The Productive Capacity And Environment: Evidence From OECD Countries

Oluc, Ihsan and Ben Jebli, Mehdi and Can, Muhlis and Guzel, Ihsan and Brusselaers, Jan

Mehmet Akif Ersoy University, University of Jendouba, BETA Akademi SSR LAB, Sirnak University, Vrije Universiteit Amsterdam

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Ihsan Oluc

Orcid ID: 0000-0002-5167-1862

ihsan.oluc@gmail.com

Department of Economics, Mehmet Akif Ersoy University, Burdur, Turkey

Mehdi Ben Jebli

University of Jendouba, FSJEG de Jendouba, Tunisia, Univ. Manouba, ESCT, QUARG UR17ES26, Campus Universitaire Manouba, 2010, Tunisia

benjebli.mehdi@gmail.com

Muhlis Can*

Orcid ID: 0000-0002-7315-2916

BETA Akademi, Social Sciences Research Lab (SSR Lab), Istanbul, Turkey

muhliscan@yandex.com

Corresponding author

Ihsan Guzel

Orcid ID: 0000-0002-9525-6628

Department of Economics, Sirnak University, Sirnak, Turkey

ihsanguzel@yandex.com

Jan Brusselaers

Assistant Professor Environmental Economics

Vrije Universiteit Amsterdam

De Boeleaan 1111, 1081 HV Amsterdam, the Netherlands

janbrusselaers@hotmail.com

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Abstract: There are many economic parameters that may affect environmental degradation. At the forefront of these parameters is the *productive economic structures* of the countries The present paper discusses the dynamic relationship between carbon dioxide (CO_2) emissions, economic growth and productive capacity index (PCI) for a panel of 38 OECD countries spanning the period 2000-2018. The empirical study applied PMG-ARDL approach, panel cointegration techniques and Granger causality tests the examine the short and long-run association between the variables. The cross-sectional dependence test of Pesaran (2004) revealed the use of the second generation panel unit root tests (CADF and CIPS). The cointegration relationships between the variables are proved using Westerlund and Pedroni cointegration tests. The estimated coefficients of PMG-ARDL revealed that the environmental Kuznets curve (EKC) hypothesis is established. Besides, the empirical findings obtained from long-run estimation confirm that productive capacity has a significant role on increasing environmental quality.

Introduction

Economic growth is a critical element in reducing poverty in all its dimensions and achieving decent living standards (Buysse et al., 2018). Continuous growth is needed to expand employment, increase income and lead a hopeful life (UN, 2021). As a result of policies prioritizing human welfare and enrichment, there have been unprecedented expansions in economic activities, which started in the twentieth century and continued until today (Malik, 2012). However, the environmental costs of this economic expansion have been increasing recently. Because economic activities such as agriculture, transportation, manufacturing and energy consumption, in other words, almost all human activities have negative effects on environmental degradation (Hoffmann, 2013).

The world population has increased from 1.65 billion to 7.71 billion since 1900s. In this process, it is observed that the world's total Gross Domestic Products (GDP) increased 33 times from 3.41 trillion dollars (2011 constant $) to 113.63 trillion dollars. When this situation is evaluated in terms of energy consumption, primary energy consumption has reached 173,340 terawatt hours from 12,128 terawatt hours (Smil, 2017; Roser, Ritchie, & Ortiz-Ospina, 2019: Bolt and Luiten Van Zanden, 2020). As a result of such increased energy demand and expanding economic activities, it is observed that the average temperature has increased by 1 °C since 1900, and CO_2 emissions have boosted from 1.95 billion tons to 36.44 billion tons (Jensen, Pfister, & Bui, 2012; Friedlingstein et al., 2020). The increase in CO_2 emissions and the rise in the global average temperature are almost entirely man-made. This situation can cause the melting of glaciers, sea level rise, deforestation, desertification, drought, serious risks in food production and irreversible negative effects on nature (IPCC, 2018).

For this reason, the Adoption of the Paris Agreement has set the target of limiting the global average temperature increase to 1.5 °C compared to pre-industrial levels. In this agreement, climate change is described as "urgent and potentially irreversible threat". Therefore, the problem of global warming is one of the most urgent common issues that need to be resolved by all the countries (Martimort & Sand-Zantman, 2013). In this direction, economists are making efforts to find solution by establishing both theoretical and empirical models (Koc and Bulus, 2020).

