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Social Sciences Indexed

SOCIAL MENTALITY AND RESEARCHER THINKERS JOURNAL
Open Access Refereed E-Journal & Refereed & Indexed
ISSN: 2630-631X
www.smartofjournal.com / editorsmartjournal@gmail.com
December 2018
Article Arrival Date: 11.11.2018 Published Date:19.12.2018 Vol 4 / Issue 14 / pp:1093-1099

ÇEVRESEL KUZNETS EĞRİSİ: İSVEÇ ÖRNEĞİ

ENVIRONMENTAL KUZNETS CURVE (EKC): EVIDENCE FROM SWEDEN

PhD Candidate Emrah BEŞE
South Russian University, Institute of Management Business and Law, Rostov-on-Don/ Russia

ÖZET

Bu çalışmada çevresel Kuznets eğrisi hipotezi İsveç için 1960 ve 2014 yılları arasında incelenmiştir. Çevresel Kuznets eğrisi, GDP, CO_2 ve enerji tüketimi (EN), ve GDP, CO_2, EN ve GDP'nin karesi ilişkileri altında incelenmiştir. GDP, CO_2 ve EN arasındaki nedensel ve uzun vadeli ilişkiler İsveç için ARDL bounds test for cointegration ve Toda and Yamamoto Granger non-causality test testleri ile incelenmiştir. GDP, CO_2, EN ve GDP'nin karesi arasındaki uzun vadeli ilişkiler ARDL bounds test ile incelenmiştir. Çevresel Kuznets eğrisi hipotezi İsveç için doğrulanmamıştır, GDP ve EN arasındaki bir nedensel ilişki bulunmamıştır ve EN'den CO_2'ye tek yönlü nedensel ilişki bulunmuştur. Neutrality hipotezi İsveç için doğrulanmıştır.

Anahtar Kelimeler: Çevresel Kuznets Eğrisi; ARDL Bounds Test For Cointegration; Toda And Yamamoto Granger Non-Causality Test; İsveç

ABSTRACT

In this study, EKC hypothesis is examined for Sweden for the period between 1960 and 2014. EKC hypothesis is examined under two nexus which are GDP, CO_2 and energy consumption (EN), and GDP, CO_2, energy consumption and the square of GDP. Causal and long-term relationships between GDP, CO_2 and EN are examined for Sweden by ARDL bounds test for cointegration and Toda and Yamamoto Granger non-causality test. Long-term relationships between GDP, CO_2, EN and the square of GDP are examined by ARDL Bounds Test. EKC hypothesis is not confirmed for Sweden, no causal relationships are found between GDP and EN, and unidirectional causality is found from EN to CO_2. Neutrality hypothesis is confirmed for Sweden. No causality is found between CO_2 and GDP.

Keywords: Environmental Kuznets Curve; ARDL Bounds Test For Cointegration; Toda And Yamamoto Granger Non-Causality Test; Sweden

1. INTRODUCTION

Kuznets (1955) studied the relationship between economic growth and income inequality and found an inverse U relationship. In 1990s, Kuznets curve was examined as EKC which stated an inverse U relationship between emissions and income. Studies of Grossman and Krueger (1991), Shafik and Bandyopadhyay (1992), and Panayotou (1993) are among the important studies in 1990s for EKC literature.

Many studies have examined the dynamic relationships between energy and income, income and emissions, and energy, income and emissions by taking EKC as a base in the academic literature. To examine these dynamic relationships, the researchers implemented many kinds of econometrical methods such as Multivariate Regressions, the Johansen cointegration test, the ADF unit root test, the VAR (Vector Autoregressive) model, impulse response analysis, variance decomposition analysis, Granger causality test and panel data analysis in the methodology section of their articles. Researchers obtained different results for the validity of EKC relationships depending on different samples, methodologies and time periods.

The main purpose of this study is to reveal the stable long-term relationships and causal relationships between emissions, income and EN, test the EKC hypothesis for Sweden and expand literature for individual country studies of Sweden. There are limited individual country studies in the literature for Sweden, so the main new contribution of this study is to use time series data to test EKC for Sweden on the individual country level and to assess causal relationships between emissions, income and EN for Sweden.

