Information and Communications Technology, Economic Growth, and Carbon Emission Levels: The Case of South Korea

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Abstract

The paper deals with the impact of information and communications technology on carbon emissions and economic growth in South Korea. The quarterly time series data from the first quarter of 1970 to the third quarter of 2010 (163 observations) are collected and retrieved from the Bank of Korea database. The paper examines long-run equilibrium relationships using cointegration techniques and Granger causality with vector error correction models. In directional causality tests, information and communications technology shows highly significant positive effects on economic growth and marginal effect on carbon emissions. Carbon emissions and economic growth exhibit an inverse relationship with each other; that is, carbon emissions have an inverse relation to economic growth and economic growth does not significantly affect carbon emissions in South Korea. We also note possible implications regarding growth policies and the information communications technology and "green" technology sectors for economies in the range represented by Korea's 1970 - 2010 data.

Keywords : green growth, green-tech, environmental management, information communications technology, economic growth, carbon emissions

JEL Classifications : O25, O33, O38, O41, O44

Ⅰ. Introduction

Since the early 1970s, South Korea has built up a remarkable record of economic growth and integration into the high-tech modern and knowledge economy. A competitive education system, a highly skilled and dedicated workforce, and the advance of information and communications technology are widely acclaimed as the key factors driving this knowledge economy. In recent years, however, a rapidly ageing population, international pressure for an environmental sustainability initiative, and widening gaps between and within industries are becoming increasingly apparent. Finding best solutions to these problems is one of the greatest challenges faced by the policymakers of South Korea today.

Economic growth is the increasing ability of a nation to produce more goods and services. Growth can occur in many different ways: for example, the increased use of land, labor, capital, and business resources and increased productivity of existing resources. The use of information and communications technology can facilitate the production of goods and services more efficiently and rapidly. Information and communications technology infrastructure provides the framework for the efficient delivery of goods and services, improves communications between firms, and spreads to other industries. This further improves the impact of information and communications technology in contributing to the economic growth of a country. The increased economic importance of information and communications technology raises new questions for governments regarding the best policy frameworks to adopt in order to encourage information and communications technology-led green growth.

This paper therefore considers the sustainable growth prospects for South Korea. Does the growth of the information communications technology sector affect economic growth? Does the growth of the information communications technology sector cause the increase of carbon emissions? These are vital questions if we are explicitly to disentangle the effect of information and communications technology on both environmental sustainability and economic growth in South Korea.

Ⅱ. Literature Review

2.1. Information Communications Technology and Economic Growth

Economic growth reflects the ability of a nation to produce more goods and services. The use of information communications technol-

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ogy infrastructure and productsenables goods and services to be produced and provided more efficiently and rapidly (Lam & Shiu, 2010). Information communications technology infrastructure and products provide a framework for the efficient delivery of goods and services, improve communications between firms, and spread to other industries, thereby contributing to overall economic growth (Koutroumpis, 2009). They ease in the trade of goods and services and the creation of new businesses and jobs (Arvanitis & Loukis, 2009; Carayannis & Popescu, 2005). Their diffusion has not only facilitated market competition but also attracted a lot of domestic and foreign investment into the economy. It has been recognized that the advancement of information communications technology is one of the driving forces of globalization and the rapid growth of the world's new economy (Al-mutawkkil et al., 2009; Meng & Li, 2002; Van Ark, 2002). Hence, the information communications technology sectorin many countries continues to attract the interest of their governments in view of its potential to contribute to economic growth.

Many studies have reported that the information communications technology sector is one of the main drivers of better economic growth and sustainable growth (Daveri & Silva, 2004; Lipsey & Carlaw, 2004) and higher productivity (Laursen, 2004; Plepys, 2002). Thompson and Garbacz (2007) reported that the growth of the information communications technology sector has a significant positive impact on productivity growth for the world as a whole by improving the efficiency of how it and other resources are used. The broad conclusion of these studies is that a positive and significant link exists between the information communications technology sector and economic growth on the country level.