There are many economic parameters that may affect environmental degradation. At the forefront of these parameters is the *productive economic structures* of the countries (Apergis et al., 2018; Can et al., 2021). In this context, the aim of this study is to investigate the productive capacity on CO_2 emissions between the years 2000 and 2018 in a case study for 38 OECD countries. OECD countries are quite suitable for the purpose of this study because their characteristics are very well adapted to the objective of this inquiry. OECD countries, with their large population and production capacity, are the most influential players in global trade and also represent the most developed industrial countries (Manzoor Ahmad et al., 2021). These countries are the countries with the highest energy consumption and use traditional sources such as natural gas, oil and coal as energy sources which cause large amounts of CO2 emissions (Saidi & Omri, 2020). For this reason, OECD countries seek urgent and optimal solutions to contribute to CO2 reduction (H. Wang & Wei, 2020). The optimal solution sought by countries can often be to increase the efficiency of productive capacity, which prevents waste of resources. For this reason, it is very important to investigate the effects of PCI on CO2 emissions in OECD countries.

This study contributes to current literature in different aspects. According to our best knowledge, this is the first attempt that introduce the the productive capacity index on environmental economics literature. Second, we test the impact of productive capacity index on environmental degradation for a panel of 38 OECD countries spanning the period 2000-2018. Third, we employed different panel estimation techniques which are appropriate for CD dependent panel of OECD countries to obtain robust findings.

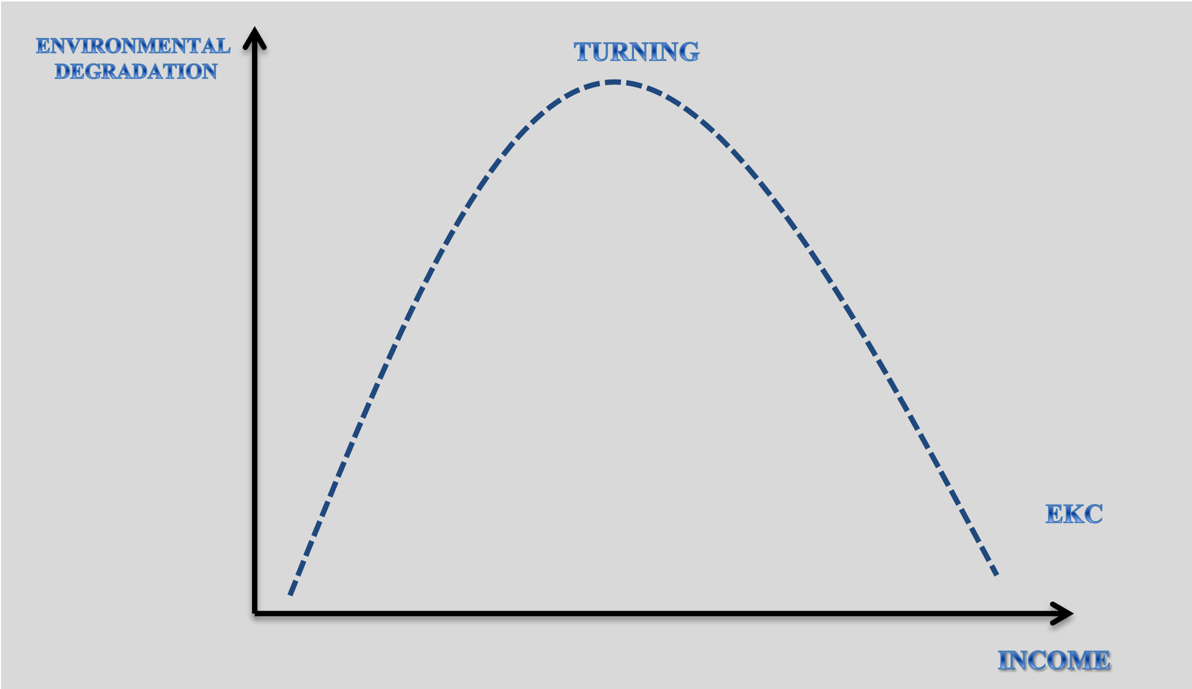
The ramining of the study is structured as follows. The the next section provides theoretical background, section 3 presents a review of literature, while section 4 describes data specification, estimation strategies and preliminary analysis. Section 5 displays the empirical outcomes and discussion. The last section concludes the research.

Therotical Background

Many researchers working on environmental economics have been trying to determine the factors affecting the environment for a long time. One of the most frequently used frameworks in these studies is the environmental Kuznets curve (EKC) hypothesis. The EKC hypothesis put forward by Grossman & Krueger (1991) has become the dominant theory among theories examining the relationship between economic growth and environmental degradation since the early 1990s (Demissew Beyene & Kotosz, 2020). According to the EKC hypothesis, in the first stage of economic development, environmental degradation increases as per capita income increases, but after per capita income reaches a turning point, environmental degradation begins to decrease. Thus, it is assumed that it leads to an inverted U-shaped relationship between income and environmental degradation. The inverted EKC hypothesis is presented in Figure 1.