For individual country studies for Sweden, Ankarhem (2005) found EKC relationships between CO_2,

SO_2 and volatile organic compounds, and GDP for the period 1918 – 1994 in Sweden. Lundgren and Kriström (2005) carried out forecasting analysis for CO_2 emissions of Sweden for the period 2000-2010 by using the period 1900-1999 data. Lundgren and Kriström (2005) found that CO_2 emissions will rise till 2010 if nuclear power is not kept at 1990s level during the period 2000-2010. Lindmark (2002) examined CO_2 emissions for the period 1870-1997 for Sweden. Lindmark (2002) found that changing fuel prices, economic growth, technological and structural change can explain variations of CO_2 in Sweden during the period 1870-1997. Marbuah and Amuakwa-Mensah (2017) examined EKC relationships for 290 municipalities in Sweden for the period 2005-2013 with panel data between carbon dioxide, sulfur dioxide, nitrogen oxide, carbon monoxide, particulate matter (2.5 and 10) and total suspended particulate matter, and income and population density. Marbuah and Amuakwa-Mensah (2017) confirmed the EKC relationship for carbon dioxide, sulfur dioxide, nitrogen oxide, particulate matter (2.5 and 10) and total suspended particulate matter but carbon monoxide. Johansson and Kriström (2007) examined the EKC relationship between SO_2 and GDP for Sweden for the period 1900-2002. Johansson and Kriström (2007) did not confirm the EKC relationship between SO_2 and GDP for Sweden. Lindmark and Acar (2014) investigated the EKC relationship between pollution and income in Sweden for the period 1850-2000. Lindmark and Acar (2014) found right tilted S form relationship between pollution and income. Liddle and Messinis (2015) investigated the EKC relationship between SO_2 and GDP for the period 1870-2005 for 25 OECD countries individually including Sweden. Liddle and Messinis (2015) confirmed the EKC relationship between SO_2 and GDP for Sweden and Finland. Urban and Nordensvärd (2018) examined the EKC relationship for Denmark, Finland, Iceland, Norway and Sweden. Urban and Nordensvärd (2018) confirmed the EKC relationship for Sweden for per capita CO_2 emissions and for total CO_2 emissions.

For studies that verify the EKC hypothesis, Balibey (2015), Katircioglu (2017) and Ozturk and Oz (2016) examined the EKC hypothesis in Turkey. Balibey (2015) verified quadratic relationship between CO_2 and GDP. Katircioglu (2017) did not verify the oil-induced EKC relationship in Turkey but emission-income the EKC relationship in Turkey. Ozturk and Oz (2016) verified the EKC relationship in Turkey both in the long-run and short-run.

For studies that do not verify the EKC hypothesis, Zoundi (2017), Wang (2012) and Saleh et al. (2014) tested and found no evidence for the EKC relationship for 25 countries, 98 countries and Iran respectively. Ghosh et al. (2014) and Amin et al. (2012) tested the EKC relationship and found no evidence for the EKC relationship in Bangladesh. Friedl and Getzner (2002) tested the EKC relationship in Austria and found no evidence for it.

In this study, the EKC hypothesis is examined between GDP, CO_2 and EN, and GDP, CO_2, EN and the square of GDP. Causal relationships are examined between GDP, CO_2 and EN.

After introduction section, methodology is discussed in Section 2. Section 3 and Section 4 present data and empirical results of this study respectively. Conclusion is discussed in Section 5 in this study.

2. METHODOLOGY

The augmented Dickey-Fuller (1981) unit root test is applied to find stationary levels of each variable. ARDL bounds test for cointegration by Pesaran, Shin and Smith (2001) is applied to examine the cointegration relationship between variables since variables are at stationary levels with combination of I(0) and I(1). Breusch-Pagan-Godfrey Heteroskedasticity Test, Normality test and Breusch-Godfrey Serial Correlation LM Test are applied to examine the stability of ARDL model.

Toda and Yamamoto (1995) granger non-causality test is applied to examine the causal relationships between variables since variables are at stationary levels with combination of I(0) and I(1). To apply Toda and Yamamoto granger non-causality test, first step is to determine the maximum number of stationary levels of variables. Second step is to select an optimum lag order with a stable VAR model. AR Root Graph and VAR Residual Serial Correlation LM Test are applied to examine the stability of established VAR model. After stable VAR model is established with optimum lag order, each variable with lag order of sum of optimum lag order and maximum number of stationary level of variables are input to exogenous variables of VAR model. Final step is to apply VAR Granger Causality/Block Exogeneity Wald Test.

Two models in this study are used to examine the EKC relationship for Sweden. Causal relationships are examined between CO_2, GDP and EN. EKC relationships are examined between CO_2, GDP and EN, and CO_2, GDP, the square of GDP and EN.

$$\ln(\mathrm{CO_2})_t = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 \ln(EN)_t + e_t \qquad (1)$$

β_0, β_1, β_2, are estimated parameters. t is time index. e is error term. CO_2 is carbon dioxide emissions per capita. GDP is gross domestic product per capita. EN is energy consumption per capita.

$$\ln(\mathrm{CO_2})_t = \beta_0 + \beta_1 \ln(GDP)_t + \beta_2 \ln(GDP)_t^{\,2} + \beta_3 \ln(EN)_t + e_t \qquad (2)$$

β_0, β_1, β_2 and β_3, are estimated parameters. t is time index. e is error term. CO_2 is carbon dioxide emissions per capita. GDP is gross domestic product per capita. EN is energy consumption per capita.

