Decoupling CO_2 Emissions from Economic Growth in Russia

Hsiao-Tien Pao*
Department of Management Science, National Chiao Tung University, Taiwan
htpao123@gmail.com
**Corresponding Author*

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Abstract

This paper examined the validity of Carbon Kuznets Curve (CKC) hypothesis within an Emission-Energy-Output (EEO) framework for the period of 1991 to 2016 in Russia. Russia has large mitigation potential to play a major role in the development and implementation of international climate policy as it is the 5^{th} largest carbon emitter country in the world. For the EEO model, the cointegration test results showed that a long-run equilibrium relationship exists among carbon emissions, energy consumption, and real GDP. The estimation results showed that emissions for real GDP are negatively inelastic, implying that the decoupling effect has already occurred and that there is no evidence to support the CKC hypothesis. The Russian economy has passed the turning point of the inverted U-shape. The results of this study may help Russia realize that real GDP growth will tend to curb carbon emissions; thus, making a significant contribution to combating global warming.

Keywords: Carbon Kuznets Curve (CKC), carbon emissions, Gross Domestic Product (GDP), Russia

1. Introduction

Climate change has potential long-term effects on residential environment and on economic development, especially in countries with large territories and long coastal line, such as Russia. The Russia Federation is a transcontinental country with 11 time zones and a great range of environments and landforms, from deserts to semi-arid steppes, to deep forests and Arctic tundra. The greenhouse effect is the main cause of climate change, while energy-related carbon dioxide (CO_2) emissions account for the majority of greenhouse gas emissions. Russia is the world's fifth largest CO_2 emitter, and one of the most important fossil fuel producers in the world (Climate Action Tracker, 2016). As a consequence, Russia has large mitigation potential, and should play a major role in international climate policy.

The argument that human society can decouple environmental pressure from economic growth is very attractive. If this decoupling is possible, it means that Gross Domestic Product (GDP) growth is a sustainable social goal. Absolute decoupling is the only way to achieve a truly sustainable growth (Ward et al., 2016). Decoupling CO_2 emissions from economic growth is usually investigated under the Carbon/Environmental Kuznets Curve (CKC/EKC) hypothesis (Riti et al., 2017; Marques et al., 2018; Pao & Chen, 2019). The CKC/EKC hypothesis assumes that CO_2 emissions initially increase in tandem with output, but decline at higher levels of output; an inverted U-shaped relationship between per capita CO_2 emissions and per capita income (Müller-Fürstenberger & Wagner, 2007; Kaika & Zervas, 2013). Due to the strong relationship between emissions and energy consumption, the study of the CKC hypothesis (decoupling) is important for the development and implementation of green economy policies under the framework of Emissions-

Energy-Output (EEO) model, which incorporates energy consumption with CO_2 emissions (Ang, 2007; Pao & Tsai, 2011a,b). In general, EEO can be framed as:

CO_2 = f (GDP, GDP^2, energy consumption)

The validity of the CKC hypothesis can vary depending on the country's attributes, research frameworks, or sample periods. In Russia, there is very little literature on CKC hypothesis, and few studies have investigated long-term data (10 years or more). This paper aims to fill this gap because of the disparities between the recent 10-year compound annual growth rate (CAGR) of emissions, energy consumption, and real GDP, and the recent 15-year or 20-year CAGR.

In the next section, the literatures on decoupling/EKC/CKC and EEO are examined. In the third section, the data sources and summary statistics used, and the current study's research hypotheses are presented. In the fourth and fifth sections, the research model and methodology, and the empirical results are described respectively. In the last section, the study's conclusion is provided.

2. Literature Review

One of the main goals of the 2030 Sustainable Development Agenda is to achieve absolute decoupling of environmental pressures and economic growth. Continued CO_2 emissions from energy use for economic growth are the main sources of environmental stress. In recent years, there has been a lot of literature discussing the issue of decoupling/CKC/EKC. Most studies done in G7 and European countries have found evidence of CKC, including those by Luo et al. (2017) in G20 panel, Shuai et al. (2017) in 164 countries panel, Can and Gozgor (2017) in France, Shahbar et al. (2017) in G7 (except Japan) and Dogan and Seker (2016) in top renewable countries panel; only the study by Dogan and Ozturk (2017) did not find evidence of CKC in the US. For the BRICS countries, Alam et al. (2016) and Nasr et al. (2015) did not find any evidence of CKC relations in India and South Africa respectively. Liu et al. (2016) found evidence of an N-shaped CKC in China and Yang et al. (2017) found evidence supporting the CKC in Russia during the period of 1998 to 2013.