Many studies have reported that the information communications technology sector plays an important role in economic growth, in particular, in the United States (Cronin et al., Gold, 1991 Wolde-Rufael, 2007) and in South Korea (Yoo & Kwak, 2004).They find that although causality is generally in both directions, the information communications technology sector more strongly precedes the economic growth of the nation. They report that the growth of the information communications technology sector plays an important role in economic growth. To conclude, this study expects that the information communications technology sector will play an important role in economic growth. Accordingly, the following hypothesis is considered:

Hypothesis 1: The information communications technology sector leads to economic growth.

2.2. Economic Growth and Carbon Emissions

Is there a relationship between carbon emissions and economic development? The question is whether or not emission levels are connected with development levels. This line of research argues that the relationship between economic activity and carbon emissions may change as the economy moves through different stages of development. Economic activity may be a key driver of carbon emissions. Economic growth is often associated with high carbon emissions per unit of output. Many studies have examined the time-series dynamics between economic growth and carbon emissions to infer the direction of causality cross-country (Coondoo & Dinda, 2008; Lee & Lee, 2009; Luzzati &Orsini, 2009). The general consensus of these studies is that there is a close correlation between economic growth and environmental degradation: when an economy grows, the quality of the environment declines.

This trend can be demonstrated by charts of human population, economic growth, and environmental indicators. A plethora of literature (Schneider et al., 2000; Swart et al., 2003; Wilbanks, 2003) introduced the relationship between sustainable development and climate change with the emphasis on the degree to which climate change mitigation can have so-called co-benefits. These effects contribute to the sustainable development goals of the economy in question.

However, a theory of how economic growth does not always contribute to environmental degradation is proposed. Grossman and Krueger (1995) propose the environmental Kuznets curve hypothesis that postulates that the relationship between economic development and the environment resembles an inverted U-curve. Many researchers provide extensive reviews and empirical studies of the hypothesis (Dinda, 2004; Martinez-Zarzoso & Bengochea-Morancho, 2004; Soytas & Sari, 2009; Stern, 2004), especially in the United States (Soytas et al., 2007), in Turkey (Akbostanci et al., 2009) and in India (Managi &Jena, 2008). However, the empirical evidence remains mixed and is still inconclusive to date because a higher national income does not necessarily warrant greater efforts to contain the emissions of pollutants.

Some researchers have examined the time-series dynamics between economic growth and carbonemissions to infer the direction of causality. This question has been formulated in terms of causality and different econometric techniques have been used to examine the possible causal linkages between these two variables, for example, in the Commonwealth of Independent States (Apergis & Payne, 2010) and in developed countries (Coondoo & Dinda, 2002). However, the empirical results of the relationship between economic growth and carbon emissions are mixed.

In this regard, many researchers employ a combined approach by examining the dynamic relationships between economic growth, energy resource use, and carbon dioxide (CO_2) emissions together, especially in the EU (Keppler &Mansanet-Bataller, 2010), in Asian-Pacific countries (Niu et al., 2011), in France (Ang, 2007), in India (Ghosh, 2010) and in China (Zhang &Cheng, 2009). They find that economic growth is closely related to CO_2emissions, especially in the recent decade in emerging economies. In sum, it is expected that higher economic growth may require greater energy resource use and thus result in high CO_2emissions. Given all these existing findings, the following hypothesis is considered:

Hypothesis 2 : Economic growth is related to an increase in CO_2 emissions.

2.3. Information Communications Technology and Carbon Emissions

The relationship between the information communications technology sector and CO_2 emissions may be jointly determined because higher growth of the information communications technology sectorrequires more energy consumption. A combined approach of the joint impact of energy consumption and environmental degradation on economic growth has emerged to examine dynamic relationships between economic growth, energy consumption,and environmental degradation (Bowden & Payne, 2009; Pao & Tsai, 2010). The results of the links are however inconclusive. The results of those studies show that there are different causal links between energy consumption, economic growth and CO_2emissions at different stages of economic development in different countries (Dinda & Coondoo, 2006; Huang et al., 2008; Soytas & Sari, 2009).

