How Can China Achieve the Emission Reduction Target According to the International Climate Conference?

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Abstract. The paper analyzes the relationship among Chinese per-capita emissions, the substitute rate of new energy and per capita of GDP from 1980 to 2018, by using multivariate analysis framework, which the result shows: the three variables can move forward simultaneously with co-integration in a long run. On the premise of constant 8% of economic growth rate, and then for the purpose of achieving the emission reduction targets of 2020, it is essential that the average annual rate of carbon reduction should be maintained between 3.3% and 3.9%, and the average substitute rate of new energy should be maintained 11.56% to 12.45%.

Introduction

With global warming, what impacts the world economic order and environment in the 21st century is an important issue. The increasing Carbon emissions trigger a series of hazards and restrict the development of the global economy. As far as China’s total carbon dioxide emission has ranked first in the world, when China promised to the world that Chinese carbon emissions would reduce 40%–45% in 2020 than that of 2005. However, the emission reduction will surely influence the economic development, so how to set an annual carbon emission reductions to reach the target of 2020, at the same time keep the 6% economic growth rate and set the replacement rate of new energy under the former condition?

There are researches who pay more attention on the issue of carbon emissions internationally. James B. Ang¹, by using the model of vector error correction, made an analysis of the dynamic relationships among carbon emissions, energy consumption and output from 1960 to 2000 in France, and got the result that: in the short term, there exists a one-way causal relationship between energy consumption and economic growth; in the long term, economic growth is the reason of intensified energy consumption. Ugur Soytas², who analyzed whether there existed long-term causality between carbon emissions, economic growth and energy consumption in the selected EU member states under the condition of fixed total amount capital and the fixed labor input, and got that carbon emission is the Granger cause of the energy consumption, but not vice. No long-term causal relationship lies between carbon emissions and incomes what the paper aims to study.

Hu Caimei³, who based on the panel data model, analyzed the 28 OECD countries’ long-run equilibrium relationship between energy consumption, economic growth and carbon emission from 1971 to 2006, finally found that energy consumption has a significant positive impact on carbon emissions. Fan Xiao⁴ used the multivariate framework to analyze the relationship between energy consumption and economic growth, and got that energy consumption would cause the movements of GDP in a single direction; then he used the vicariate analysis framework to analyze relationship between energy consumption and carbon emission, got that there is no Granger causality between energy consumption and carbon emissions in Brazil. Niu Shuwen⁵, Min Jisheng⁶, Zheng Changde and Liu Shuai⁷, used the method of spatial econometrics analysis the relationship between...
economic growth and carbon emission in various provinces of our nation, the results show that China's carbon emissions showed spatial autocorrelation to some extent, there was a positive correlation between economic growth and carbon emissions, economic growth relies more on carbon emissions.

From numerous studies, most scholars put carbon emissions, GDP and energy consumption together, while few scholars make quantitative research about the annual emission reductions and substitute rate for new energy, which are set for the reduction target in 2020. In the paper, by introducing the new energy substitute rate, it puts the substitute rate of carbon emissions per capita, GDP per capita, and the new energy together, under which it calculates annual emission reductions and the corresponding new energy substitute rate under the economic growth rate 6% and the reduction target of 2020.

The Methods and Modeling

Data

The paper selects sample from 1980 to 2018 about China’s total population, GDP and energy consumption data, which come from the China Statistical Yearbook, and select the three important indicators, including per capita carbon emissions, new energy substitute rate and the per capita GDP, then calculates the average annual carbon emission reductions and the average new energy substitute rate.

Per Capita Carbon Emission. Since China does not have the direct data of carbon emissions, most scholars’ carbon emissions are calculated based on energy consumption. Depending on the different types of energy carbon emission factors, the paper references the formula of calculating the carbon emission:\[ 1 \]

\[ C = \sum E_i \times \frac{E}{E} \]

As for equation (2), C is the total amount of carbon emissions, \( M_i \) is the proportion of the energy in the total energy consumption, \( R_i \) is said to the coefficient of energy carbon emissions. E is the consumption of total energy. In order to facilitate the calculation, the carbon emission factor of the various types of energy is considered constant according to the assumption of IPCC. The energy indicators about the various types of carbon emissions are as follows:

Substitute Rate of New Energy. As for major new energy sources, hydropower, nuclear power and wind power, they do not produce any carbon emissions; coal, oil and natural gas are all traditional energy resources, carbon emissions come from the three emissions, ignoring other factors. New energy substitute rate is defined as the proportion which new energy sources (hydropower, nuclear, wind) occupy old energy (coal, oil, natural gas). This indicator represents the energy structure, old energy usage is in

