Journal of Sustainable Development; Vol. 9, No. 1; 2016
ISSN 1913-9063 E-ISSN 1913-9071
Published by Canadian Center of Science and Education

Urbanization, Public Finance and Carbon Intensity – Based on Panel Data and Error Correction Model

Shih-Feng Tsai[1]

[1] Institute of Taiwan Studies, School of Public Policy and Management, Tsinghua University, Beijing, China

Correspondence: Shih-Feng Tsai, School of Public Policy and Management, Tsinghua University, Beijing 100084, China. Tel: 86-182-0101-8368. E-mail: a8565257@gmail.com

Received: October 19, 2015 Accepted: November 14, 2015 Online Published: January 26, 2016

doi:10.5539/jsd.v9n1p23 URL: http://dx.doi.org/10.5539/jsd.v9n1p23

Abstract

Aiming at six big emerging economies in the world, namely, China, United States, United Kingdom, Germany, France and Japan, this paper analyzes their carbon emission conditions based on the data of carbon emission, energy consumption and economic development during 1970—2008 from the statistics in the World Development Index Database (WDI) of the World Bank, and carries out empirical analyses based on theories & policies and driving factors of their low carbon economy. It is found that energy intensity, economic growth and urbanization progress exert more remarkable influences on carbon intensity, and the effect of carbon emission reduction depending on government fiancé is not sustainable. Thus, this paper is intended to explain that China needs more actively promoting green sustainable towns with its sustainable development, and developing urban low carbon industries and buildings for more civilized ecological towns.

Keywords: carbon intensity; urbanization; public finance; error correction model

1. Introduction

Since the reform and opening-up policy in 1978, China boasts its development at an annual growth rate of 9.8%. In 2013, China became the first big trading nation in the world. In recent years, nationwide large-scale hazy weather and PM2.5 have become hot topics as well, and a heavier price was paid just because of widespread pollution problem. From 2004 to 2010, its direct economic loss incurred by pollution had more than doubled. China has surpassed the US and became a big carbon emission nation in the world since 2005. It was wrongly blamed and became one of the nations which were under the huge pressure in carbon emission in the global climate harmonization and consultations. On the other hand, China is basking in the period of accelerated urbanization. The quest for development pattern of sustainable urbanization is the important basis for China to realize ecological civilization (Cai Qin, Liu Zhilin & Qi Ye,2008; Qiu Baoxing, 2008).

The same growth trend is distinct for total carbon emission and gross domestic product (GDP). Many scholars and policy makers at home and abroad drilled down the problem in different angles of view respectively based on their own conditions. These angles of view are: first is carbon emission's driving factors and its relation with economic growth; second is the ways and mechanism for low carbon economy, such as exploration of carbon trading and tax system; and third is cooperation and harmonized mechanism of carbon emission for all nations in global background (Yin Xiguo, 2008).

In empirical literatures about carbon emission, the environmental Kuznets curve (EKC) was used mostly for different analyses. The evidences proposed by Unruh and Moomaw (1998) indicated that the EKC didn't represent many nations' development in pollutant discharging trajectory. They mainly questioned the EKC mode of the "theory of income determination". The pollution trajectory for many countries was analyzed in a non-linear dynamic system. The non-linear time trajectory demonstrated the historical events happening in the same period and sudden changes of generalized incomes. However, there are quite a few of empirical literatures about relations of environment quality and economic development & income level, written by following scholars: Hettige, Lucas and Wheeler (1992), Holtz-Eakin and Selden (1992), Selden and Song (1994), Cropper and Griffiths (1994), and Vincent (1997). They found that the indexes related to environment pollution were not according with the EKC U-converted hypothesis. By trans-regional and time series data, Suri and Chapman (1998) found that the increase of energy demand for industrial products and industrialized countries' export finished products had been far higher than those stated in the environmental Kuznets hypothesis. The research results by Bruvoll and Medin (2003) show that lowering energy intensity was a most important mean for carbon dioxide decrement, whereas the importance for improving energy structure ranked only second to lowering energy intensity.

Until the late of the 1990s, China ushered in the acceleration phase of urbanization, with an urbanization rate of over 30%. The increasing level of urbanization means a transition from current agglomeration industry to agglomeration service industry, that is, readjustment of overall industrial structure. Moreover, the higher urbanization rate just means improvement of household consumption level as well as the supply of living standard. What is on earth the influence of urbanization on carbon intensity? Within the existing researches and discussions, this paper focuses on six big emerging economies in the world, namely, China, United States, United Kingdom, France and Japan, and carries out empirical analyses their carbon intensity and urbanization, financial expenditure and other driving factors based on the data of carbon emission, energy consumption and economic development during 1970—2008 from the statistics in the World Development Index Database (WDI) of the World Bank.

2. Data Analysis and Research Method

Based on statistical data, six countries—China, US, UK, Germany, France and Japan made up a bigger proportion in global carbon emission respectively. In overall tendency, the world's several biggest emitters had the changing proportions in total global carbon emission, and most of developed countries contributed to a decreasing proportion of carbon emission in recent years. This is mainly thanks to their earlier start of industrialization process and relatively rational industrial restructuring up to now. Fig. 1 shows changing proportions of carbon emission in the past 50 years from 1961 to 2009 for six economies.

