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Analysis of South Korea's economic growth, carbon dioxide emission, and energy consumption using the Markov switching model

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ABSTRACT

Recently, many countries have been making an effort to reduce their carbon dioxide (CO_2) emission, and as part of such effort, the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Kyoto Protocol in 1997. South Korea is very likely to be included in the second batch of countries that must reduce their greenhouse gas emission after the end of the implementation of the Kyoto Protocol in 2012. Reducing the country's CO_2 emission, however, can have an impact on the economy. Therefore, in this study, the correlations between South Korea's economic growth, CO_2 emission, and energy consumption were analyzed. The analysis period was from Q1 1991 to Q4 2011, and the analysis methods that were used were regression analysis for the relational analysis among the various overall indices, and the Markov switching model for a more detailed analysis. The results of the analyses showed that South Korea's economic growth and CO_2 emission were coincidental. The correlation analysis of the country's economic growth and energy consumption showed a significant correlation between economic growth and fossil fuels, which emit CO_2, such as coal in the industrial sector, petroleum products in the industrial and transportation sectors, and liquefied natural gas (LNG) in the residential/ commercial and industrial sectors. It is expected that the results of this study will pave the way for the conduct of various researches on controlling the country's CO_2 emission management, and for suggestions for such to be given, such as policies for reducing the energy consumption in each sector, using the methodology proposed in this study.

Contents

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1. Introduction

For the last few decades, the global economic growth has caused various side effects, including climate changes due to global warming. Thus, the international interest in carbon dioxide (CO_2) emission is increasing. In 1997, the United Nations Framework Convention on Climate Change (UNFCCC) adopted the Kyoto Protocol, based on which many countries have exerted various efforts to reduce their CO_2 emission. As the implementation of the Kyoto Protocol will end in 2012, the world is now focusing on the post-Kyoto Protocol scenario. In particular, the world is waiting to see which countries will be included in the batch of countries that must reduce their greenhouse gas emissions in the post-Kyoto Protocol.

South Korea has achieved rapid economic growth over the last few decades. Its gross domestic product (GDP), which was USD 3892 million in 1960, soared to USD 1,116,247 million in 2011, making South Korea the 15th largest economic market in the world [1]. At the time that the Kyoto Protocol was adopted, South Korea was still considered a developing country and was thus not designated as a country that must reduce its greenhouse gas emission. South Korea's recent economic growth, however, is likely to make UNFCCC consider putting the country on the list of the second batch of countries that must reduce their greenhouse gas emission. Recently, many studies have begun considering the economic impact of each country's CO_2 reduction, and to minimize such impact, many studies have made an effort to determine the correlation between economic growth, CO_2 emission, and energy consumption [2].

Therefore, this study examined the correlation between South Korea's economic growth, CO_2 emission, and energy consumption. The analysis period spanned 84 quarters, from Q1 1991 to Q4 2011. In the case of CO_2 emission, because a sufficient amount of data on it is difficult to acquire as it is reported as annual data, it was limited in this study, and it was estimated from the amount emitted based on the primary energy consumption presented in a previous study [3].

For the progression of this study, regression analysis was used for identifying correlations between the overall indices, and the Markov switching model was used for a more detailed analysis. With the use of these two analysis methods, the correlation between economic growth and CO_2 emission was first analyzed, after which the correlation between primary energy consumption, which was used in estimating CO_2 emission, and economic growth was determined. Finally, the factors that affect the consumption of each energy source were identified and examined through the analysis of the trends of consumption of the energy sources related to economic growth, among the primary energy sources.

2. Motivation

A number of studies have been conducted that aimed to analyze the correlation between economic growth, CO_2 emission, and energy consumption. First, via autoregressive distributed lag (ARDL) cointegration analysis, Ozturk and Acaravci [4] analyzed the long-run and causal correlation between Turkey's CO_2 emission, energy consumption, and gross domestic product (GDP) between 1968 and 2005. The results that they obtained in their study showed that Turkey's CO_2 emission and energy consumption hardly affected its GDP. The results also showed that the country's GDP had only a slight impact on its CO_2 emission, and there was little evidence of a causal correlation between the country's CO_2 emission and its energy consumption.

Menyah and Wolde-Rufael [5] analyzed the correlation between the United States' CO_2 emission, its renewable- and nuclear-energy consumption within the period from 1960 to 2007 and GDP, using the granger causality test. The analysis results showed a bidirectional causality between the country's GDP and CO_2 emission, and a unidirectional causality between its GDP and renewable-energy consumption. On the other hand, no causality between the country's GDP and nuclear-energy consumption was shown. Finally, it was found that the country's nuclear-energy consumption affected its CO_2 emission but that its renewable-energy consumption did not.

Lotfalipour et al. [6] analyzed the correlation between Iran's GDP, CO_2 emission, and fossil fuel consumption within the period from 1967 to 2007, using the unit root test and the Granger causality test. The results showed a unidirectional causality between the country's consumption of petroleum products and natural gas, which emit CO_2, and the country's GDP, but no causality was shown between the country's total fossil fuel consumption and its CO_2 emission.

Hatzigeorgiou et al. [7] analyzed the correlation between Greece's CO_2 emission, GDP, and energy intensity (primary energy consumption per GDP) within the period from 1977 to 2007, using the multivariate co-integration and granger causality tests. The results showed a unidirectional causality between the country's GDP and its energy intensity or CO_2 emission.

Pao et al. [2] analyzed the correlation between Russia's CO_2 emission, energy use, and GDP within the period from 1990 to 2007, using co-integration and granger causality tests. Their study results showed that while there was a long-run equilibrium correlation between the country's CO_2 emission and Energy use, between the country's CO_2 emission and GDP. The correlation between Russia's CO_2 emission and energy use was elastic, and it was inelastic between the country's CO_2 emission and GDP.

Glasure and Lee [8] examined the causality between energy consumption and GDP in South Korea and Singapore from 1961 to 1999 using the co-integration and error-correction tests. In this study, a bi-directional causal relationship between energy consumption and GDP in South Korea was discovered.

Oh and Lee [9] analyzed the causal relationship between the energy consumption and economic growth of South Korea from 1970 to 1999 using the vector error correction model (VECM). This study used annual data on real GDP, energy consumption, capital, and labor and uncovered a long-term bi-directional causal relationship and a short-term unidirectional causal relationship between energy consumption and real GDP. On the other hand, another study of Oh and Lee [10] wherein data from Q1 1981 to Q4 2000 and VECM were used showed no causal relationship in the short term and a unidirectional causal relationship in the long term between energy consumption and real GDP.