The relationship between energy consumption with the particular sectors of the economy and environmental degradation has not gained much attention. The information communications technology sector is one of them. So far, there is no systematic time series that analyses the relationship between the information communications technology sector, CO_2emissions and economic growth. The development of information communications technology infrastructure and the use of information communications technology products can contribute to economic growth while leading to an increase in energy consumption. For example, the increased use of information communications technology products and the development of information communications technology infrastructure result in higher demand for energy which may lead to an increase in CO_2 emissions. Hence, the following hypotheses are formulated:

Hypothesis 3: The growth of the information communications technology sector is related to an increase in CO_2 emissions.

Hypothesis 4: There is a long-run equilibrium relationship between the information communications technology sector, economic growth and CO_2 emissions.

Ⅲ. Methodology

3.1. Data

This section describes data and outlines the methodology used in the development or selection of indicators and the normalization of data.

CO_2. CO_2emissions are those stemming from the burning of fossil fuels and the manufacture of cement in million metric tons. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels, and gas flaring. These statistics are collected and published by the International Energy Agency. The data used in the model are on a quarterly basis, transformed from the annual data reported by the International Energy Agency.

GDP. GDP is used to measure economic growth. GDP represents gross domestic product at market prices in billion Korean won.These statistics are collected and published quarterly by the Bank of Korea.

Information communications technology. Information communications technology represents the economic output of the information communications technology industry at market prices in billion Korean won, including communication and publishing, broadcasting, film, and information services. These statistics are collected and published quarterly by the Bank of Korea.

Electricity. Electricity represents the economic output of electricity supply at market prices in billion Korean won. These statistics are collected and published quarterly by the Bank of Korea.

Manufacturing. Manufacturing represents the economic output of manufacturing sectors at market prices in billion Korean won, including production of food, beverages, and tobacco; textiles and leather; wood, paper, publishing, and printing; petroleum, coal, and chemicals; non-metallic mineral products except petroleum and coal; metal, fabricated metal products; machinery equipment; electrical and electronic equipment; precision instruments; transport equipment; and furniture and other manufacturing industries. These statistics are collected and published quarterly by the Bank of Korea.

The two series of electricity and manufacturing are included in the model as control variables. All five series of economic data are collected and retrieved from the Bank of Korea Economic Statistics System database (http://ecos.bok.or.kr/). The sample is restricted to those periods in which quarterly data are available from the first quarter of 1970 to the third quarter of 2010 (163 observations).

Normalization of the data is necessary before any aggregation can be made. It is important to transform the values to the same unit of measurement as CO_2 emissions are expressed as a metric ton whereas the other indicators are expressed as billion Korean won. In addition, the time series are seasonally unadjusted. Therefore, transformation into a natural log mitigates any possible distortions of dynamic properties of the series. Table 1 displays descriptive statistics along with various summary statistics for the time series. Figure 1 displays the line chart of growth trends of major indicators. Table 2 displays the results of Pearson correlation analysis among the time series.

Table 1. Descriptive Statistics of Data

	CO_2[1]	GDP	ICT[2]	Electricity	Manufacturing
Mean	65.5	*108,306*	*3,091*	*1,804*	*23,148*
Median	57.3	*91,567*	*1,124*	*1,153*	*17,373*
Maximum	128.8	*262,432*	*11,292*	*6,525*	*74,343*
Minimum	13.1	*12,807*	*51*	*49*	*1,031*
Std. Dev.	39.8	*77,069*	*3,613*	*1,751*	*20,457*
Observations	163	*163*	*163*	*163*	*163*

Note: All units are in billion Korean won. [1] CO_2 is in million metric tons. [2]ICT refers to information and communications technology.