China kept its total carbon emission rising mainly because its economy was ever-accelerated in recent years. Its carbon emission absolute value far ahead constituted a serious problem with its extensive economy development over years. The US had its total carbon emission declining after the 1970s. The reasons always rest in two aspects: one is its economic growth slowing down, the other is a great change in its economic structure—that its tertiary industry accounted for over 60% in GDP after the 1980s under a series of spurring and adjustment policies and measures. However, as a developed country, the America had still accumulated a great deal of carbon emission in the past two centuries of industrialization process. The United Kingdom, as the cradle of the world industrial revolution, first enjoyed the achievements from advancement of industrial civilization, and experienced resources, environmental costs and sufferings from traditional industry at the earliest. In addition, it is also the first nation advocating the "low carbon economy". In the 1960s, the United Kingdom first initiated readjustment of industrial structure, and allowed its economy towards sustainable low-energy development. After that, as the third big economy, Germany contributed to less in global carbon emission relatively. However, due to the statistical data at a span from East and West Germany Reunion in 1990 to 2009, the previously huge demand, especially in Germany's postwar recovery, should not be ignored for the high energy consumption industries in energy, steel, construction and auto manufacturing. Japan didn't show a significant decline in carbon emission like US, UK and Germany. On the contrary, it maintained the emission at a higher level at the beginning of 1960s, but ever up to 5.89% to the maximum. The main reason is that Japan recovered its economy gradually after postwar, and experienced a rapid development period. According to statistics, Japan enjoyed an annual average growth rate of industrial production which was as much as 13.6% during 1956—1973. This inevitably led to increase of its energy consumption and carbon emission. France presented a distinct decline in carbon emission from 2.98% in 1961 to 1.13% in 2009. As one of major world developed countries, Japan is now sitting at a relatively low proportion in carbon emission. This has more to do with its industrial structure, and energy conserves and consumption. The nuclear energy accounts for around 70% as its main energy, petroleum is the next, whereas coal is the least. So it contributes to less carbon emission relatively.

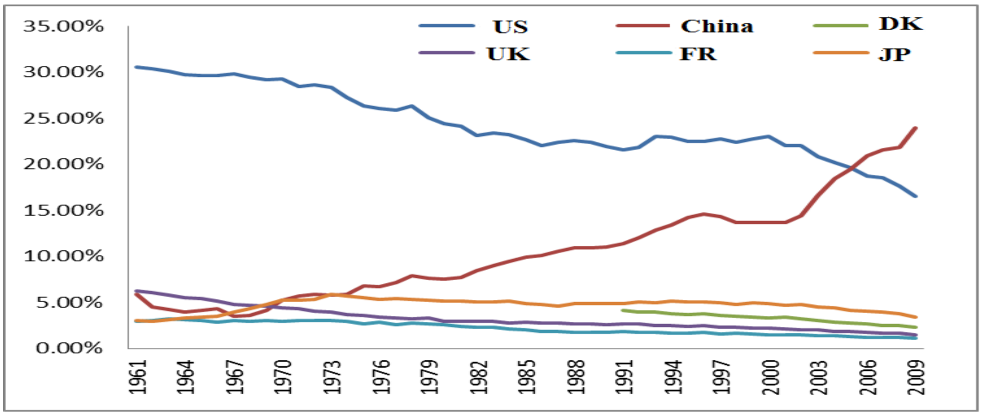

Figure 1. Proportions for some countries in total world carbon emission

Data source: World Bank's WDI database http://data.worldbank.org/data-catalog/world-development-indicators

Generally speaking, the carbon emission has a positive correlation with economic development for all countries. From the world average level, total carbon emission presents a same growth with GDP. From each nation's respective situations, total carbon emission for presents a decline with economic development for several European countries such as UK, Germany and France. Such other countries as China, US and Japan, both total emission and economic development increase in the same pace. This indicates these European countries have made great contribution to low carbon economic development in recent years.

This paper employs the panel data co-integration model for analysis. Due to less data but more variables in the model, all explaining variables are generally ones in model setting in order to ensure no distinguishing in freedom for "different slope coefficients for different explaining variables in various section individuals". In addition, the "cross—section specific" item is set as null value, and the intercept item is also applying the mixed variable model estimated. Finally, an integrated comparable analysis is done.

In this paper, the carbon intensity is selected as an explained variable to measure the relative relation of economic development and carbon emission. The formula is: carbon intensity = total carbon emission/the nation's GDP in the same period. The explaining variables are determined as six variables based on existing theoretical results: energy intensity, economic growth, urbanization progress, proportion of the secondary industry, degree of opening to the outside, and financial surplus or deficit proportion. Energy intensity refers to the energy consumption per unit of GDP. As a main source of carbon emission, energy consumption has a remarkable convergence with carbon emission in a great extent. The economic growth is a comprehensive measuring factor, including increase of production efficiency and technological advancement. In fact, it reflects the relation of carbon intensity and economic growth. The urbanization progress is measured by the proportion of urban population. It may be used to measure the relation of urbanizing process and carbon intensity. The proportion of secondary industry is the weight of industrial added value in GDP, and it is used to balance the influence of industrial structure changes on carbon intensity. The degree of opening to the outside is the proportion of total export-import volume in total GDP, and is used to weigh the impact of international merchandise trade on carbon emission intensity. Financial surplus or deficit proportion refers to the weight of financial surplus or deficit in GDP, and to estimate the governments' expenditure in energy conservation and emission reduction.