Table 1. ADF Unit Root Tests for Sweden.

Variable	At Level	At first difference
	Intercept	Intercept
$LNCO_2$ Sweden	-0.225651(0)	-7.274891(0)*
LNEN Sweden	-3.727088(0)	-7.379564(0)*
LNGDP Sweden	-2.615928(0)	-5.158945(0)*
LNGDP2 Sweden	-2.335217(0)	-5.242850(0)*

Notes: * and ** show the statistical significance at 1% and 5% levels, respectively.
The lag length is shown by the values in parentheses.
Source: Authors' Calculations.

3. DATA

The data is obtained from World Bank's official web site for CO_2 emissions (metric tons per capita), EN (kg of oil equivalent per capita) and GDP per capita (constant 2010 US$). Period for data is over 30 to carry out parametrical tests. Period for data in this study is determined according to the availability of data sets in data sources. Period for data in this study is from 1960 to 2014 for Sweden.

4. RESULTS

4.1 CO_2, GDP and Energy Consumption Nexus

ARDL model is used since variables are at stationary levels with combination of I(0) and I(0). ARDL bounds test for cointegration results are not significant at 5% level so there is no cointegration between CO_2, GDP and EN (see Table 1). With regard to the Normality test, the Breusch-Godfrey Serial Correlation LM test and the Breusch-Pagan-Godfrey test results, the model is stable (see Table 2, Table 3 and Table 4). There is no long-run relationship between CO_2, GDP and EN. The EKC hypothesis is not confirmed.

Table 1. ARDL Bounds Test For Cointegration Results of CO_2-GDP-EN for Sweden.

Test Statistic	Value	K
F-Statistic	1.862006	2
	Critical Value Bonds	
Significance	I0 Bound	I1 Bound
10%	3.17	4.14
5%	3.79	4.85
2.5%	4.41	5.52
1%	5.15	6.36

Toda and Yamamoto Granger non-causality test is applied to examine causal relationships between CO_2, GDP and EN. VAR model stability test results show that VAR model satisfies stability results (see Table 5 and Figure 1). According to VAR Granger Causality/Block Exogeneity Wald Test Results, no causal relationship is found between GDP and EN, and CO_2 and GDP (see Table 6).

Unidirectional causality running from EN to $CO_2$is found for Sweden. Causal relationship results confirm neutrality hypothesis for Sweden which states there is no causal relationship between EN and GDP.

Table 2. Breusch-Godfrey Serial Correlation LM Test Results of CO_2-GDP-EN for Sweden.

Breusch-Godfrey Serial Correlation LM Test			
F-Statistic	0.407827	Prob. F(1,47)	0.5262
Obs*R-squared	0.464537	Prob. Chi-Square(1)	0.4955

Table 3. Normality Test Results of CO_2-GDP-EN for Sweden.

Normality Test	
Jarque-Bera	1.122396
Probability	0.570525

Table 4. Heteroskedasticity Test Breusch-Pagan-Godfrey Test Results of CO_2-GDP-EN for Sweden.

Heteroskedasticity Test Breusch-Pagan-Godfrey Test			
F-Statistic	0.853323	Prob. F(5,48)	0.5192
Obs*R-squared	4.408115	Prob. Chi-Square(5)	0.4923
Scaled explained SS	4.063657	Prob. Chi-Square(5)	0.5403

Table 5. VAR Residual Serial Correlation LM Test Results of CO_2-GDP-EN for Sweden.

Lags	LM-Stat	Prob
1	5.204992	0.8161
2	9.061844	0.4316
3	9.200286	0.4190
4	14.09591	0.1190

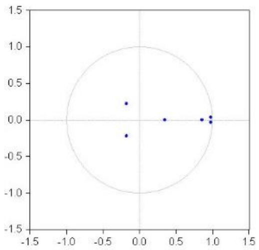

Figure 1. VAR Model Stability Results of CO_2-GDP-EN for Finland.

Table 6. VAR Granger Causality/Block Exogeneity Wald Tests Results of CO_2-GDP-EN for Denmark.

