\ln(CO_2)_t(-1)$	0.503929	-0.439608	-0.020418
$\ln(CO_2)_t(-2)$	0.074373	0.266964	-0.008833
$\ln NC_t(-1)$	0.087433	0.372701	0.026300
$\ln NC_t(-2)$	0.003875	-0.366399	0.016666
$\ln GDP_t(-1)$	0.622730	1.797959	1.341906
$\ln GDP_t(-2)$	-0.595321	-1.532582	-0.437395
C	0.441682	-1.387701	0.021263
R^2	0.953928	0.902496	0.986048

Analysis is as follows:

1) Carbon emissions and new energy consumption. It can be seen from the table that, due to the influence of carbon emissions, the lag values of the first and second periods of new energy consumption are 0.1 and 0.004 respectively; Affected by the consumption of new energy, the lag values of the first and second periods of carbon emissions are-0.44 and 0.27 respectively. This shows that there are positive and

negative comprehensive effects between new energy consumption and carbon emissions, which means, the use of “new energy” (nuclear and renewables) may not result in carbon emission reductions.

2) Carbon emissions and economic growth. With the continuous growth of economy, its impact on carbon emissions is first positive and then negative. Carbon emissions have negative effects on economic growth in the short term. The combined effect of the two reflects the short-term environmental Kuznets curve. As Maneejuk (2020) [18] explains, the environmental Kuznets curve initially is positive (in the short-term), demonstrating how pre-industrial economies and at first industrial economies, have an increasing level of environmental degradation due to economic growth, but in the long-term, the same economy but now as a postindustrial starts to have a decreasing level of environmental degradation, which means a negative environmental Kuznets curve.

3) New energy consumption and economic growth. The impact of new energy consumption on GDP has always been a positive effect. With the increase of lag period, the role of new energy in economic growth is gradually increasing, which has a long-lasting impact on the environmental Kuznets curve (EKC), since the reduction in emissions per unit of output (the increase in efficiency), is due to the growing use of “new energies”.

4. Conclusion.

In this work we have presented and tested two ways of achieving carbon neutrality: the private project called Ant Forest and the use of new sources of energy. The AF project demonstrates how it is possible to achieve a high-quality economic growth in the process of realizing "carbon neutrality" with the participation of more than 500 million people and the interest of the government to support it. However, the path of coexistence of "carbon neutrality" and economic growth does not seem to be very clear.

Therefore, through the study of carbon emission reduction and economy in AF, we come to the conclusion that acting on consumer behavior is an essential tool to achieve carbon neutrality. At present, the relevant energy-saving and emission-reduction policies are mainly concentrated on the supply side, with administrative supervision as the main means, but there is a lack of relative market-oriented means. However, relying only on the low-carbon policy on the supply side may not significantly reduce carbon emissions. Therefore, consumers, the largest group in the whole society should become active participants in carbon neutrality. Consumers' cognition of carbon neutrality behavior and storage of carbon emission reduction are decisive factors to achieve the goal of carbon neutrality. Further improvements in the carbon trading market rules and establishing a carbon trading account belonging to individuals will drive consumers in the right direction.

Another problem is the carbon trading market. Through our analysis, we know that the contribution rate of new energy consumption to economic growth does not seem to be very high: the impact of economic growth on carbon emissions is positive, and the contribution rate is constantly increasing; the positive relationship of economic growth and new energy consumption to carbon emissions is constantly increasing. Therefore, in the process of realizing "carbon neutrality", it is necessary to further improve the energy efficiency and the use of renewable energy, so that it can truly replace the traditional energy consumption technology gradually.

In order to understand these relationships, we built a VAR model to demonstrate dynamic relationships among them. We took new energy consumption as the research object, established autoregressive model and impulse response function, and studied the long-term and short-term relationship among new energy consumption, carbon emissions and economic growth. The VAR model is very useful when there is evidence of simultaneity between a group of variables, and that their relationships are transmitted over a certain number of periods. The ADS test results of residual sequence is 0.0029, which means the null hypothesis is rejected, so it exists such relationships with stationarity. The adjusted R2 of the autoregressive equations of new

energy consumption, carbon emissions and economic growth are 0.903410, 0.963927 and 0.999084, respectively, indicating that the VAR model has a strong fitting degree. The regression coefficients of the three variables have passed the t statistical test, so the model is theoretically valid.

Thus, the empirical results of the model are: 1) there are positive and negative comprehensive effects between new energy consumption and carbon emissions; 2) carbon emissions have negative effects on economic growth in the short term. Therefore, the combined effect of these two results might reflect a short-term environmental Kuznets curve (EKC) in the analyzed data. At this point, the VAR model proves the first two phases (preindustrial economies and industrial economies) of the EKC, where it exists a positive relationship between economic growth and the level of environmental degradation.

To push up China's economy, we need to ensure the balance between energy, environment, and economy under the background of carbon neutrality. In this vein, result 3) is that the impact of new energy consumption on GDP has always been positive. With the increase of lag period, the role of new energy sources in economic growth is gradually increasing, which means a long-lasting impact on EKC. That means that the key to achieve the goal of "carbon neutrality" is to replace the traditional technology with green energy technology, rather than reducing the production capacity and that is how the final phase of the EKC is achieved (postindustrial economy) with a turning point, having as a result less negative impact on the level of environmental degradation due to economic growth.