Based on the non-stability of time sequence for selected variables, this paper employs Johansen co-integration test rather than general OLS regression to find out the long-term con-integration relationship between carbon intensity and selected explaining variables. The basic form of its model is (long-term co-integration relation; not including China):

$$LCI_t = \beta_1 LEI_t + \beta_2 g\_GDP + \beta_3 Urb + \beta_4 DK_t + \beta_5 DG_t + \varepsilon_t \quad (1)$$

On the basis of the co-integration, the error correction model (ECM) is established for further analyzing the short-term fluctuation relation of variables.

Table 1. Selection and meaning of variables in model (Note 1.)

Variable	signification	Index Calculation	Unit
LCI	Carbon Intensity	Ln(Carbon emission/GDP)	Tons of CO2/USD thousand
LEI	Energy Intensity	Ln(energy consumption /GDP)	Ton of oil equivalent/USD thousand
g_GDP	Economic Growth	GDP growth rate	%
Durb	Urbanization Process	URBAN	%
DI	CR2	Industrial added value /GDP	%
DK	Degree of Openness	Import and Export volume/GDP	%
DF	Fiscal Deficit	fiscal deficit/GDP	%
Deb	Proportion of Loans	LOAN/GDP	%

3. All Nations' Regression Results

3.1 Long-term Co-Integration Analysis and Error Correction for China's Carbon Intensity Driving Factors

On Chinese government's fund support, this paper applies the proportion of financial expenditure in GDP for this study, so as to differ from the proportion of deficit as a variable used below for several countries. However, essentially there is no big difference in the two variables. The data were available during 38 years totally from 1971 to 2008. The available regression for time sequence data should meet data stability condition, Johansen co-integration test, and late long-term co-integration relation:

$$\widehat{LCI}_t = 0.7534LEI_t + 0.0478g\_GDP_t + 0.7574DK_t - 2.2373Urb_t - 2.4929DG_t$$

$$(18.4471) \quad (0.2327) \quad (8.0741) \quad (-6.1615) \quad (-6.6979) \qquad (2)$$

From the regression results, China's carbon intensity has a significant positive correlation with energy intensity and the degree of opening to the outside, and has a certain positive correlation with economic growth rate, but a certain negative correlation with urbanization degree and governmental financial expenditure. This result lives up to the general logic among social production, energy consumption, economic growth and environmental pollution. Concretely, the following relation exists between carbon intensity and explaining variables: The elastic coefficient between carbon intensity and energy intensity is 0.7534, i.e. in other things equal, one percentage of increase in energy intensity means 0.7534% up in carbon intensity; one percentage of GDP can lead to 0.0478% up in carbon intensity, with a less influence relatively; one percentage of increase in the degree of opening to the outside can cause 0.7574% up in carbon intensity; one percentage of increase in population of urban population may result in d 2.2373% down in carbon intensity; and one percentage of increase of government finance expenditure can cause 2.4929% down in carbon intensity.

It depends on stability of residual sequence that the long-term relation described by the regression equation is stable or not. The unstable residual sequence indicates that other variables can be used to explain the explaining variables. It is seen from the following graphs the residual sequence is stable roughly. (Note 2.) Thus, above long-term relation is stable by and large.

$$ECM_t = LCI_t - 0.7534LEI_t - 0.0478g\_GDP_t - 0.7574DK_t + 2.2373Urb_t + 2.4929DG_t \qquad (3)$$

The ECM model is built according to above long-term equilibrium relation: obtain the residual sequence ECMt first from the integration regression in co-integration test, then estimate the correction error model, and gain the ECM estimating equation as follows after removing indistinctive variable g_GDP and Age: (t value in bracket):

$$\Delta LCI_t = 0.9455\Delta LEI_t + 0.1823\Delta g\_GDP_t + 0.1926\Delta DK_t + 0.0027ECM_{t-1}$$

$$(9.509884) \quad (1.661087) \quad (1.543223) \quad (0.825095) \qquad (4)$$

This result shows that in the short term, the changes of energy intensity, economic growth rate and degree of opening to the outside have a positive influence on carbon intensity. In addition, the short-term adjustment coefficient becomes relatively significant, indicating that carbon intensity adjusts to the equilibrium state by 0.0027 as it deviates from the short-term fluctuation in a short-term fluctuation.

3.2 Long-term Co-Integration Analysis and Error Correction Model for the US Carbon Intensity Driving Factors

According to above same approaches, the US long-term co-integration relation is available as follows:

$$\widehat{LCI}_t = 0.8828 + 1.0523LEI_t + 0.2445DI_t + 0.1810DK_t(-1) - 0.1156DF_t(-1) + 6.9263Durb_t(-2)$$
$$(8.93) \quad (22.45) \quad (1.40) \quad (1.35) \quad (1.21) \quad (3.36) \qquad (5)$$

From regression results, the US carbon emission presents a significant positive correlation with energy intensity, proportion of secondary industry, first-order lag in degree of opening to the outside, and second-order lag in urbanization progress, but has a negative correlation with government financial surplus to some extent, that is to say, financial deficit is in a positive correlation with carbon intensity, i.e. excess financial expenditure doesn't cause the reduction of carbon intensity. This result is according with the general logic between social production, energy consumption and environment pollution in general. From US actual situations, both energy intensity and secondary industry are in a decreasing proportion. At the same time, its urbanization is up to quite a high level. So from the development trend, the combined effect of above factors cuts the US carbon intensity.

