The Impact of Urbanization on CO_2 Emissions in Transition Countries

Erginbay Uğurlu♦

ABSTRACT

This paper investigates the relationship among urbanization, energy consumption and CO_2 emissions in the CEE countries. In this paper dynamic causal relationship of urbanization and CO emission is investigated using panel cointegration techniques by taking the period 1995–20010 in to consideration for CEE and Baltic countries. There is a long run relationship between these countries and have a positive relationship both from urbanization and energy consumption to CO_2 emissions. Main results of the causality tests show that strong Granger causality running from CO_2 emissions to urbanization.

INTRODUCTION

Global warming caused by increased greenhouse gas emissions has been widely investigated recent years. Two important reasons of the greenhouse gas emissions are economic growth and energy consumption. However, energy consumption is more severe when accompanied by demographic growth and rural migration into cities. Growing number of population in urban settlements lead to increases in energy consumption (Martínez-Zarzoso and Maruotti, 2011) and the process of urbanization can also encourage the use of mass transport in place of motor vehicles (Jones, 1991). Urbanization and high urban densities might influence economy wide patterns of resource use. Parikh and Shukla (1995) state that; countries undergoing the development transition have greatest potential for incremental degradation. Buckley and Mini (2000) focus on cities of transition economies and stated that in ECA[1] is the second most urbanized region with urban population of 67 percent. Just as many countries of the region may be considered "over-industrialized," they may also be considered "overurbanized."

This paper aims to investigate the relationship between urbanization, energy consumption, and CO_2 emission in the European transition economies using Panel Cointegration Method with annual data for 1995-2010 period. To see the whether long run and short run relationship is exist or not, we will use Pedroni (1999, 2004) and Kao (1999) cointegration test then Granger causality based on the vector error-correction model (VECM) respectively.

The study focuses on transition economies in Europe. Transition economies are the economies of the countries which are changing from a centrally planned economy to a free market. The process has

♦ Assoc. Prof. Dr., Department of Economics and Finance, Istanbul Aydın University, Istanbul, Turkey e-mail: erginbayugurlu@aydin.edu.tr. The author would like to acknowledge and thank Graciela Chichlinsky at Columbia University for her invaluable assistance and support in completing this work.

been experienced applied in China, the former Soviet Union and Communist bloc countries of Europe, and many third world countries. The IMF[2] listed countries with transition economies in two main classifications; transition economies in Europe and the former Soviet Union and transition economies in Asia. First classification separated in three sub-classifications: Central and Eastern European economies (CEE), the Baltics and the Commonwealth of Independent States (CIS).

- CEE: Albania, Bulgaria, Croatia, Czech Republic, FYR Macedonia, Hungary, Poland, Romania, Slovak Republic, Slovenia
- Baltics: Estonia, Latvia, Lithuania
- CIS: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyz Republic, Moldova, Russia, Tajikistan, Turkmenistan, Ukraine, Uzbekistan

We select European transition countries which are CEE and Baltics except FYR Macedonia because of data availability then the data set includes 13 countries. For these countries relationship between urbanization, energy consumption, and CO_2 emission is investigated. To test this relationship the Pedroni (1999) and the Kao (1999) tests are based on the Engle-Granger (1987) two-step (residual-based) cointegration tests are used. The fully modified OLS estimator (FMOLS), which is proposed by Pedroni (1996, 2001), is used to show long-run relationship. Based on the existence of the long run relationship short-run dynamics can be investigated using the vector error correction model (VECM) approach suggested by Engle and Granger (1987).

LITERATURE REVIEW

The relationship between urbanization, energy consumption and carbon dioxide emission has been investigated by a number of researchers.

Dietz and Rosa (1997) and York et al. (2003) study the impact of population on CO_2 emissions and energy use within the framework of the IPAT1 model. Both two studies find that the elasticity of CO_2 emissions and energy use with respect to population are close to unity.

Parikh and Shukla (1995) examine the variations of the aggregate energy requirements of economies or urbanization for developed and developing countries and find that the emissions and energy consumption were positively correlated with the urbanization level. Karaca et al. (1995) uses annual mean values of temperature data of Istanbul and Ankara stations and analyzes these data They find that the urbanization in these cities increases the pollution level in Turkey.