This point of view, which ignores the importance of energy in the growth process, has changed over time and many studies, which can be called the second generation, use energy consumption as an explanatory variable as well as growth in environmental degradation (Aye & Edoja, 2017). However, today, researchers add some additional explanatory variables such as globalization, foreign direct investments, institutional quality, innovation (Islam et al., 2021) population and urbanization (Chekouri et al., 2020), tourism (Ren et al., 2019), industrial structure as explanatory variables (Guo & Guo, 2016) in empirical models.

Figure 2: Traditional U-inverted EKC

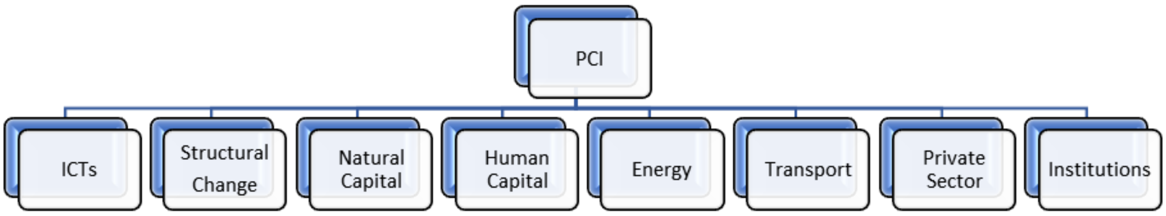


Source: Prepared by authors

Productive economic structure (knowledge-based, skill-based, and sophisticated) of countries are among the parameters that can have a significant impact on environmental parameters (Can & Gozgor, 2017; Doğan, Saboori, & Can, 2019). This productive economic structure is represented by many different parameters in the literature such as economic complexity, export concentration, trade diversification, industrial structure. However, these parameters partially represent the whole of productive economic structure of a given country. Last year, the Product Capacity Index, which represents the productive economic structure of countries holistically, was presented by the UN (UNCTADSTAT, 2021).

Productive Capacity is the backbone of a country's economic development and economic structural transformation of its ability to produce goods and services (UNCTAD, 2006). The PCI index, prepared by UN, is a composite index composed of 46 indicators, including eight main components (UNCTAD, 2021) which is presented in Figure 2. Considering its scope and diversity, it can be said that it is the most comprehensive index ever prepared for the measurement of productive capacities of countries. A high value of this index indicates that countries have a productive economic structure, while a low value indicates that their economic productivity is low.

Figure 2: Productive Capacity Index and Components



Source: UNCTADSTAT, (2021).

Each of the sub-parameters that make up the PCI has a relationship with the environment. Information and Communication Technology (ICT) comes first among the basic parameters that make up PCI. The literature highlights the impact of ICT (the internet, mobile phones, and telephone penetration levels) on economic growth and productivity (Qureshi & Najjar, 2017). In addition, ICT has the potential to potentially affect the environment. ICT optimizes resources in many different fields, especially logistics and transportation companies, increases efficiency and reduces energy consumption and therefore CO2 emissions (Chatti, 2021; Wang, Rodrigues, & Evans, 2015). In addition, the structural change in economy has a significant role in increasing or decreasing environmental quality. Because the change of economy from agriculture to industry increases the energy demand. At this stage, countries mainly operate in energy intensive heavy industry. Thus, this stage may have detrimentional impact on environmental quality. In the next stage, the transition to the high technology production structure takes place which leads to a reduction in energy consumption and an increase in environmental quality (Yuan et al., 2009).

On the other hand, economic models that do not include natural capital miss the role of natural capital in production. Natural capital is an important element of sustainable economic development as well as changing productivity growth (Brandt et al., 2017). This contribution may have a potential to impact on environmental quality. There are many studies that show human capital, directly and indirectly affects economic growth strongly and robustly by increasing productivity (Fafchamps & Quisumbing, 1999). In this case, human capital increases the use of non-renewable resources and pollution emissions until a certain threshold is reached. After this threshold is exceeded, environmental awareness increases, the use of environmentally friendly technology expands and CO_2 emissions are reduced with the efficient use of resources (M. Khan, 2020).

In structurally weak economies, it is very difficult to use energy for productive purposes. Especially, that rural areas encounter problems (shortage) in accessing energy limits the production capacities of the whole economy, prevents companies from producing competitively and weakens their export capacity (UNCTAD, 2021). Therefore, energy performance is one of the key elements of inclusive and sustainable economic growth (Ahmad & Zhang, 2020). The increase in energy efficiency will also lead to less energy consumption and reduce environmental degradation. Another important issue in ensuring energy efficiency is the ease of transportation. Investments in transportation infrastructure save time and cost, and increase economic growth by playing an important role in increasing regional productivity (Alotaibi et al., 2021). This increase in efficiency in the transportation sector also means less energy consumption and less environmental pollution. This is very crucial since transportation sector is responsible for about 18% of CO_2 emissions in the World (International Energy Agency, 2022). Therefore, while the transportation sector increases productivity on the one hand, it also has the potential to increase environmental pollution due to its dependence on fossil fuels (Santos, 2017).