The ECM model is built according to above long-term equilibrium relation: obtain the residual sequence ECMt first from the integration regression in co-integration test, then estimate the correction error model, and gain the ECM estimating equation as follows after removing indistinctive variable g_GDP and Age: (t value in bracket):

$$\Delta LCI_t = 0.9612\Delta LEI_t + 0.3702\Delta DI_t - 0.2330\Delta DF_t(-1) - 1.3349ECM_{t-1}$$
$$(11.31) \quad (1.39) \quad (-1.81) \quad (-5.34) \qquad (6)$$

This result shows that in the short term, the changes of energy intensity, industrial structure and financial surplus or deficit for US have an influence on carbon intensity. In addition, as the short-term adjustment coefficient is negative and more significant, it means that the short-term fluctuation deviates from the long-term equilibrium, and will adjust to the equilibrium state by 1.3349.

Although the US leads the world in total carbon emission, its unit GDP carbon emission is at a lower level. This possibly benefits from the decreasing proportion of high energy-consuming industries in the US post-industrial age and rapid development of the service industry's low energy consumption.

From the long-term relation, the America's carbon intensity is affected mainly by energy intensity, economic structure and urban culture level. Both energy intensity and secondary industry have a decreasing proportion, but the urbanization has been up to quite a high level. Thus, from development trend, the combined effect of above factors made US carbon intensity decreasing. From a single nation, the United States has not too big pressure to cut emissions. On one hand, it had accumulated a huge of carbon emission in the past two centuries as a developed nation. This causes a very devastating consequence on the deterioration of global climatic environment. On the other hand, it extended its high energy consuming industry chain to other developing countries by taking advantage of its hegemonic position in global economy and politics. Thus, from actual consumption, the US has much more carbon emissions than the statistical data.

Finally, from the short term, the changes in America's energy intensity, industrial structure and financial surplus or deficit all have influences on carbon intensity. In addition, the short-term adjustment coefficient becomes relatively significant, indicating that carbon intensity adjusts to the equilibrium state by 1.3349 as it deviates from the short-term fluctuation in a short-term fluctuation.

3.3 Long-term Co-Integration Analysis and Error Correction Model for UK Carbon Intensity Driving Factors

The following long-term relation exists between carbon intensity, energy intensity, economic growth rate, industrial structure, population structure and degree of opening to the outside obtained by co-integration test (t statistical value in bracket):

$$\widehat{LCI}_t = 1.1314LEI_t - 0.6796g\_GDP_t - 1.3417DK_t + 0.9134DI_t + 0.8601Urb_t + 0.2408DG_t$$
$$(9.03) \quad (-2.547) \quad (-11.22) \quad (2.65) \quad (0.36) \quad (-0.68) \qquad (7)$$

From the regression results, UK carbon intensity presents an evident positive correlation with energy intensity, secondary industry proportion and urbanization progress, but has a negative correction to some extent with economic growth and degree of opening to the outside. This result is according with the general logic among social production, energy consumption, economic growth and environmental pollution. However, it is worth noting that UK carbon intensity has not a significant relation with government finance expenditure, and both are judged not to show a negative correction in sign. This is mainly because the British government has a lower financial expenditure, and its energy saving and emission reduction mostly benefit from adjustment of industrial structure rather than financial support. From UK actual conditions, the secondary industry was in a decreasing proportion all the time since the 1960s, and its urbanization stood at quite a high level. So from development trend, the combined effect of above factors made UK carbon intensity declining.

According to above long-term equilibrium relation, the ECM estimating equation gained after the indistinctive variables are removed is (t value in bracket):

$$\Delta LCI_t = 1.0869\Delta LEI_t + 0.6148\Delta DI_t - 0.251\Delta DK_t + 0.408\Delta DG_t - 0.0011ECM_{t-1}$$

(9.7298) (1.2037) (-2.65) (1.1204) (0.1717) (8)

This result shows that in a short term, the changes of UK energy intensity, secondary industry proportion, degree of opening to the outside and financial expenditure all have influences on carbon intensity. In addition, the short-term adjustment coefficient becomes relatively significant, indicating that carbon intensity adjusts to the equilibrium state by 0.0011 as it deviates from the short-term fluctuation in a short-term fluctuation.

First, from total global carbon emission, the UK carbon emission decreased from 6.24% in 1961 to 1.48% in 2009, a relatively less carbon dioxide discharged in economic development in near decades. At the same time, the UK unit GDP carbon emission was sitting at a lower level, too. From industrial distribution, the sectors with biggest pressure to cut emission for UK currently are electricity and thermal production. Traffic, residential construction commerce and public service sectors as well as manufacturing and building industries are in a second place.

Secondly, from a long run, the UK carbon intensity will go on declining. It is thus seen that the British doesn't have too big pressure to cut emissions. As a first industrialized nation, the UK takes the lead to carry out industrial restructuring, and proposes the development mode of "low carbon economy", so that it becomes an example for other nations in energy saving and emission reduction.

3.4 Long-term Co-Integration Analysis and Error Correction Model for Germany's Carbon Intensity Driving Factors

The regression for time series data requires satisfying co-integration test in data stability condition, and the following long-term relation exists between carbon intensity and variable (t statistical value in bracket):

$$\widehat{LCI}_t = 0.9345LEI_t - 0.0631g\_GDP_t - 0.0964DK_t + 0.5265DI_t - 0.8660Urb_t + 0.5119DG_t$$

(23.94) (-1.87) (-9.39) (13.12) (-2.45) (2.01) (9)

From regression results, Germany's carbon intensity has a more significant positive correlation with energy intensity and secondary industry proportion, but presents a negative correlation to a certain extent with economic growth, degree of opening to the outside and urbanization degree. It is worth noting that Germany's carbon intensity doesn't have a distinctive relation with government finance expenditure, and both are judged not to show a negative correction in sign. This is mainly because the German government has a lower financial expenditure, and its energy saving and emission reduction mostly benefit from adjustment of industrial structure rather than financial support. From Germany's actual conditions, the secondary industry was in a decreasing proportion all the time since the 1970s, and its urbanization stood at quite a high level. So from development trend, the combined effect of above factors made Germany's carbon intensity decline.