Wang et al. (2003) use Pressure-State-Response (PSR) and Balanced Scorecard (BSC) for Shandong Province from 2005 to 2009 with factor component analysis. They find that overall level of sustainable development is in an upward trend in Shandong in the study period. Martinez-Zarzoso and Maruotti (2011) analyzes the impact of urbanization on CO_2 emissions in developing countries from 1975 to 2003. They use STIRPAT formulation for three groups of countries and find that for the first and third sets of countries the elasticity emission urbanization is positive and for the second group urbanization is not statistically significant. Also Martínez-Zarzoso et al. (2007) found a differential impact of population on emissions for old and new EU members.

Sadorsky (2004) uses a dynamic model is to capture both short-run and long-run impacts of income, urbanization, and industrialization on energy intensity. The results of Sadorsky paper show that increasing income reduces energy intensity in developing countries. Hossain (2011) find that urbanization had a long run positive relationship with CO_2 emission in newly industrialized countries (NIC) using the time series data for the period 1971–2007. O'Neill et al. (2012) use a computable general equilibrium model to investigate the impact of urbanization of energy use in China and India. They find that the urbanization has a somewhat less than proportional effect on energy use and carbon emission for both countries.

Zhu et al. (2012) find weak evidence of an inverted U-shape relationship between urbanization and CO2 emission using semi-parametric panel data model with fixed effects. Al-Mulali et al. (2012) investigate relationship between urbanization, energy consumption, and CO2 emission for East Asia and Pacific, East Europe and Central Asia, Latin America and the Caribbean, Middle East and North Africa, South Asia, Sub-Saharan Africa, and Western Europe countries. They found that majority of the countries positive long relationship between the variables used. Zhang and Lin (2012) use panel data covering 29 provinces of China over the period 1995–2010 and find that urbanization would increase energy consumption and CO_2 emissions. Also Al-Mulali et al (2013) investigate same relationship for MENA countries and find that slowing down the urbanization level can help reduce the level of pollution and energy consumption.

METHODOLOGY:

Data

Our data set include CEE and Baltics except FYR Macedonia which covers 13 countries. Data of these countries are reported since the early 1990's after their economies began to open up. The data used in this paper are urban population as an indicator of urbanization, total primary energy consumption and the total carbon dioxide emission. The source of the data are World Development Indicators (WDI) for urban population and Energy Information Administration (EIA) for total primary energy consumption and the total carbon dioxide emission, then the data are titled CO_2, EC and UR respectively. The period used is 1995-2010.

Method

In this paper relationship between urbanization, energy consumption, and CO_2 emission is investigated. The first step is to examine the stationarity of the variables; then if the variables are same order integrated the panel unit root test will be utilized. Various unit root tests are used namely LLC defined by Levin e. al. (2002), Breitung defined by Breitung (2000), IPS defined by Im et al. (2003) and Fisher-type tests using Augmented Dickey–Fuller (ADF-F) and PP (PP-F) defined by Maddala and Wu (1999) and Choi (2001) .

If the variables are same order integrated, the Pedroni and Kao cointegration tests will be used to examine the bi-directional long run relationship between the variables. From the long run estimated regression the residuals of the long run regression is refined and named as an error correction term (ECT). Then the VECM is used for correcting disequilibrium in the cointegration relationship, captured by the ECT, as well as to test for the causality among cointegrated variables, both for long-run causality by the error correction terms and short-run causality by the lagged dynamic terms.

We use three type of causality tests based on Ang (2008) and Pao and Tsai (2010); which are short-run Granger non-causality test, weak exogeneity (long-run non-causality test) and strong exogeneity tests respectively.

In the first type the statistical significance of the lagged dynamic terms is tested by F test with the null hypothesis variables which coefficients are tested do not Granger-cause of the dependent variable of the investigated model. Second type of test is the test of the ECT, which has null hypothesis which implies that non-causality from long-run equilibrium deviation in the previous period to dependent variable of the investigated model. The last type is strong exogeneity test examines the joint significance of both the lagged dynamic terms and ECT parameter. Because of this test concludes by testing the joint significance of both the lagged dynamic terms and ECT it imposes stronger restrictions and satisfies both Granger non-causality and weak exogeneity.