For the EEO framework, Pao and Chen (2019) found evidence supporting the CKC hypothesis in G20. Meanwhile, Al-Mulali and Ozturk (2016), Dogan and Seker (2016), Bento and Moutinho (2016), and Kasman and Duman (2015) have found evidence in support of the CKC hypothesis in G7 and European countries. For the BRICS countries, Dong et al. (2018) and Riti et al. (2017) in China, Dong et al. (2017) in BRICS panel, Solarin et al. (2017) and Wolde-Rufael and Idown (2017) in China and India have found evidence of CKC. Pao et al. (2011) found no evidence of CKC in Russia during the period of 1990 to 2007.

Recent literatures on the linkage between Emissions, Energy, and Economy (3Es) (without discussing CKC) for sustainable development have also shown fruitful results. These studies include those by Han et al. (2018) in China, Saboori et al. (2017) in China, Japan, and South Korea, Saidi and Mbarek (2016) in 9 developed countries panel, Al-Mulali et al. (2015) in 23 European countries panel, Pao et al. (2015) in US, Pao and Fu (2015) in Mexico, and Pao et al. (2014) in the MIST countries panel. The present study explored Russia's CKC which may be particularly useful for the Russian government in terms of policy development for emissions reduction and environment and climate protection.

3. Data

This study collected annual per capita data for the period of 1991 to 2016 on Russia's real GDP from World Development Indicators (WDI), and CO_2 emissions and energy consumption from BP Statistical Review of World Energy (2017). Real GDP was measured in US dollars at 2010 prices; while CO_2 emissions, which are by-products of fossil fuel burning and cement manufacturing, were measured in metric tons of carbon dioxide ($MtCO_2$). Energy consumption was measured in metric tons of oil equivalent (Mtoe).

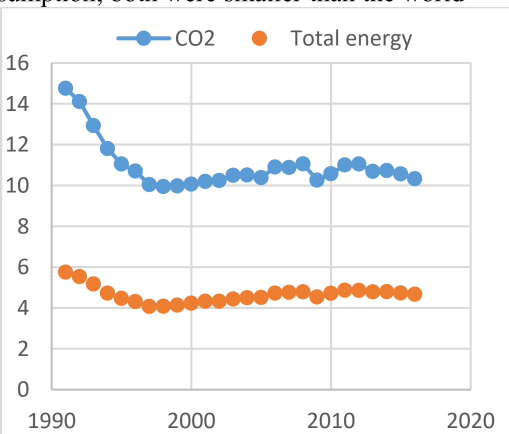
As shown in Figure 1, the trends in Russia's CO_2 emissions and energy consumption as well as real GDP started to decline beginning 1995 and continued to decline up to 1999; then, steadily increased starting year 2000. Table 1 shows the descriptive statistics of Russia's emissions, energy consumption, and real GDP. Table 2 shows the average percentage growth rate of each series before 2017. Different periods of growth rates were computed including 2001 to 2016 (15 years), 2006 to 2016 (10 years), and 2011 to 2016 (5 years). During the 15-year period (2001-2016), Russia's compound annual growth rate (CAGR) for per capita real GDP was 3.27%, which was considerably higher than the world trend (1.58%). In the same period, Russia obtained a CAGR of 0.09% per capita emissions, and 0.52% per capita energy consumption; both were smaller than the world CAGR of 0.90% for emissions and 1.15% for energy consumption, despite being the world's fifth-largest emitter of GHG after China, US, the European Union, and India. In addition, during the 10-year period (2006-2016), Russia's CAGRs per capita emissions and energy consumption were negative, while the rest of the world obtained positive values; and Russia's CAGR per capita GDP was higher than the world. Russia's negative CAGR per capita emissions and positive CAGR per capita GDP, imply that decoupling has already occurred. This shows that Russia has made huge progress in promoting sustainable development and in achieving the goals of the 2030 Agenda.