According to above long-term equilibrium relation, the ECM estimate equation gained in model building is (t value in bracket):

$$\Delta LCI_t = 1.097\Delta LEI_t + 0.034\Delta DK_t - 0.0044ECM_{t-1}$$

(13.62) (1.83) (-3.83) (10)

This result shows that in a short term, the changes of energy intensity and degree of opening to the outside both have influences on carbon intensity. In addition, the short-term fluctuation deviates from the long-term equilibrium, and will adjust to the equilibrium state by 0.0044.

First, Germany's total global carbon emission decreased from 4.12% in 1991 to 2.29% in 2009, a relatively less proportion in total global carbon emission as the third big economy—Germany. However, the statistical data were available from East and West Germany reunion in 1990 to 2009, the previously huge demand, especially in Germany's postwar recovery, should not be ignored for the huge demand of high energy consumption industries in energy, steel & iron, construction and auto manufacturing. From industrial distribution, currently Germany's departments with the biggest pressure to cut emissions are electricity and thermal production, the next are transport, residential construction commerce and public service sectors as well as manufacturing and building industries.

Second, from a long-term relation, Germany's carbon intensity is mainly affected by energy intensity, economic structure and urbanization level. Energy intensity, proportion of secondary industry both are in a decreasing trend, while urbanization is up to quite a high level. So from development trend, the combined effect of above factors keeps Germany's carbon intensity declining. However, its pressure for emission reduction is not optimistic as its automobile and manufacturing industries, which are two heavy industries with bigger energy consumption, are still pillar industries. Since European debt crisis in 2008, the Stability and Growth Pact carried out by the European Union requires its member states remain less than 3% of GDP in deficit, and the deficit has a less influence coefficient in emission reduction. As a result, it is less possible for Germany to realize energy saving and emission reduction only depending on financial disbursement.

3.5 Long-term Co-Integration Analysis and Error Correction Model for Japan's Carbon Intensity Driving Factors

The regression for time series data requires satisfying the co-integration test as a data stability condition. The following long-term relation is got between carbon intensity, energy intensity, economic growth rate, industrial structure, population structure and degree of opening to the outside (t statistical value in bracket):

$$\widehat{LCI}_t = 1.2817LEI_t - 6.005g\_GDP_t + 0.397DK_t + 3.188DI_t + 2.505Urb_t - 6.989DG_t$$

(22.86) (-8.55) (1.51) (3.03) (4.46) (-3.27) (11)

From regression results, Japan's carbon intensity has a more significant positive correlation with energy intensity, proportion of secondary industry, urbanization degree and degree of opening to the outside, but a negative correlation to a certain extent with economic growth and government finance expenditure. From Japan's actual conditions, the proportion of secondary industry has been in a decreasing trend since the 1970s, and its urbanization is at quite a high level. So from development trend, the combined effect of above factors can keep Japan's carbon intensity declining.

The ECM estimate equation is available after the indistinctive variables are removed from the variables in model (t value in bracket):

$$\Delta LCI_t = 1.036\Delta LEI_t + 0.243\Delta g\_GDP_t + 1.353\Delta Urb - 0.0042ECM_{t-1}$$

(9.42) (1.93) (-2.14) (-2.42) (12)

This result indicates that in a short term, the changes of Japan's energy intensity, economic growth rate and urbanization degree have influences on carbon intensity. In addition, the short-term adjustment coefficient becomes relatively significant, indicating that carbon intensity adjusts to the equilibrium state by 0.0042 as it deviates from the short-term fluctuation in a short-term fluctuation.

First, from total global carbon emission, Japan doesn't present an evident decreasing proportion in carbon emission like US, UK and Germany. On the contrary, it has kept the proportion at a higher level since the 1960s, and ever up to 5.89% to the maximum. This is mainly because Japanese economy is recovered gradually and experienced a rapid development period after the World War II. By statistics, the average annual growth rate for its industrial production was up to 13.6% during 1956—1973, which certainly led to an increase of its energy consumption and carbon emission. Currently, its electric and thermal production are the biggest sectors with the pressure to cut emission, next for manufacturing, building industries, as well as transport, residential construction commerce and public service departments.

Second, from the long-term relation, Japan's carbon intensity is mainly affected by energy intensity, economic structure, financial surplus or deficit level, economic growth rate and urbanization level. Energy intensity and proportion of secondary industry both stand in a decreasing trend, while its urbanization is up to quite a high level. So, from development trend, the combined effect of above factors keeps its carbon intensity declining. However, currently in Japan's energy consumption, petroleum is still in the highest flight, while clean energy remains in less proportion. From distribution of other industries, all sectors are in an increasing trend in carbon emission, so the carbon dioxide emission is not neglected yet. At the same time, the negative correlation of government financial surplus and carbon intensity means that financial deficit is positively correlated to carbon intensity, and over-much financial expenditure doesn't exert a good effect on emission reduction.