EMPRICAL RESULTS

The first step of empirical application is testing stationarity of the variables. Table 1 shows the result of the panel unit root tests used that are LLC, Breitung, IPS, ADF-F and PP-F panel unit root tests.

Whereas LLC and Breitung tests assume that there is a common unit root process across cross-sections, IPS and F-ADF tests assume individual unit root processes across cross-sections. The null hypotheses of these tests are each series in the panel contains a unit root. Although different test results are obtained if overall the unit root test results considered majority of the tests concluded that all series are stationary in their first differences, in other words they are integrated at order one, I(1) .

Table 1: Results of the Panel Unit Roots Tests

Variables	LLC		Breitung		IPS	
	Level	**1st diff.**	**Level**	**1st diff.**	**Level**	**1st diff.**
CO_2	-1.0339	-9.0536***	-0.1062	-2.0033**	-0.3958	-7.6956***
EC	-1.8490**	-10.5623***	-1.8297**	-3.1374***	-1.0437	-8.0561***
UR	-2.0609**	-1.7200**	-0.3819	-0.0707	-0.8270	-1.9485**
Variables	**ADF-Fisher**		**PP-Fisher**			
	Level	**1st diff.**	**Level**	**1st diff.**		
CO_2	29.0296	92.4276***	29.0296	92.4276***		
EC	29.0859	95.1922***	29.0859	95.1922***		
UR	34.0658*	39.5875**	34.0658*	39.5875**		

Note: The lag lengths are selected using SIC. ***,***,* denotes the rejection of the null hypothesis at 1% ,%5,%10 level of significance.

Table 2: Results of the Panel Cointegration Tests

Pedroni Cointegration Tests		
Test	**Statistics**	**Weighted Statistics**
Panel v-Statistic	1.8076**	-2.9187
Panel rho-Statistic	0.6757	0.6774
Panel PP-Statistic	-2.3059**	-2.6596***
Panel ADF-Statistic	-4.0047***	-3.2972***
Group rho-Statistic	2.0129	
Group PP-Statistic	-2.9139***	
Group ADF-Statistic	-5.1656***	
Kao cointegration tests		
Test	Statistics	
ADF	-2.6233***	

Note: The lag lengths are selected using SIC. ***,** and * denote the rejection of the null hypothesis at 1%, 5% and 10 % level of significance.

Table 2 shows Pedroni and Kao cointegration test results. Four of the seven statistics of Pedrioni reject the null hypothesis of no cointegration and two of the four weighted statistics reject the null hypothesis of no cointegration thus the result of the Pedroni test concluded that the cointegrating regression exist for these variables. Kao test has one statistics and the null hypothesis of no cointegration is rejected in 1% level significance. Based on cointegration test results the log-run panel model is estimated which's general equation is below:

$$\mathrm{CO2}_{\mathrm{it}} = \alpha_{0\mathrm{i}} + \alpha_{1\mathrm{i}}\mathrm{EC}_{\mathrm{it}} + \alpha_{2\mathrm{i}}\mathrm{UR}_{\mathrm{it}} + \mathrm{u}_{\mathrm{it}}$$

We use FMOLS model to estimate cointegrating regression model for both grouped and pooled model. Phillips & Hansen (1990) is based on FMOLS estimators also Pedroni (1996) proposed new small sample results for the group mean panel FMOLS model. In this model group mean estimator is based on the so called "between dimension" of the panel, while the pooled estimators are based on the "'within dimension" of the panel. Pooled FMOLS estimators are used in Kao and Chiang (2000) for heterogeneous cointegrated panels. Pedroni (2001, 2004) proposed various techniques to estimate systems of cointegrated variables using the Fully Modified OLS. This cointegration equation corrects for endogeneity and serial correlation to the OLS estimator.

Table 3: Cointegrating Regression

	Model	
Variables	**FMOLS- Pooled**	**FMOLS- Grouped**
EC	3.7474***	8.7611***
UR	3.0935***	2.9107***
R^2	0,9622	0,9523

***,** and * denote the rejection of the null hypothesis at 1%, 5% and 10 % level of significance.

Table 3 shows the cointegrating regression model. All coefficients of the models are statistically significant in 1% level. Energy consumption and urbanization have a positive effect on CO_2 emission as it expected. Whereas in the grouped model effect of energy consumption is considerably higher than urbanization, in pooled model it is slightly close.

