The Study on CO_2 Emissions of G-7 Countries

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Abstract. Basing on the data of seven western countries from 1980 to 2006, this paper applies Logarithmic mean Divisia index method and time-series decomposition method to decompose carbon dioxide per capita emissions in the seven western countries. And it also analyzes the economic scale along with energy intensity and structure produce impact on the CO_2 emissions. The results showed that the economic scale is the increasing factor of CO_2 emissions, and the energy intensity and structure are decreasing factors of CO_2 emissions. But these three factors show great differences in each country, and they display different energy policies of these countries.

Introduction

In recent years, global warming and low carbon development have always been hot topics to academia, and as the Kyoto Protocol expires in 2012, the concern on the global climate change have already heated obviously throughout the world. The Development of Economy of these seven western countries (USA Canada France Germany Italy Japan and UK) has taken the leading position in the world, as well as CO_2 emissions.

According to the data from USA Energy Information Administration (EIA), the 7 countries' CO_2 emissions related to energy accounted for 34.5% of global CO_2 emissions in 2006.

These countries' per capita CO_2 emissions were much more than the worldwide per capita figure. For instance, the figures of USA and Canada were nearly four times than the worldwide. Meanwhile, the China's slightly higher than the average level in the world, which was about equal to it.

At present, the Decomposition Method as one of main methods of analyzing CO_2 emissions has already widely used. Basing on the Logarithmic mean Divisia index method, the paper uses Time-series decomposing method to decomposes CO_2 emissions of 7 western countries (G-7), and thus analyzes and studies the differences of CO_2 emissions effects among developed countries.

Literature Review

In recent years, the analysis on CO_2 emissions effects from worldwide scholars had been increasing, and the research into CO_2 emissions decomposition were gradually perfecting, especially after the Logarithmic mean Divisia index method (LMDI) presented by Ang in the 1990s[1].

The longest time-span analysis of CO_2 emissions in China was presented by Wang Can[2] in 2003 who analyzed the effects of CO_2 emissions in China from 1957 to 2000. It turned out that the energy intensity was the main factor of the CO_2 emissions reduction, also the energy structure had its contributions, and the development of economy was the main factor of the growth of CO_2 emissions. Other scholars used the method to study the CO_2 emissions effects in China in different ways; Zhang (2005) [3] presented the effects of the energy intensity, the energy structure, and the development of economy in quantitative analysis, in China from 1990 to 2004. And it turned out that the development of economy made contributions to CO_2 emissions in an exponential way, and the energy intensity associated with the energy structure contributed a U-shaped curve. Some scholars such as Kihoo (2008) [4] respectively used ADMI approach and LMDI approach to study CO_2 emissions of Greece in contrasts; Tunç (2009) used LMDI approach to study CO_2 emissions of

Turkey; Liaskas (2000) [5]used decomposition approach to analyze the CO_2 emissions of 13 selected-European Union (EU) countries.

In these above time-series analyses, a common conclusion is that the energy intensity is the main factor of the CO_2 emissions reduction, also the energy structure plays a role in the reduction, and the development of economy is the main factor of the growth of CO_2 emissions. But in most of countries, energy intensity plays a more important role than the energy structure.

The Methodology and Data

The Kaya Identity. The Kaya Identity was advanced by Japanese Dr. Yoichi Kaya in the Intergovernmental Panel on Climate Change (IPCC) in 1996.

The Kaya Identity is defined as below.

$$CO_2 = \sum CO_{2i} = \sum \frac{CO_{2i}}{E} \frac{E}{Y} \frac{Y}{P} P \tag{1}$$

E is consumption of primary energy; E_i is the consumption of energy i; Y is GDP; P is Population. Emission coefficient $F_i = {CO_{2i}}/{E_i}$, energy structure $S_i = {E_i}/{E}$, energy intensity $I = {E}/{Y}$, GDP per capita $R = {Y}/{P}$.1=Petroleum, 2=natural gas, 3=coal, 4=nuclear energy, 5=hydrogen energy.