Based on Russia's descriptive statistics, the three hypotheses are proposed:

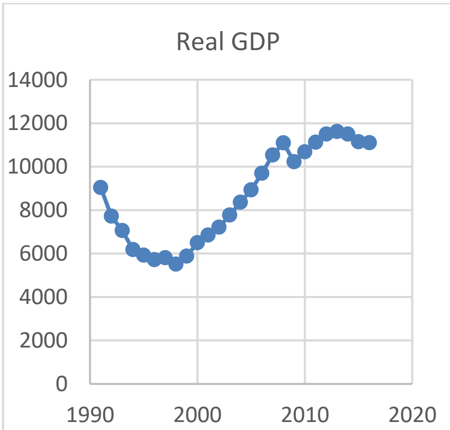
H1: There is no evidence that support CKC.

H2: There is a significant and negative correlation between real GDP and emissions.

H3: There is a significant and positive correlation between energy consumption and emissions.



(a)



(b)

Figure 1: Trends in the (a) Emissions and Energy Consumption, and (b) Real GDP of Russia, 1991-2016.

Table 1: Descriptive Statistics of Emissions, Energy Consumption, and Real GDP in Russia, 1991-2016

Variables	Mean	S.D.	Min.	Max.
Per capita Emissions ($MtCO_2$)	10.97	1.20	9.94	14.76
Energy (Mtoe)	4.65	0.40	4.07	5.75
Real GDP	8637.84	2216.03	5505.63	11493.73

Table 2: Average Growth Rates in Emissions, Energy Consumption, and GDP (shown in percentages): Russia *vs.* The World

	Russia			**The World**		
	Emissions	**Energy**	**GDP**	**Emissions**	**Energy**	**GDP**
15-year growth rate (2001-2016)	0.09	0.52	3.27	0.90	1.15	1.58
10-year growth rate (2006-2016)	-0.54	-0.12	1.37	0.07	0.56	1.25
5-year growth rate (2011-2016)	-1.26	-0.80	-0.04	-0.57	0.16	1.40

4. Research Model and Methodology

4.1 Model

Following the empirical literature in energy economics, the long-run relationship among CO_2 emissions, energy consumption, and economic growth in linear logarithm quadratic form can be calculated using Equation 1 to test the validity of the CKC hypothesis.

$$LCO_t = \beta_0 + \beta_1 LEC_t + \beta_2 LGDP_t + \beta_3 LGDP_t^2 + u_t \quad \text{Eq.1}$$

where:
t represents the time period (from 1991 to 2016,
LCO represents natural logarithm of per capita CO_2 emissions
LEC represents natural logarithm of total energy consumption
LGDP represents natural logarithm of real GDP
β_1, β_2, β_3 represent the elasticity of emissions to be estimated

Using Equation 1, if $\beta_2 > 0$ and $\beta_3 < 0$ then, the CKC hypothesis is said to be valid, and an inverted U-shape exists between per capita emissions and GDP, where the turning point of per capita GDP is $-\beta_2/2\beta_3$ in log-level. If the resulting value of LGDP is negative but significant, and $LGDP^2$ is negative and non-significant then, a monotonic relationship between per capita CO_2 emissions and per capita income exists (Halicioglu, 2009). It is expected that the value of LEC is positive because a high level of EC can lead to higher CO_2 emissions. Using this model, the long-run equilibrium among variables was examined.

4.2 Cointegration Methodology

To test the CKC/EKC using Equation 1, this study determined first the order of integration by performing three different unit root tests on each variable namely Augmented Dickey-Fuller (ADF, 1981), Phillips-Perron (PP, 1988), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS, 1992). The null hypothesis for ADF and PP is expressed as *the series is I (1)*; while for KPSS, *the series is I (0)*. The KPSS was used to complement the widely used ADF and PP tests to obtain robust results.

If all variables integrated in the same order, say I (1) then, they should be tested for cointegration. The presence of cointegration could avoid the spurious regression problem and could provide important economic information including the existence of a long-run equilibrium relationship among variables. The Johansen procedure is used to test cointegration among variables in Equation 1 (Johansen & Juselius, 1990).

5. Empirical Results

The results for the three unit root tests are shown in Table 3. All of the time series integrated at order one (i.e., *I* (1)); thus, this study conducted the Johansen cointegration test. Based on the results of the Johansen cointegration test shown in Table 4, per capita CO_2, energy consumption, and GDP are co-integrated, implying that there is a long-run equilibrium relationship among the three variables. The results are also consistent with the estimations for Equation 1.