The error-correction terms are derived from long-run cointegrating relationships which are FMOLS-pooled and FMOLS-grouped and named as an ECT. To test for long-run and short-run causality among cointegrated variables the vector error correction model (VECM) is used for correcting disequilibrium. To test for panel causality, a panel-based VECM is specified as follows:

$$\Delta\mathrm{CO2}_{\mathrm{it}} = \alpha_{1\mathrm{i}} + \sum_{j=1}^{p_{11}} \beta_{11\mathrm{ij}}\Delta\mathrm{CO2}_{\mathrm{it-j}} + \sum_{j=1}^{p_{12}} \beta_{12\mathrm{ij}}\Delta\mathrm{EC}_{\mathrm{it-j}} + \sum_{j=1}^{p_{13}} \beta_{13\mathrm{ij}}\Delta UR_{\mathrm{it-j}} + \theta_{1i}ECT_{\mathrm{it-1}} + \varepsilon_{1it}$$

$$\Delta EC_{it} = \alpha_{2i} + \sum_{j=1}^{p_{21}} \beta_{21ij}\Delta CO2_{it-j} + \sum_{j=1}^{p_{22}} \beta_{22ij}\Delta EC_{it-j} + \sum_{j=1}^{p_{23}} \beta_{23ij}\Delta UR_{it-j} + \theta_{2i}ECT_{it-1} + \varepsilon_{2it}$$

$$\Delta UR_{it} = \alpha_{3i} + \sum_{j=1}^{p_{31}} \beta_{31ij}\Delta CO2_{it-j} + \sum_{j=1}^{p_{32}} \beta_{22ij}\Delta EC_{it-j} + \sum_{j=1}^{p_{33}} \beta_{23ij}\Delta UR_{it-j} + \theta_{3i}ECT_{it-1} + \varepsilon_{3it}$$

where $ECT_{it} = CO2_{it} - \alpha_{0i} - \alpha_{1i}EC_{it} - \alpha_{2i}UR_{it} - u_{it}$

At first, short run causality is tested by testing the lagged dynamic terms of the models except lagged independent variables. The null hypotheses tested are tabled in Table 4.

Table 4: Summary of the Panel Causality Tests Hypothesis I

Dependent variables	**Null hypothesis of short run**		
	ΔCO_2	**ΔEC**	**ΔUR**
ΔCO_2	-	$\beta_{12ip} = 0\ \forall ip$	$\beta_{13ip} = 0\ \forall ip$
ΔEC	$\beta_{21ip} = 0\ \forall ip$	-	$\beta_{23ip} = 0\ \forall ip$
ΔUR	$\beta_{31ip} = 0\ \forall ip$	$\beta_{32ip} = 0\ \forall ip$	-

Then the short run causality is tested by ECT term using t statistics. At last strong exogeneity is tested using F statistics of significance of lagged dynamic terms and ECT. The null hypotheses are represented in Table 5.

Table 5: Summary of the Panel Causality Tests Hypothesis II

Dependent variables	**Null hypothesis of long run and joint (Short run / Long run)**			
	Long run	**Joint (Short run / Long run)**		
	ECT	**ΔCO_2, ECT**	**ΔEC, ECT**	**ΔUR, ECT**
ΔCO_2	θ_{1i}=0 $\forall ip$	-	$\beta_{12ip} = \theta_{1i} = 0\ \forall ip$	$\beta_{13ip} = \theta_{1i} = 0\ \forall ip$
ΔEC	θ_{2i}=0 $\forall ip$	$\beta_{21ip} = \theta_{2i} = 0\ \forall ip$	-	$\beta_{23ip} = \theta_{2i} = 0\ \forall ip$
ΔUR	θ_{3i}=0 $\forall ip$	$\beta_{31ip} = \theta_{3i} =\ \forall ip$	$\beta_{32ip} = \theta_{3i} = 0\ \forall ip$	-

Table 6: Results of the Panel Causality Tests (FMOLS Pooled Model Resids)