$$\begin{aligned} \Delta A &= A_t - A_{t-1} \\ &= \sum F_i^t S_i^t I^t R^t - \sum F_i^{t-1} S_i^{t-1} I^{t-1} R^{t-1} \end{aligned} \tag{2}$$

Decomposition method. Some scholars such as Ang, Zhang and Choi put forward LMDI time-series analyses and cross-countries analyses respectively around 1997 and 2001.

$$\begin{aligned} \Delta A &= A_t - A_{t-1} \\ &= \sum F_i^t S_i^t I_i^t R_i^t - \sum F_i^{t-1} S_i^{t-1} I^{t-1} R^{t-1} \\ &= \Delta A_F + \Delta A_S + \Delta A_I + \Delta A_R + \Delta A_{rsd} \end{aligned} \tag{3}$$

⊿A is the change of per capita CO_2 emissions. ⊿AF is the effect of emission coefficient on CO_2 emissions, ⊿AS is the effect of energy structure on CO_2 emissions, ⊿AI is the effect of energy intensity on CO_2 emissions, ⊿AR is the effect of per capita GDP on CO_2 emissions. Ang(1997) proved ⊿Arsd is equal to 0.

The paper selects the data related to car CO_2 emissions from Energy Information Administration of USA. The data related to primary energy consumption in G-7 root in Statistical Review of World Energy June 2009 which released by British Petroleum. Because of availability and accuracy of the data, the primary energy in this paper involves petroleum, natural gas, coal, nuclear energy and hydrogen energy, but not includes wind energy, geothermal energy and solar energy. The data related to Nominal GDP and Population comes from IMF (International Monetary Fund). The Real GDP is based on constant prize of countries in the world in 1980, and all the calculations of GDP shall be in US Dollars.

The Decomposition of CO_2 emission of G-7

According to the total energy consumption the absolute quantity of energy consumption in USA remains the largest one, even it is greater than the total quantity of other 6 countries. Both the total and per capita of CO_2 emissions in USA remains the first position and the per capita of CO_2 emissions in France and Italy are in the last phalanx.

From the change of per capita of CO_2 emissions, France and Germany have the greatest decline. The per capita of CO_2 emissions declines by 25.64% in France and by 16.78% in Germany, cumulatively; it also has been declining in USA and UK, but the trend is not obvious; in Japan and Italy, it has the evidently rising trend; and in Canada, it has a volatile trend.

In the four factors which effect per capita of emissions, the per capita GDP increases emission, both the energy intensity and the energy structure decrease it, and the coefficient of per energy has little effect. This conclusion is the same as others in the domestic and foreign research.

USA The gross of energy consumption as well total and per capita of CO_2 emissions in USA, had the first position among G-7. In 2006, the per capita of CO_2 emissions in the France was 6.78 t, 19.76 t in USA. The USA's was 2.91 times as France, 1.05 times as Canada, 1.90 times as Germany, 2.47 times as Italy, 2.04 times as UK, and 2.02 times as Japan. Between 1980 and 2006, the CO_2 emissions reduction in USA mainly depends on the reduction of energy intensity, but because the economic growth limits the energy intensity, so the per capita of pollution emission in USA has a weak performance on reduction. USA's weaker reduction reflects its attitudes for emissions reduction and its characters of energy policy. During this period, the Bush administration disavowed the Kyoto Protocol, didn't take on the obligation of CO_2 emissions reduction, and denied the principles of "common but differentiated responsibilities".

In 2003, Bush administration proposed a new scheme for reducing CO_2 emissions and advocated the Intensity Target (IT), which was quit different than the Absolute Target (AT) in European Countries. Bush administration unilaterally proposed IT policies, which in some ways affected the regulation of energy structure. During 1965 and 2006, the rate of fossil energy in primary energy consumption declined slowly, and where 89.08% of energy was fossil energy in 2006.

There are big changes in climates and energy policies since President Obama administration took charge. It plans invest $150 billion in exploiting clean energy, during the coming decade. According to some scholars' expectation, the actualization of President Obama administration's new energy policies will greatly change energy consumption structure of USA, and promote the reduction of greenhouse gas.