Per Capita GDP. A large number of studies show that carbon emissions is the main cause of economic growth. The paper adopts per capita GDP to express China’s economic development from 1980 to 2018, assuming that the annual economic growth rate has always maintains at the level of 6%.
Model Built

The paper aims to build the models of long-term relationships between per capita carbon emissions, new energy substitute rate and per capita GDP, it shows below:

\[ Y = \alpha + \beta_1 U + \beta_2 X + \beta_3 X^2 + \epsilon \]  \hspace{1cm} (3)

\( Y \) is per capita carbon emissions (in tons), \( \alpha \) the constant term of the model, \( U \) is the new energy alternatives, \( X \) is the per capita GDP (Yuan), \( x \) is the square of the per capita GDP, \( \beta_2, \beta_3, \beta_4 \) represents the coefficient of \( u, x, x^2 \) respectively, the random error term \( \epsilon \) should meet the assumption of zero mean and homogeneity of variances. Thinking over the economic significance of each variable, the rise and fall of data, possible emergency of ARCH and so on, this paper carry on natural logarithm conversion of all these variables above. When \( \beta_1 < 0 \), it means the per capita carbon emissions decrease with the increasing of new energy substitute rate; when \( \beta_2 < 0, \beta_4 > 0 \), there exists a "U" shaped relationship between carbon emissions and per capita GDP. When \( \beta_2 > 0, \beta_4 < 0 \), there exists an inverted “U”-shaped relationship between per capita carbon emissions and per capita GDP.

Methods

Firstly does autocorrelation test to variable sequence and then eliminate autocorrelation by method of difference. Secondly does unit root tests to the variable sequence, confirm the smoothness of the variables sequence, take the method of Johansen’s co-integration to test sequence multivariate stationary. Finally, uses the least squares method to predict the model.

Empirical Results and Description

Modeling

In order to ensure the validity and authenticity of the estimated results and avoid spurious regression, it is necessary to test the corresponding data.

Data Autocorrelation Test. Through using Eviews, it makes the auto-correlation detection between \( u \) and \( x \), \( x^2 \), the results show that \( u, x \) (correlation coefficient = 0.929614), and \( u, x^2 \) (correlation coefficient = 0.937024) exists the high autocorrelation. To eliminate problem of autocorrelation, do the first order differential processing to the three variable sequence and go through autocorrelation again, then obtain the correlation significantly reduced between \( u, x \) (correlation coefficient \( r = -0.038937 \)) and \( u, x^2 \) (correlation coefficient \( r = 0.00823 \)), then we can consider that there is no autocorrelation between them after first-order differential.

Stationary Test. The most common method of data stationary test is ADF unit root test. It is known from the practical significance that per capita carbon emissions \( Y \) presents a trend ranging from increase to decrease as time goes by, so to detect it by the no trend items ADF unit root, while existing single trend items among per capita GDP, per capita GDP in the square and new alternative energy rate, so it is proper to select ADF unit root with no trend items to detect.

Co-integration Test of Data. Johansen’s co-integration test method is usually used to test co-integration relationship among multiple variables. This text will do some co-integration analysis for the sequence of \( r, u, x, x^2 \). Selecting test equation in which the sequence without decided trend and the co-integration equation has intercept, the maximum lag order of the original sequence is the threshold of 3.5%. Knowing from the test results, both the trace statistic and the maximum eigenvalue statistic are greater than the test value, in which critical value is 5%, so the sequences of \( r, u, x, x^2 \) exist co-integration relationship

Using the least squares method to predict the model, the results are as follows:

\[ \hat{Y} = -1.435160 - 0.754746 \hat{U} - 0.684875 \hat{X} + 0.066813 \hat{X}^2 \]  \hspace{1cm} (4)
The goodness of fit $R^2$ which is the regression model coefficient of determination was 0.968, corrected value of $R^2$ is 0.965, showing that fitting degree is good, the regression model has strong explanatory power. The t-statistic value of $\alpha$, $\beta_1$, $\beta_2$ are less than 5%, indicating that they were highly significant. According to the model regression residuals to analyze Co-integration relationship among variables, namely do some unit root test to the residuals of the regression equation, co-integration relationship exist between the dependent variable and the explanatory variables of the equation indicates if the residual series is stable. Otherwise, there it’s not. Through the test of model residuals ADF unit root to model residuals, the results are as follows: t-statistic in residual unit root test is equal to -2.799964, its corresponding probability value $p$ is equal to 0.076, which is less than the test level of 10% , then it exists units root null hypothesis in rejecting the presence of residual series, namely they can do further inspection to examine whether it exists co-integrated among $y$, $u$, $x^1$, $x^2$.