3.6 Long-term Co-Integration Analysis and Error Correction Model for France's Carbon Intensity Driving Factors

According to the co-integration test of time series, the following long-term relation is gained among carbon intensity, energy intensity, economic growth rate, industrial structure, urbanization degree and degree of opening to the outside (t statistical value in bracket):

$$\widehat{LCI}_t = 4.5226LEI_t + 1.5819g\_GDP_t + 3.2775DK_t + 6.9314DI_t + 8.7511Urb_t + 4.2609DG_t$$

$$(12.41) \quad (-1.41) \quad (-9.28) \quad (12.08) \quad (-12.06) \quad (2.77) \qquad (13)$$

From regression results, France's carbon intensity has a more significant positive correlation with energy intensity, proportion of secondary industry, economic growth, degree of opening to the outside, and urbanization degree. This result is by and large according with the general logic between social production, energy consumption, economic growth and environment pollution. However, it is worth noting that its carbon intensity has not a distinctive relation with government financial expenditure, and it is judged in sign that both do not present a negative correlation. This is mainly because France had a low government expenditure, and its energy saving and emission reduction mostly benefit from industrial restructuring rather than financial support.

According to above long-term equilibrium relation, the ECM estimating equation is got as follows after the indistinctive variable g_GDP and Age are removed (t value in bracket):

$$\Delta LCI_t = 1.252\Delta LEI_t + 0.6161\Delta g\_GDP_t + 3.833\Delta Urb_t + 0.0064ECM_{t-1}$$

$$(7.50) \quad (2.17) \quad (2.21) \quad (3.66) \qquad (14)$$

This result shows that in a short term, changes in France's energy intensity, economic growth and urbanization degree all have influences on carbon intensity. In addition, the short-term adjustment coefficient becomes relatively significant, indicating that carbon intensity adjusts to the equilibrium state by 0.0064 as it deviates from the short-term fluctuation in a short-term fluctuation.

From total global carbon emission, France's carbon emission presents a significant decreasing trend from 2.98% in 1961 to 1.13% in 2009, accounting for a relatively less proportion. This has a lot to do with industrial structure and energy reserves and consumption. France mainly operates nuclear energy, which makes up around 80%; petroleum is the next, and coal is the least. For this reason, it contributes to relatively less carbon dioxide emission. From industrial trend, the carbon dioxide emission from transportation sector in the 1980s went up year by year, and becomes a major carbon emission source at present. The carbon emission for residential construction commerce, public service, manufacturing and building industries as well as electric and thermal production departments started to decline to a lower level after it was at an increasing stage during 1961—1980. Currently, the transportation sector is faced with the biggest pressure to cut emission for France, next for residential construction commerce and public service sectors, manufacturing and building industries, electrical and thermal production departments.

From the long-term relation, France's carbon intensity is mainly affected by energy intensity, economic structure, urbanization level, economic growth and degree of opening to the outside. The energy intensity and proportion of secondary industry both are in a decreasing trend, and its urbanization is up to a higher level. So from development trend, the combined effect of above factors can keep its carbon intensity declining.

4. Comparative Analysis of Carbon Intensity Driving Factors for Six Nations

The long-term co-integration regression results are compared for six nations: China, US, UK, Germany, Japan and France, and the comparative results are put into their Panel Data Model.

Table 2. Cointegration model results

Coefficient	CH	US	UK	DE	JP	FR
C	-	0.8828	0.6725	0.4280	0.4349	-0.6564
LEI	0.7534	1.0523	0.9448	1.1097	1.1450	0.9531
g_GDP	0.0478	—	-0.5636	—	0.4606	—
Durb	(Urb) -2.2373	(lag 2)0.9263	—	3.7541	4.4105	7.4769
DI	-	0.2445	1.2661	0.2871	1.9662	4.0373
DK	0.7574	(lag 1)0.1810	-0.4341	-0.0754	-0.4935	—
DF	(DG) -2.4929	(lag 1)-0.1156	(lag 1)-0.2590	(lag 1)0.0890	-0.4021	(lag 1)-1.1126

Firstly, a positive correlation exists between carbon intensity and energy intensity for each nation. The energy intensity is measured by energy use amount per unit GDP. As what is measured in carbon emission is carbon dioxide released with all kinds of solid, liquid and gas fuel burning, so the more the energy use amount is, the bigger the carbon intensity is. From their actual conditions, carbon intensity all presents a decreasing trend.

Secondly, all nations show a different relation of carbon intensity and economic growth. From above results, this difference is mainly because of different driving factors of economic growth. In addition, the variable economic growth is removed as its trend and other nations' regression effect are not significant.

Thirdly, the influence of urbanization progress presents a positive correlation with carbon intensity for all nations. This is because there are more and more carbon emission sources with urbanization level increasing. Because the carbon emission from transportation and residents life in urban life is more than that of rural residents, carbon intensity and urbanization level present a positive correlation for the most part.

Fourthly, industrial structure and carbon intensity present a positive long-term correlation, which accords with general logic. This is because the industrial structure factor used in this paper is the added value proportion of secondary industry in GDP, while the secondary industry is also the biggest one with most consumption and carbon emission in economic production. From five nations' current trend, the secondary industry presents a decreasing proportion to different extents, and accordingly the carbon intensity goes down.

Fifthly, all nations have different influences of the degree of opening to the outside on carbon intensity. The main reason is there are different import or export commodities. Some nations have import trades in priority in foreign trade; the carbon emission in production for its imported high-carbon products is charged to the exporting country. Other nations are mainly oriented to export trade, and their exports are mostly the commodities with high energy consumption and carbon emission.