Dependent variables	Independent variables						
	Short run			Long run	Joint (Short run / Long run)		
	ΔCO_2	ΔEC	ΔUR	ECT	ΔCO_2,ECT	ΔEC,ECT	ΔUR,ECT
	F-statistics			t-statistics	F-statistics		
ΔCO_2	-	0.5400	3.0299*	-1.8480*	-	1.5792	2.5851*
ΔEC	2.1228	-	5.9699**	-1.0041	1.8825	-	3.0753**
ΔUR	4.4900**	1.0304	-	0.7038	2.8447*	0.9732	-

Note: The lag lengths are selected using SIC. ***,** and * denote the rejection of the null hypothesis at 1%, 5% and 10 %level of significance.

Table 6 shows causality test results for FMOLS-pooled model. Short run test results show that short run the null hypothesis of no existence of Granger causality is rejected for CO_2 variable in urbanization VECM and for urbanization variable for CO_2 VECM and energy consumption VECM model. This result implies that there is one way causality for these three variables, therefore CO_2 granger causes urbanization and urbanization granger causes CO_2 emissions and energy consumption.

Result of the weak exogeneity test of the dependent variable, which is a notion of long-run non-causality test shows that only CO_2 model has long run relationship. However, the statistical significances of interactive terms of change in CO_2 emissions, along with the ECT in urbanization mean that there is strong Granger causality running from energy consumption to urbanization. Also for urbanization the results shows that strong granger causality running from urbanization to emissions and energy consumption.

Table 7: Results of the Panel Causality Tests (FMOLS Grouped Model Resids)

Dependent variables	Independent variables						
	Short run			Long run	Joint (Short run / Long run)		
	ΔCO_2	ΔEC	ΔUR	ECT	ΔCO_2, ECT	ΔEC, ECT	ΔUR, ECT
	F-statistics			t-statistics	F-statistics		
ΔCO_2	-	0.6122	2.1579	-1.9288*	-	1.6818	2.6898**
ΔEC	2.3024	-	5.1466**	-0.4555	1.4754	-	2.6624*
ΔUR	6.1064**	2.0881	-	-1.1102	3.2250**	1.3451	-

Note: The lag lengths are selected using SIC. ***,** and * denote the rejection of the null hypothesis at 1%, 5% and 10 %level of significance.

Table 7 shows causality test results for FMOLS-grouped model. For the short run the null hypothesis for CO_2 variable in urbanization VECM and for urbanization variable for energy consumption VECM in 5% level. This result implies that CO2 granger causes urbanization and urbanization granger causes energy consumption. Result of the weak exogeneity test of the dependent variable, which is a notion of long-run non-causality test shows that only CO_2 model has long run relationship. However, the statistical significances of interactive terms of change in CO_2 emissions along with the ECT in urbanization mean that there is strong Granger causality running from CO_2 emissions to urbanization. Also for urbanization the results shows that strong Granger causality running from urbanization to emissions and energy consumption.

CONCLUSION

The investigation of the effect of urbanization and energy consumption on CO_2 emissions in transition countries of Europe is goal of the paper. To achieve this goal, the panel model cointegration method was utilized taking the period 1995–2010 into consideration. The cointegration used are Pedroni and Kao cointegration and FMOLS model used the estimate long run cointegration model.

The cointegration tests showed that there is a cointegration between investigated variables and the relationship between urbanization and energy consumption is positive for the panel of country over the period. In addition Granger causality results reveal that there were long and short run causal relationships between the variables. CO_2 granger causes urbanization and urbanization Granger causes energy consumption and there is strong Granger causality running from CO_2 emissions to urbanization and urbanization to CO_2 emissions and energy consumption. Also it is found that only CO_2 model has long run relationship.

On the conclusion the investigated variables have uni-directional causality. Thus slowing down the urbanization level can help reduce the both energy consumption and CO_2 emission. However tests results show causality from CO_2 to urbanization this implies vicious circle.

ENDNOTES

1. The CEE comprises 12 countries. The World Bank's Eastern Europe and Central Asia (ECA) Region covers the 27 countries above, plus Turkey
2. http://www.imf.org/external/np/exr/ib/2000/110300.htm#I

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