France and Germany French reduction of emissions profits from optimization of energy structure, and the energy structure has a greater effect than energy intensity, which is different from American. The French energy policy has its prominent character that is the French government actively boosts clean energy which is represented by nuclear energy. In 1965, the French consumption of fossil energy (petroleum, coal, natural gas) made up 90.55% of its total energy consumption, and then reduced to 55.76% in 2006, but the consumption of new energy which represented by nuclear energy and hydrogen energy had an increasing rate. In 2006, about 50% of energy consumption was primary energy consumption, compared with 10.9% in USA and 4.6% in Italy. In the near future, in order to further optimizing its energy structure, the French government plans to greatly increase renewable energy such as nuclear energy, wind energy, solar energy and so on, strive to develop high-speed railway, limit build speedway as well.

German reduction of CO_2 emissions depends on energy structure and energy intensity. Not only does the German government emphasize energy structure, but also the adjustment of energy intensity. In recent years, however, worrying about the safety of nuclear energy, Germany uses it more and more carefully. For example, German government decided shut nuclear plants in stages in 1999, so it made Germany has much less adjustment related to energy structure than France

UK, Canada, Italy and Japan UK places development of low carbon (LC) economy in significantly strategic position. UK took the lead in proposing the concept of LC economy in British Energy White Paper in 2003, and aiming at promoting its economic recovery through development of Green Economy, it also proposes a "Green Stimulus Plan" recently. The per capita CO_2 emissions in UK declines slowly, and besides the obviously decline of energy intensity, the energy structure also adjusts slowly.

Italian per capita CO_2 emissions increase year by year. This is due to relatively slow decline of energy intensity, unreasonable energy structure, and boost of economic growth. Italian energy structure mainly bases on fossil energy (petroleum, natural gas, coal), which emits more CO_2, and its fossil energy proportion was from 85.87% to 95.40% between 1965 and 2006. It is the sole country whose consumption of fossil energy has an increasing proportion in G-7.

Canada gets rid of fossil energy gradually. In 2006, in Canada, 68.14% of energy consumption was fossil energy, and the energy structure had more effect on reduction of CO_2 emissions than

energy intensity for a time during 1990s. But Canadian energy intensity took first place in G-7, so its higher energy intensity limited the speed of CO_2 emissions reduction.

In recent years, Japan is committing itself to develop and apply energy savings technologies, improving energy efficiency, meanwhile actively putting strategies related to development of new energy sources into practice.

On the one hand, taking these actions, Japan conforms to the developing trend of LC economy, and strives to use its more advanced environmental technology and experience to seek the peak of the world economy. On the other hand, Japan guarantees the safety of energy by developing renewable energy sources and improving energy structure.

Conclusions

The CO_2 emission in different countries is mainly affected by economic scale and energy intensity. That is the increasing economic scale will facilitate CO_2 emissions, to the contrary the declining energy intensity and optimizing energy structure will reduce CO_2 emissions. In France, the optimizing energy structure is the foremost factor of CO_2 emissions reduction, whereas the effect related to energy structure in USA and Italy is very weak, which reflect the differences of national energy policies in different countries.

Whatever happens, developing LC Economy and reducing pollution emission need the adjustment and cooperation of energy intensity, energy structure and industrial structure. The reduction of energy intensity and optimization of energy structure undoubtedly rely on the productivity of clean energy in long term, and the clean energy has a characteristic of low or zero emissions. But suffering from funds and technology, countries have difficult in developing clean energy. Even France, whose clean energy take a big proportion, doesn't form a kind of mature industries now, compared with the development of hydrogen energy, solar energy and wind energy. For the near future, the CO_2 emissions reduction still needs the decline of energy intensity, which can not decline rapidly in short term but rely on the adjustment and cooperation of economic structure and industrial structure, so as to separate the use of energy from the reality of economic growth.

Although G-7 have announced CO_2 reduction policies and measures, but there are different CO_2 reducing-standpoints and benefits between developed counties and developing countries even among G-7. So these subjective factors mean that there are a lot challenges on the road of CO_2 emissions reduction.

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