Finally, the financial surplus or deficit exerts different influences on all nations' carbon intensity. In US, UK, Japan and France, the proportion of financial deficit in GDP is proportional to carbon intensity, that is to say, over-much financial expenditure is mainly used to stimulate economic growth or other items rather than energy saving and emission reduction. So, deficit results in the effect of emission reduction. Exceptionally, Germany's financial deficit is negatively correlated to carbon intensity, and the deficit facilities emission reduction, but with a less coefficient. Meanwhile, as the financial deficit should not exceed 3% according to the Stability and Growth Pact implemented by the EU after the European Debt Crisis, it is less possible to realize energy saving and emission reduction by financial expenditure.

5. Panel Data Model Analysis for Six Nations' Carbon Emission Influencing Factors

After the regression results for above single model, the Panel Data Model is used for analysis in order to explicitly achieve the influencing factor of carbon intensity and their different expressions in different nations. The seven variable data related to carbon emission for six nations are: carbon intensity, energy intensity, proportion of secondary industry, degree of opening to the outside, economic growth rate, urbanization progress and government surplus or deficit.

In selecting the panel data model, different slope coefficients of these explaining variables in different cross section individuals are assumed in model setting in consideration of some nations' common and different grounds as well as their special explaining variables. When the EVIEWS is used for estimation, the variables DI and DF (-1) are assumed as "cross—section specific", and other explaining variables are set as "common coefficient". In addition, for the intercept item, the combined coefficient test can be done by the residual sum of squares of regression results. By this way, it is to determine whether there are different intercepts in different cross section individuals to select the mixing influencing model.

From the following regression results the model regression results are fairly satisfactory except that a few of variables t statistics are not too significant. Energy intensity, economic growth and urbanization progress all have a more positive influence on carbon intensity, but the degree of opening to the outside presents a negative influence on carbon intensity. From different cross section individuals, Germany's secondary industry proportion has a negative influence on carbon intensity, and other five nations' have a positive influence. From financial surplus or deficit, the coefficient for US, Germany and Japan is positive value, reflecting the inhibiting effect of financial deficit on carbon intensity. The things are opposite for other three nations.

Table 3. Panel data model results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.776607	0.069006	11.25424	0.0000
LEI?	1.020059	0.025803	39.53275	0.0000
DK?	**-0.134497**	0.052919	-2.541550	0.0130
G_GDP?	0.678955	0.257841	2.633230	0.0102
DURB?	3.078708	1.431180	2.151168	0.0345
CHN--DICHN	0.791834	0.125088	6.330204	0.0000
USA--DIUSA	0.719920	0.209633	3.434191	0.0009
GBR--DIGBR	0.754670	0.198017	3.811138	0.0003
DEU--DIDEU	**-0.983668**	0.184508	-5.331311	0.0000
JPA--DIJPA	0.484675	0.146973	3.297723	0.0015
FRA--DIFRA	2.754260	0.428311	6.430519	0.0000
CHN--DF1CHN	-83.20154	86.32713	-0.963794	0.3381
USA--DF1USA	**0.075771**	0.337639	0.224414	0.8230
GBR--DF1GBR	-0.316196	0.606474	-0.521368	0.6036
DEU--DF1DEU	**0.077683**	0.594031	0.130773	0.8963
JPA--DF1JPA	**0.318670**	0.309732	1.028859	0.3067
FRA--DF1FRA	-3.928261	0.436438	-9.000727	0.0000
R-squared	0.999067	Mean dependent var		-0.532663
Adjusted R-squared	0.998878	S.D. dependent var		0.870448
S.E. of regression	0.029154	Akaike info criterion		-4.073170
Sum squared resid	0.067147	Schwarz criterion		-3.619067
Log likelihood	212.5122	Hannan-Quinn criter.		-3.889614
F-statistic	5287.881	Durbin-Watson stat		0.799435
Prob(F-statistic)	0.000000			

From the relation of financial surplus or deficit with carbon intensity, the financial surplus or deficit coefficient is significantly negative only for US, Germany and Japan, that is to say, the decreasing effect of financial deficit on carbon intensity is only embodied for three countries. However, it is worth specifying that these nations' financial deficit all is standing a relatively higher level, and they are all faced with debt crisis. In a long run, the effect of carbon emission reduction only by financial deficit is not sustainable. On one hand, the self-regulation without market mechanism can make enterprises idle to initiatively carry out energy saving and emission reduction; the government's subsidy fund for energy saving and emission reduction may be appropriated for other purposes in lack of supervision, or looked as an extra welfare from governments by some operators. On the other hand, the amount supported by the governments is limited. European debt crisis and US fiscal Cliff both warned governments of expanding financial deficit by issuing national debt without limitations, and a nation's financial revenue and expenditure are involved in all aspects of social life. The governments may live frugally in other aspects by strengthening financial supports in energy saving and emission projects, which doesn't facilitate long-term economic development.

6. Conclusions

At first, from national level, there is a positive correlation between carbon intensity and energy intensity for each nation. However, no distinctive effect can be shown for economic growth for advanced nations; even if economic development reaches a certain level, the economic growth is improbable to increase carbon emission, but urbanization and industrial structure have a significant correlation with carbon emission.

Besides that, financial surplus or deficit can exert different influences on all nations' carbon intensity. This also indicates if the government doesn't have to apply its financial expenditure to improve environment, especially for advanced nations, so their overmuch financial expenditure is mainly used stimulate economic growth or other projects rather than energy saving and emission reduction. Therefore, deficit can't result in the effect of energy saving and emission reduction. However, as this is the regression calculation done in the past time, especially in recent years, all nations initiate the green industrial development and energy, so this part content can be regarded as the follow-up studies.