Acknowledgements

After a year's postgraduate study, when the thesis is finished, I would like to express my sincere gratitude to the teachers and professors who guided and helped me.

I would like to thank my tutor Professor **Jorge Bielsa** in particular. During the whole process from the topic selection, the design scheme to the completion of the thesis, Professor **Jorge Bielsa** gave patient and meticulous guidance.

References

[1] Sardonar Lee (2017). Talking about the future development prospect of "ANT FOREST" in the field of carbon finance [J]. Global Market, 2017, 000(022):3-4.

[2] Iwata, Hiroki and Okada, Keisuke & Samreth Sovannroeun, (2010). Energy policy, Elsevier, vol. 38(8), pp. 4057-4063.

[3] Hiroki Iwata, Keisuke Okada & Sovannrouun Samreth, (2012). Taylor & Francis Journals, Volume I. 4 (27), pp. 3513-3519.

[4] Apergis, Nicholas & Payne, James E, Menyah, Kojo & Wolde-Rufael, Yemane, (2010). Ecological Economics, Elsevier, Vol. 69(11), pp. 2255-2260.

[5] Antweiler, Werner, Brian R. Copeland & M. Scott Taylor. (2001). Is free trade good for the environment? American Economic Review, 91 (4): 877-908.

[6] Leng Xue (2019). Study on the Relationship between Carbon Emissions and China's Economic Development [D]. Fudan University.

[7] Statistical Bulletin of the People's Republic of China on National Economic and Social Development (2018) [R], 2019-02-28, National Bureau of Statistics of China.

[8] Dr Jan Ivar Korsbakke & Robbie Andrew (2019). China’s CO2 emissions grew slower than expected in 2018 [R],2019-03-05. Robbie Andrew. China’s CO2 emissions grew slower than expected in 2018.

[9] Tao Feng & Liu Hanlin. (2021) Looking for the best path from" carbon account "to green development of carbon market" [R], China Youth Daily.

[10] Zhu Jiaqi. (2019). “ ANT FOREST planted 122 million real trees in three years” [R], China Daily Online.

[11] TechWeb (2021). “The value of ANT FOREST was announced for the first time: 500 million people planted 11.3 billion trees on mobile phones" [R], Sina.com.

[12] ChinairnZSM, (2013). "2010-2012 China Carbon Trading Market Research and Investment Analysis Report" [R], China Industry Research Network.

[13] Zhang Jing. "Analysis of Opportunities and Challenges in the Development of China's Carbon Trading Market." Zhifu Times 5X(2018):34-34.

[14] R&D Trends 46 (2010). Coal Gasification Technology [J].

[15] Qi Xuan, Kong Xiaoxi, Gong Yiyan, et al (2020) Evaluation of ANT FOREST's potential competitiveness from the perspective of carbon finance [J]. Market Weekly: Theoretical Research. 000(003) :P.8-11.

[16] Chen Zheng (2011). Prediction of China's energy consumption based on the relationship between economic growth and energy consumption [J]. Journal of Northwestern University, (9): 65-70.

[17] Han Xu. (2010) An Empirical Analysis of Environmental Pollution and Economic Growth in China [J]. china population resources and environment, (4): 85-89.

[18] Apergis, Nicholas & Payne, James E. & Menyah, Kojo & Wolde-Rufael, Yemane, (2010). Elsevier, volume. 69(11), pp. 2255-2260.

[19] Maneejuk Nutnaree (2020) Does the Environmental Kuznets Curve Exist? An International Study [J].

Appendix

appendix A, Statistical Table of Per capita carbon emissions 、Total new energy sources consumption 、Per capita GDP from 1985 to 2019.			
Year	**Per capita carbon emissions**	**Total new energy sources consumption**	**Per capita GDP (yuan)**
1985	1.87	4.9	866
1986	1.94	4.8	973
1987	2.04	5.2	1123
1988	2.15	4.7	1378
1989	2.15	5.2	1536
1990	1.92	5.1	1663
1991	2	4.8	1912
1992	2.08	4.9	2334
1993	2.24	5.2	3027
1994	2.32	5.7	4081
1995	2.56	6.1	5091
1996	2.52	6	5898
1997	2.54	6.4	6481
1998	2.6	6.6	6862
1999	2.7	5.9	7229
2000	2.87	7.3	7942
2001	2.99	8.4	8717
2002	3.2	8.2	9506

2003	3.69	7.4	10666
2004	4.42	7.6	12487
2005	4.75	7.4	14368
2006	5.25	7.4	16738
2007	5.72	7.5	20494
2008	5.81	8.4	24100
2009	6.2	8.5	26180
2010	6.74	9.4	30808
2011	7.34	8.4	36302
2012	7.47	9.7	39847
2013	7.62	10.2	43684
2014	7.66	11.3	47173
2015	7.64	12	50237
2016	7.62	13	54139
2017	7.74	13.6	60014
2018	7.88	14.5	66006
2019	8.12	15.3	70892