Dependent variable: $LNCO_2$			
Excluded	**Chi-sq**	**df**	**Prob.**
LNEN	6.737382	2	0.0344
LNGDP	1.411427	2	0.4938
All	9.459736	4	0.0506
Dependent variable: LNEN			
Excluded	**Chi-sq**	**df**	**Prob.**
$LNCO_2$	4.355287	2	0.1133
LNGDP	1.108479	2	0.5745
All	5.004978	4	0.2868
Dependent variable: LNGDP			
Excluded	**Chi-sq**	**df**	**Prob.**
$LNCO_2$	1.784847	2	0.4097
LNEN	0.554590	2	0.7578
All	3.251745	4	0.5166

4.2 CO_2, GDP, Squre of GDP and Energy Consumption Nexus

ARDL model is used since variables are at stationary levels with combination of I(0) and I(1). No cointegration is found between variables since ARDL bounds test for cointegration results are not significant at 5% level (see Table 7). With regard to the Normality test, Breusch-Godfrey Serial Correlation LM test and the Breusch-Pagan-Godfrey test results, the model is stable (see Table 8, Table 9 and Table 10). There is no long-run relationship between CO_2, GDP, EN and the square of GDP. EKC hypothesis is not confirmed for Sweden.

Table 7. ARDL Bounds Test Results of CO_2-GDP-EN-SQUARE OF GDP for Sweden.

Test Statistic	Value	K
F-Statistic	1.919528	3
	Critical Value Bonds	
Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

Table 8. Breusch-Godfrey Serial Correlation LM Test Results of CO_2-GDP-EN-SQUARE OF GDP for Sweden.

Breusch-Godfrey Serial Correlation LM Test			
F-statistic	0.217548	Prob. F(1,45)	0.6432
Obs*R-squared	0.259801	Prob. Chi-Square(1)	0.6103

Table 9. Normality Test Results of CO_2-GDP-EN-SQUARE OF GDP for Sweden.

Normality Test	
Jarque-Bera	0.813850
Probability	0.665694

Table 10. Heteroskedasticity Test Breusch-Pagan-Godfrey Test Results of CO_2-GDP-EN-SQUARE OF GDP for Sweden.

Heteroskedasticity Test Breusch-Pagan-Godfrey Test			
F-statistic	0.433257	Prob. F(7,46)	0.8762
Obs*R-squared	3.340030	Prob. Chi-Square(7)	0.8519
Scaled explained SS	2.312530	Prob. Chi-Square(7)	0.9405

5. CONCLUSION

The EKC hypothesis states that economic growth will lead to reduction in emissions. Results of this study did not verify this statement. Our results are different from Urban and Nordensvärd (2018) which confirmed the EKC relationship for CO_2emissions in Sweden.

Main findings in this study are there is no long run relationship between CO_2, GDP and EN, and between CO_2, GDP, EN and the square of GDP. The EKC hypothesis is not confirmed for Sweden for the period between 1960 and 2014, so there is no inverted U relationship between income and emissions. Neutrality hypothesis is confirmed for Sweden which states there is no causal relationship between GDP and EN. No causality is found between CO_2 and GDP, and GDP and EN variables. Unidirectional causality running from EN to CO_2 is found.

No causal relationship between GDP and CO_2, which is found for Sweden, means that a country's economic growth will not have an effect on emissions. Sweden is likely to achieve further economic growth without causing environmental degradation since no causal relationship is found between CO_2 and GDP.

No causal relationship between GDP and EN, which is found for Sweden, means that a country's economic growth will not have an effect on energy consumption. The economic growth of Sweden is not dependent on oil consumption. Also, oil consumption is not a source for economic growth in Sweden.

For Sweden, energy consumption causes emissions. Oil was the first in Sweden's final energy consumption as 32.5% in 2011. Oil is mostly used in the transport sector at 59.1% of all oil consumption. Transport sector accounted for 40% of total emissions in 2011 which was the highest among all sectors. Road transport accounted for 92% of emissions related with transport sector excluding international shipping sector emissions such as international shippinh and aviation. Transport sector accounted for 59.1% of all oil consumption in Sweden in 2011. Sweden maintained the increase in energy efficiency and in the use of biofuels in transport sector, but the increase in road transport traffic prevented further reduction in emissions of transport sector. Sweden should carry out policies to shift road transport to other types of transport such as shipping. Sweden should increase the renewable energy use in transport sector and carry out policies to solve the problems related with road transport traffic. Passenger cars accounted for majority in the emissions of road transport. Sweden should increase the number of electric vehicles in transport sector for passenger cars. Sweden should carry out policies to prevent the further increase in the number of passenger cars and the further usage frequency of passenger cars.

Economic growth is not likely to help Sweden to fight climate change by itself. Increases in the use of renewable energy and in the number of electric vehicles for passenger cars in transport sector, shifting road transport to other types of transport such as shipping and carrying out policies to prevent the further increase in the number of passenger cars and the further usage frequency of passenger cars will help Sweden to fight climate change and meet emission targets. Authorities in Sweden should continue to invest in energy conservation and emission reduction policies since these policies do not have a detrimental effect on economic growth. Sweden is likely to achieve further economic growth without causing environmental degradation since no causal relationship is found between CO_2 and GDP.

The Limitations of our study are that results are obtained for Sweden and the period between 1960 and 2014 is examined for Sweden.

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