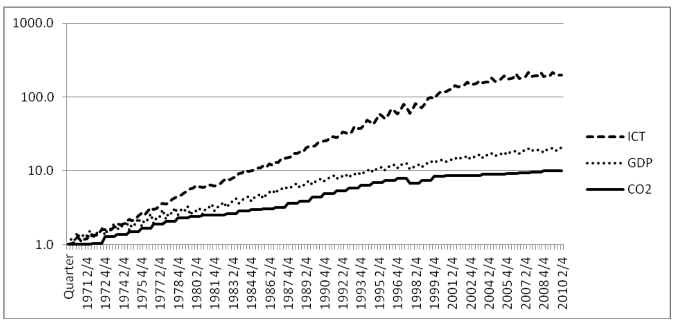

Figure 1. Line Chart of Growth Trends of Major Indicators (Logarithmic scale in X axis)

Table 2. Results of Pearson Correlation Analysis

	GDP	CO_2	ICT	Electricity	Manufacturing
GDP	*1.000*				
CO_2	*0.991****	*1.000*			
ICT	*0.993****	*0.992****	*1.000*		
Electricity	*0.993****	*0.992****	*0.938****	*1.000*	
Manufacturing	*0.995****	*0.991****	*0.982****	*0.993****	*1.000*

Note: ***, p-value < 0.01, Correlation is significant at the 0.01 level (2-tailed).

3.2. Unit Root Test

A time series is said to be stationary if the autocovariances of the series do not depend on time. The formal method for testing the stationarity of a series is the unit root test. There are several well-known tests for this purpose which are based on individual time series. They are the augmented Dickey-Fuller (1979), Phillips-Perron (1988), the GLS-detrended Dickey-Fuller (Elliott et al., 1996) and Ng-Perron's (2001) unit root tests. The unit root tests described above test the null hypothesis: a series has a unit root (non-stationary). The optimal lag in the augmented Dickey-Fuller test is automatically selected based on the Schwarz information criterion and the bandwidth for the Phillips-Perron test is automatically selected based on theNewey-West estimator (Newey & West, 1994) using the Bartlett kernel function. Kwiatkowski et al. (1992) propose a different approach from the unit root tests described above in that the series is assumed to be stationary under the null hypothesis.

3.3. Cointegration Test

Engle and Granger (1987) point out that a linear combination of two or more non-stationary series may be stationary. If such a stationary linear combination exists, the non-stationary time series are said to be cointegrated. The stationary linear combination is called the cointegrating equation and may be interpreted as a long-run equilibrium relationship betweenthe variables. There are several tools for testing for the presence of cointegrating relationships among non-stationary variables in a multivariate setting. They are the Johansen (1991) cointegration test, and the Engle-Granger (1987) and Phillips-Ouliaris (1990) residual-based cointegration tests.

The Johansen procedure uses two ratio tests, a trace test and a maximum eigenvalue test, to test the number of cointegration relationships. Both can be used to determine the number of co-integrating vectors present, although they do not always indicate the same number of cointegrating vectors. If trace statistics and maximum eigenvalue statistics yield different results, the result of the maximum eigenvalue test is preferred because of the benefit of carrying out separate tests on each eigenvalue.

3.4. Granger Causality Test

The conventional modeling techniques for testing the direction of Granger causality in a multivariate setting employ vector autoregressive and vector error correction models. Engle and Granger (1987) and Granger (1988) report that if two or more variables are cointegrated, there always exists a corresponding error correction representation in which the short-run dynamics of the variables in the system are influenced by the deviation from equilibrium. The vector error correction model is a technique that captures both the dynamic and the interdependent relationships of regressors, and corrects a disequilibrium that may shock the whole system.