Table 3: Unit Roots Tests Results, 1991-2016

	ADF		PP		KPSS	
	Level	**1st diff.**	**Level**	**1st diff.**	**Level**	**1st diff.**
LCO	-1.00	-2.88***	-1.42	-2.88***	0.15**	0.29
LEC	-1.32	-2.54**	-0.91	-2.40**	0.20**	0.27
LGDP	-0.22	-3.09**	-0.75	-3.09**	0.20**	0.29
$LGDP^2$	-0.21	-3.12***	-0.73	-3.15**	0.15**	0.21

Note: Significance at the 1% and 5% levels are denoted by *** and ** respectively.

Table 4: Johansen's Cointegration Test Result

No. of CEs	Eigenvalue	Trace Stat.	5% critical value	Max Eigen. Stat.	5% critical value
r = 0	0.77	56.40***	47.86	36.84***	2.58
r ≤ 1	0.40	19.56	29.80	12.91	21.13

Note: *** indicates rejection of the null hypothesis at the 1% level; r is the cointegration rank.

The values of both R^2 and JB statistic (Jarque & Bera, 1980) in Table 5 imply that Equation 1 can be used. In panel A, the coefficients of GDP and GDP^2 are statistically insignificant, and the variance inflation factors (VIF) for GDP and GDP^2 are also high, indicating the existence of multi-collinearity. The GDP^2 is then deleted from Equation 1 and the estimated results are shown in panel B of Table 5. The VIFs for LEC and LGDP are less than 2. Also, the LGDP coefficient is negative but statistically significant, implying that H1 and H2 are supported. Further, the LEC coefficient is positive and statistically significant, implying that H3 is supported. This means that emissions for energy consumption are positive, elastic, and emissions for real GDP are negative, inelastic. In addition, the results illustrate that an increase in real GDP will tend to curb carbon emissions and that there is no evidence to support the CKC hypothesis.

Table 5: Coefficients of Equation 1

	LEC	LGDP	$LGDP^2$	Intercept	R^2	JB	p-val.
Panel A	1.38***	-0.61	0.02	3.88	0.991	3.25	0.20
	(44.71)	(-0.72)	(0.49)	(1.02)			
	[1.60]	[12264.56]	[12264.20]				
Panel B	1.38***	-0.19***		2.03***	0.991	3.75	0.15
	(49.21)	(-22.05)		(29.77)			
	[1.36]	[1.36]					

Notes: JB represents the test statistic for the Jarque-Bera test under the null hypothesis of normality; figures in parentheses indicate *t*-statistics; figures in brackets indicate VIF statistics; *** indicates rejection of the null hypothesis at the 1% level.

6. Conclusion and Implications

This study investigated the CKC and the decoupling of environmental pressure and economic growth in Russia. Also, the literature on the emission-growth nexus of Russia was extended to the emission-energy-growth nexus. The descriptive statistical analysis suggested that the decoupling effect seemed to have occurred with the decrease in related environmental pressure and the continuation of economic growth. This study found that within an EEO framework, a long-run equilibrium relationship exists among carbon emissions, energy consumption, and real GDP. The estimation results suggested that decoupling exists between economic growth and CO_2 emissions, but not CKC, and that economic growth was found to have beneficial effects on the environment. In addition, the energy consumption per capita elasticity of CO_2 emissions demand was found to be greater than 1.

Russia, the world's 5th largest CO_2 emitter and 1st energy producer, has enormous potential to mitigate carbon emissions and play a significant role in the development and implementation of international climate policies. The main policy implication of our finding is that Russia should actively promote economic development to benefit the environment. Also, Russia should further increase their efficiency in energy consumption and improve their technologies to reduce the intensity of their CO_2 production. Through this, Russia can make a significant contribution in combating global warming and achieving the goals of the 2030 Agenda.

In the future, the methodology of this paper may be helpful to countries with high carbon emissions when proposing policies and strategies to decouple environmental pressures from economic growth for environmental sustainability.

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About Author

Hsiao-Tien Pao is a Professor in the Department of Management Science at the National Chiao Tung University. Her main research areas include Data modeling and forecasting, Neural network model and applications, Big data analysis, Economy-Energy-Environment nexus and policy. Her research papers have been published at the International Journal of Commerce and Strategy, Energy Policy (SCI, SSCI), Energy(SCI), Renewable and Sustainable Energy Reviews(SCI), and others. Currently, she already has four highly cited papers.