If $\beta_1 < 0$, the substitute rate of per capita carbon emissions and new energy are negatively correlated. With the increasing rate of new energy alternatives, the per capita carbon emissions will continue to decrease. If $\beta_2 < 0$, $\beta_3 > 0$, saying that the relationship between China's per capita carbon emissions and per capita GDP is the first decreased and then increased, namely “U” shaped relationship.

How to Achieve the Targets

Emission Reduction Target

According to the carbon emissions calculation formula (2) \[ C = \sum \bar{M} \times \bar{F} \times E, \] we can calculate carbon emissions $Y_{2005} = 1463432$ (ten thousand tons) in 2005, under the emission reduction targets in 2020 reckon average carbon emissions $Y_{2020} = 84147.3$ (ten thousand tons) at that time, ordering annual reduction rate is $r\%$, by the following formula (5), we can calculate the annual per capita rate of carbon reduction.

\[ Y_{2005}(1 - r\%)^{15} - Y_{2020} \]

Therefore, the annual carbon emission reduction rate $r\%$ should between 3.3% and 3.9%. Then the targets of annual emission reduction are as shown in Table 1.

| Time   | 2006 | 2008 | 2010 | 2020 |
|--------|------|------|------|------|
| Emission reductions | 5268 | 4893 | 4545 | 4222 |

| Time   | 2013 | 2015 | 2017 | 2019 |
|--------|------|------|------|------|
| Emission reductions | 4069 | 3780 | 3512 | 3262 |

Table 1: 2006-2020 average annual carbon emission reduction units (10,000 tons).

Substitution Rate of New Energy

Assumed that the economy maintained the level of 6% in a growth rate, $X_{2005} = 14185.36$ (RMB/per), by the formula

\[ X = -1.435160 -1.75476U + 0.684875 \hat{X} + 0.066833 \hat{X}^2 \]

 drawn that $\nu$ is between 39.19% and 43.98%. By the formula
As is known that t\% of the new alternative energy rate is between 11.56\% and 12.45\%. Our commitment of emission reduction is much more challengeable. In fact, China has a large population, the task of developing the economy and improving people’s livelihood is hard; at the same time, the pace of industrialization and urbanization has never stopped. This means that China’s control on carbon emissions face enormous pressures and difficulties. Therefore, our country should actively develop low-carbon economy, levy carbon tax, and develop a reasonable carbon budget program. 

**Developing of Low-carbon Economy.** China must vigorously develop nuclear power, wind power and hydropower and other new energy sources, improve the utilization of new energy and increase the use of energy sources that have a lower carbon emission factor, such as oil, gas and so on, reduce the use of coal and traditional energy sources. By using low-carbon economy, China will reduce carbon emission, and reduce the friction with other countries on this issue, creating a good atmosphere for China’s development in the international world. On the basis, we would further promoted the global climate cooperation, thereby to increase the influence as a big country.

**Carbon Tax.** Some foreign enterprises levy carbon tax and apply it to the open and use practices of the new energy, this practice is worth learning. Adopting the proactive fiscal policy and collecting corporate carbon tax on high pollution and high carbon emissions will do some help to limit carbon emissions and improve energy utilization. The carbon tax can encourage enterprises to transfer to a lower pollution and lower emission. We should optimize the industrial structure and guide energy consumption to be reasonable.

**What is a Reasonable Carbon Budget?** Carbon budget is the foundation of setting absolute emission reductions, setting carbon tax suitable for China’s national conditions, establishing carbon trading system, as well as promoting green innovation. The carbon budgets connect emission reduction obligations; deal with the instability for the currency market factors. Through a series of rolling plan, carbon budget make current and future linked, through the support of the relevant domestic laws and regulations to achieve the final emission reduction targets.

**Conclusion**
In order to achieve the targets of emission reduction in 2020, meanwhile ensuring economic growth rate more than 6\%, the average annual carbon emission reduction rate should be controlled between 3.3\% and 3.9\%, and annual substitute rate of new energy should be maintained at 11.56\%-12.45 \%. Though achieving this goal faces some difficulties, China must make corresponding efforts to seek a new development way in all aspects.

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