The vector error correction model can distinguish between short-run and long-run Granger causality because it can capture both the short-run dynamics between the time series and their long-run equilibrium relationship. The long-run causality is implied through the significance of the t-statistics of the lagged error correction terms. The short-run Granger causality in the vector error correction model can be tested by the Wald test. The Block exogeneity Wald test in the vector error correction system provides Chi-squared statistics of coefficients on the lagged endogenous variables, which are used to interpret the statistical significance of coefficients of the regressors. The hypothesis in this test is that lagged endogenous variables do not Granger-cause the dependent variable.

Ⅳ. Results of Hypothesis Testing

Table 3 reports the results of unit root tests. The null hypothesis of a unit root cannot be rejected in the level of the series, but all null hypotheses of a unit root are rejected in the first difference of the series. The results in Table 3 unanimously confirm that all series are integrated in the order of one (1).

Table 3. Results of Unit Root Test

Methods	GDP(0) GDP(1)	CO_2(0) CO_2(1)	ICT(0) ICT(1)	Electricity(0) Electricity(1)	Manufacturing(0) Manufacturing(1)
ADF test	*-2.206* *-3.576****	*-2.513* *-4.727****	*-2.457* *-3.931****	*-2.470* *-3.798****	*-2.373* *-5.715****
PP test	*-2.379* *-48.222****	*-2.254* *-14.564****	*-2.453* *-16.560****	*-2.376* *-33.358****	*-2.159* *-27.463****
DF-GLS	*0.823* *-2.481***	*1.125* *-3.665****	*0.795* *-3.566****	*0.990* *-2.675***	*1.071* *-2.477***
NP test	*3.764* *-2.632***	*3.830* *-5.853****	*6.543* *-4.896****	*1.493* *-2.730***	*1.415* *-2.586***
KPSS test	*1.571**** *0.331*	*1.549**** *0.313*	*1.576**** *0.336*	*1.574**** *0.334*	*1.556**** *0.327*

Note: In the ADF, PP, and DF-GLS tests, probability values for rejection of the null hypothesis are employed at the 0.05 level based on MacKinnon (1996) one-sided p-values. In the NP test, probability values for rejection of the null hypothesis are based on the Ng and Perron (2001) p-values. In the KPSS test, probability values for rejection of the null hypothesis are based on the Kwiatkowski, Phillips, Schmidt, and Shin (1992) LM statistic p-values (***, p-value < 0.01 and **, p-value < 0.05).

Table 4 reports the results of the Johansen cointegration test and reports that the trace statistic and the maximum eigenvalue statistic are larger than the critical values; the trace test indicates at least three cointegrating vectors at the 0.05 level whereas the maximum eigenvalue test indicates at least one cointegrating vector at the 0.05 level. The results indicate that there exists at least one cointegrating relationship among the variables at the 0.05 level. Therefore, Hypothesis 4 that there is a long-run equilibrium relationship between the information communications technology sector, CO_2 emissions, and economic growth is supported.

Table 4. Results of Johansen Cointegration Test

Number of cointegrating equations (r)	Trace statistic	Maximum eigenvalue statistic
r = 0	*114.196****	*54.621****
r ≤ 1	*59.574****	*24.234*
r ≤ 2	*35.340***	*18.159*
r ≤ 3	*15.181**	*10.609*
r ≤ 4	*3.140*	*3.140*

Note: The probability value for rejection of the null hypothesis of no cointegration is based on the MacKinnon-Haug-Michelis (1999) p-values (***, p-value < 0.01, **, p-value < 0.05, *, p-value < 0.1).

Table 5 and 6 report the results of Granger causality tests using vector error correction models. In testing Hypothesis 1 that the information communications technology sector leads to economic growth, Table 5 and 6 show that the information communications technology sector has a positive effect on economic growth and is statistically significant at the 0.01 level. It also suggests that a 1% increase in the information communications technology output increases economic growth by 0.233%.

Hypothesis 2 tests whether there is directional causality between economic growth and CO_2 emissions. The results indicate that there exists an inverse relationship between CO_2 emissions and economic growth. For example, a 1% increase in economic growth increases CO_2 emissionsby -0.331%. This finding confirms the environmental Kuznets inverted U-curve hypothesis that when rising incomes pass beyond a turning point environmental pollution levels begin to decline as higher national income warrants greater efforts to control the emissions of pollutants.