In conclusion, we may be explicitly aware that the urbanization progress accompanies the increase of carbon emission. In recent years, China is unceasingly making efforts to boost urbanization, and shortening the urban-rural difference. However, the environment pollution from extensive production has incurred a great deal of economic loss in recent years, whereas a new round of pollution occurs in advancing urbanization. Thus, China should drive economic transition by a new urbanization pattern, actively promote green sustainable towns with a sustainable development, and develop urban low carbon industries and buildings for more civilized ecological towns.

References

Beijing Shuhuitong. Environmental Technical Research Institute Co., Ltd. Retrieved from http://www.3edata.c

Brundtland, G. H. (1987). World commission on environment and development. *Our common future, 8*(9). http://dx.doi.org/10.1017/s037689290001523x

Cropper, M., & Griffiths, C. (1994). The interaction of population growth and environmental quality. *The American Economic Review, 84*(2), 250-254. Retrieved from http://EconPapers.repec.org/RePEc:aea:aecrev:v:84:y:1994:i:2:p:250-54

Friedl, B., & Getzner, M. (2003). Determinants of CO_2 emissions in a small open economy. *Ecological economics, 45*(1), 133-148. http://dx.doi.org/10.1016/s0921-8009(03)00008-9

Gao, T. M. (2009). *Metric-economic Analytic Methods and Model Building-Eviews Application and Practical Examples* (2nd ed.). (pp. 293,301,302). Beijing: Tsinghua University Press.

Hettige, H., Lucas, R. E. B., & Wheeler, D. (1992). The toxic intensity of industrial production: global patterns, trends, and trade policy. *The American Economic Review*, 478-481. Retrieved from http://www.jstor.org/stable/2117448

Holton. Eakin, D., & Selden, T. M. (1995). Stocking the fires? CO2 emission and economic growth. *Journal of public Economics, 57*, 85.101.

Liu, C. Q., & Qi Ye, Z. L. (2008). Challenges and Responses in Urban Governance Under Scientific Development.*Urban Studies, 15*(3), 144-149,155.

Liu, Q., & Zhao, P. S. (2012). Carbon emissions and economic growth of 15 major carbon emitters countries: an empirical analysis and comparative study. *Inquiry into Economic Issues*, (2), 137-144.

Ministry of Commerce <<United Kingdom industrial structure adjustment>> Retrieved from http://www.mofcom.gov.cn/aarticle/subject/chanyejishu/other/201201/20120107924959.html

Ministry of Environmental Protection of the People's Republic of China. (2008). Retrieved from http://www.mep.gov.cn

National Bureau of Statistics of China. (2007). Retrieved from http://www.stats.gov.cn/tjsj/ndsj/

Pan, S.-C. (2009). *Intermediate Teaching Course on Metric-Economics* (pp.164). Beijing: Tsinghua University Press.

Qiu, B. X. (2008). Creating a low carbon society to enhance national competitiveness--United Kingdom experience and enlightenment of greenhouse-gas emissions.*Urban Studies*, (2), 127-134.

Selden, T. M., & Song, D. (1995). Neoclassical growth, the J curve for abatement, and the inverted U curve for pollution. *Journal of Environmental Economics and management*, *29*(2), 162-168. http://dx.doi.org/10.1006/jeem.1995.1038

Selden, T. M., Forrest, A. S., & Lockhart, J. E. (1999). Analyzing Reductions in US Air Pollution Emissions: 1970 to 1990. *Land Economics, 75*(1), 1-21. Retrieved from http://www.jstor.org/stable/pdfplus/3146990

Shaw Daigee. (1993). The significance of sustainable development-economic viewpoint. *Taiwan Economic Forecast, 24*(1), 43-61. Retrieved from http://ir.sinica.edu.tw/handle/201000000A/945

Suri, V., & Chapman, D. (1998). Economic growth, trade and energy: implications for the environmental Kuznets curve. *Ecological economics, 25*(2), 195.208. http://dx.doi.org/10.1016/s0921-8009(97)00180-8

Unruh, G. C., & Moomaw, W. R. (1998). An alternative analysis of apparent EKC-type transitions. *Ecological Economics, 25*(2), 221-229. http://dx.doi.org/10.1016/s0921-8009(97)00182-1

Vincent, J. R. (1997). Testing for environmental Kuznets curves within a developing country. *Environment and Development Economics, 2*(4), 417-431. http://dx.doi.org/10.1017/s1355770x97000223

World Bank WDI data. Retrieved from http://data.worldbank.org/data-catalog

Yang, S.-C. (2008). The Characteristics and Measures of Energy Saving and Reducing the Emission of Pollution and Greenhouse Gases in Japan and the Problems It Faces. *Japanese Studies*, (1), 15-25.

Yin, X. G., & Hou, T. (2010). A Synthesis of Foreign Scholars' Research on Low Carbon Economy. *China Population Resources and Environement, 20*(9), 18-23.

Notes

Note 1. Due to data availability and optimization of models adjustments, this variable does not appear in the table results in each country, but the variables are listed in the table is the starting point of the analysis of influencing factors in carbon intensity of this article, and listed together here for convenience, national model analysis is not to dwell on this.

Note 2. The effect is bad for ECM unit root test of residual sequence. Here the hypothesis of residual weak stability may be accepted temporally in consideration of the different between model and theory. In fact, we are intended to add urbanization degree and population growth rate in modeling process, but the regression result is not improved yet.