Hypothesis 3 that the growth of the information communications technology sector leads to the increase of CO_2emissions is not supported and is not statistically significant. A negative effect of the information communications technology sector on CO_2 emissions shows that a 1% rise in the information communications technology output reduces CO_2 emissions by 0.010%.

Table 5. Results of Granger Causality Test

	"X"/ "Y"	GDP	CO_2
Long-run dynamics	*ECT*	*-0.774 (6.551)****	*0.416 (5.936)****
Short-run dynamics	*GDP*		*-0.109 (1.725)*
	CO_2	*-0.331 (2.405)***	
	ICT	*0.233 (3.921)****	*-0.010 (0.297)*
	Electricity	*0.317 (6.308)****	*-0.003 (0.103)*
	Manufacturing	*0.536 (4.965)****	*0.030 (0.471)*
Adjusted R-squared		*0.803*	*0.318*
F-statistic		*109.995*	*13.439*

Note: The probability value for rejection of the null hypothesis is employed at the 0.05 level (***, p-value < 0.01 and **, p-value < 0.05).

Ⅴ. Discussion and Policy Implications

The results indicate that information and communications technology has played a leading role in fostering environmental and social sustainability within both its own sector and the overall economy and at the same time is an important contributor to the sustainable growth of South Korea. On the other hand, economic growth may drive technological change, increase efficiency, and foster the development of institutions and preferences more conducive to environmental protection and emission mitigation. Comparing the trends in

Table 6. Results of Hypothesis Test

Hypothesis	t-statistic	Results
H1: The information communications technology sector leads to economic growth.	3.921***	*Supported*
H2: Economic growth is related to an increase in CO_2 emissions.	-2.405**	*Supported*
H3: The growth of the information communications technology sector is related to an increase in CO_2 emissions.	0.297	*Not supported*
H4: There is a long-run equilibrium relationship between the information communications technology sector, economic growth and CO_2 emissions.	5.936***	*Supported*

Note: The probability value for rejection of the null hypothesis is employed at the 0.05 level (***, p-value < 0.01 and **, p-value < 0.05).

the efficiency of energy use by the information communications technology sector and CO_2 emissions per unit GDP change in South Korea, this study demonstrated the importance of technological progress in the path of energy saving and CO_2emission reduction, thereby facilitating useful policy decisions.

Specifically, the results of this study suggest there may be an alternative "way out" of what may be a false dilemma of having to choose between economic growth or environmental protection, at least for countries in similar economic range as represented by the last forty years of Korea.

Conventional thinking:

Generalized economic growth is produced as a result of making increased carbon emissions, an undesirable environmental effect. Therefore a painful choice must be made to protect environment by slowing or stopping generalized economic growth via government policy.

New thinking:

Generalized economic growth can be produced by making decreased carbon emissions, a desirable environmental effect, plus the presumed benefits of economic growth itself. Therefore a choice does not have to be made between generalized economic growth and environmental protection. Growth of the information communications technology sector may be an especially effective tool to ramp economic growth in addition to its other presumed benefits, with proven marginal effect on carbon emissions.

The study's results should be seen as neither supporting nor disconfirming the environmental Kuznets curve ("inverted U-curve") proposed by Grossman and Kreuger (1995) and others and with mixed empirical support to date. Because the study looked only at data representing Korea from 1970 – 2010, the possibility still exists that a study of earlier data from Korea's economy would have found a positive relationship between carbon emissions and economic growth, which would be consistent with an interpretation that Korea's economy for some period prior to 1970 demonstrated the claimed first part of the Kuznets curve where environment worsens as the economy grows.

What is clear for however for the 1970 – 2010 range studied is that there is a positive relation between generalized national economic growth in Korea and less carbon emissions. The study shows as well that an information communications technology policy should be considered a leading area to address for achieving twin goals of continued economic growth (and its related aspects such as quality employment and positive trade balances) and environmental quality.

Furthermore, given the Korean experience with information and communications technology as shown in this study, and given that its effects on environment and economic growth can also be logically envisioned, it may that the support of other forms of technology whose impact can be similarly envisioned, should also be considered as part of a unified national policy in this area, and their impact closely studied. This might especially include so called "green-tech" such as advanced solar cells, light emitting diodebased lighting, better batteries, better insulating materials, and software optimization of power conservation.

Certainly in the area of information and communications technology, and related fields such as semiconductor and materials science, the world is currently entering what is commonly referred to as the knowledge society, which is driven by information and intellectual products as the raw materials. In this context, the ability to transmit information over the information and communications technology infrastructure is a key resource for every nation's effective participation in the global information society and for addressing the environmental challenges. The information communications technology sector in South Korea could be an important enabler of sustainable and green growth in such a context. Its unique function as a key element of infrastructure for efficient industries and as a critical productivity enhancer is crucial for sustaining growth and laying the foundations for theeconomy that should be competitive in the long term. As an important contributor to the sustainable growth of South Korea, the information and communications technology sector seems to have played a leading role in fostering environmental and economic sustainability both within its own sector and as an industry-wide infrastructure.

Societies, businesses and citizens should all be scrambling for a more efficient and greener way to operate and grow. Supporting this pressing need is a growing consumer population and a proliferation of innovative services. Information and communications technology lends itself to new models of profitable services so businesses will find it lucrative to innovate in this space. The green use of information and communications technology, coupled with innovative business models and progressive policymaking, will play a critical role in the reduction of carbon emissions. Information and communications technology offerings could address environmental sustainability concerns in ways that can also be aligned with social and economic goals.

There is a growing role for the information communications technology sector in the pursuit of green or sustainable goals because government and local authorities alike are increasingly expected to focus on environmental sustainability. Goals include efficiency and social inclusion measures that can make a considerable contribution to the sustainability of programs and initiatives. Information and communications technology can facilitate smart energy and resourcemanagement and lead to the creation of new services that benefit company, society and government. Therefore, the government must design strategies that will allow the nation to move from its present processes of growth onto a path of green growth.

The discussion above implies that actors and actor coalitions are important and that there is increasing evidence of multilevel patterns of governance and transnational networks of influence on global environmental issues. Emphasis should be placed on sectors with high potential for green job creation or employment that contributes to protecting and preserving the environment (see above regarding "green-tech" sector). It is criticalto identifying how these activities can accelerate the transition to green growth. Although several social, economic and technological policies would produce an emission reduction, actual mitigation will require the implementation of policies to reduce CO_2 emissions.

Ⅵ. Conclusions

This study investigated a long-run equilibrium relationship and Granger causality between the information communications technology sector, CO_2 emissions, and economic growth in South Korea. The results indicate that the information communications technology sector has played a leading role in fostering environmental and social sustainability within both its own sector and the overall economy of South Korea. Comparing the trends in the efficiency of energy use by the information communications technology sector and CO_2 emissions per unit GDP change in South Korea, this study demonstrated the importance of technological progress in the path of energy saving and CO_2 emission reduction, thereby facilitating useful policy decisions.

New policies may be different from those pursued in the past as they not only have to lead to high growth rates but must also lead to rapid and sustained employment generation and structural changes in the industriesof the economy. Simultaneously, the challenge facing South Korea is how to develop policy responses to counter the effects of the current environmental problems and climate change and lay the foundations for robust and sustainable growth that generates employment and at the same time reduces CO_2emissions from industries. In order for such an approach to be implemented, empirical analyses are needed to estimate future associated emissions and the current and future mitigation potential of development actions. Policymakers can then weigh the emissions reduction potential against other sustainability aspects of the action when choosing the appropriate policy to implement.

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