The private sector has a significant role to play in the creation and expansion of productive capacity. Most of the time, this role can go far beyond the capacity of the public with limited resources. While the private sector creates and improves productivity, it provides jobs and income for individuals, presents goods and services for consumers, expands tax revenues for governments, and plays an important role in the development of technology (Hancock et al., 2011). The increasing role of the private sector in economic activities, which makes resource use more efficient than the public sector, has brought environmental pollution concerns along with it (Talukdar & Meisner, 2001). Considering the role of the private sector in meeting human needs and essential stakeholder for protecting the environmental quality, it may have negative effects on the environment, as well as an important element in ensuring sustainable development (Rashed & Shah, 2021).

On the other hand, studies on institutions deal with institutions as a set of formal and informal rules and regulations to a large extent. In these researches, the scholars focus on the impact of institutitons on economic activities. Studies show that poor institutional quality is an obstacle to the enrichment of poor countries and limits the productive capacity of these countries and prevents the emergence of their economic potential (Casson et al., 2010). Studies show that institutions can increase efficiency with regulatory and supervisory regulations and play an important role in reducing CO_2 emissions (Bhattacharya, et.al 2017).

Literature Review

Productive economic structure is an important player for environmental quality. In current environmental economics literature, researchers explore the components of PCI. These are economic complexity, renewable energy consumption, institutional quality, human capital etc. Some of these studies provided in the Table 1. However, so far, there is not any study explore the holistic impact of productive capacity on environment.

Table 1: The Effect of PCI Indicators on Environmental Degradation Litarature (Summarized Results)

Authors	Period	Country/Country Group	PCI Indicators	Environmental Degradation Indicator	Method	Result
Can and Gozgor (2017)	1964-2014	France	Economic Complexity	CO2	DOLS	(-)
Neagu and Teodoru (2019)	1995-2016	25 EU countries	Economic Complexity	GHG Emissions	FMOLS, DOLS	(+)
Liu et al.(2018)	1990-2013	Japan, Korea, China	Export Concentration	EF	VECM	Inverted U-shaped for Japan and Korea but (+) for China
Adebayo et al. (2022)	1965-2019	Turkey	Structural Change	CO2	NARDL	(-)
Sharma et al.(2021)	1990-2015	8 developing countries of Asia	Renewable Energy Consumption	EF	CS-Ardl	(-)
Charfeddine (2017)	1970-2015	Qatar	Energy Consumption	EF, CO2	MarkovSwitching Equilibrium Correction Model	Inverted U-shaped
Khan and Hou (2021)	1995-2018	38 International Energy Agency (IEA) countries	Energy Consumption	EF	FMOLS	(+)
Christoforidis and Katrakilidis (2021)	1984-2016	29 OECD countries,	Institutional Quality	EF	CS-DL, DOLS-MG	(-)
Abid (2016)	1996-2010	25 SSA countries (Sub-	Institutional Quality	CO2	GMM-DIFF, GMM-SYST	(-)

		Saharan Africa)				
Hosseini and Kaneko (2013)	1980-2007	129 countries	Institutional Quality	CO_2	Period SUR	(-)
Bano et al. (2018)	1971-2014	Pakistan	Human Capital	CO_2	ARDL	(-)
Ahmed and Wang (2019)	1970-2014	India	Human Capital	EF	ARDL, DOLS FMOLS, CCR	(-)
Nathaniel (2021)	1980-2016	G7	Human Capital	EF	GMM, ARDL, FGLS,	(-)
Sahoo and Sethi (2021)	1990-2016	36 Developing countries	Natural Resource	EF	MG, AMG, DCCE, FMOLS, DOLS	(-)
Ahmad et al. (2020)	1984-2016	22 emerging economics	Natural Resource	EF	CS-ARDL, AMG	(+)
Danish et al. (2019)	1990-2015	BRICS countries	Natural Resource	CO_2	AMG	(X)
Haseeb et al. (2019)	1994-2014	BRICS countries	ICTs	CO_2	DSUR	(-)
Zhang and Liu (2015)	2000-2010	China	ICTs	CO_2	FGLS	(-)
Danish et al. (2018)	1990-2015	N-11 countries	ICTs	CO_2	AMG	(+)
Godil et al.(2020)	2000M1-2019M8	USA	Transportation services	CO_2	QARDL	(-)
Saboori et al. (2014)	1960-2008	27 OECD Countries	Road transport sector	CO_2	FM-OLS	(+)
Ben Jebli and Hadhri, (2018)	1995-2013	The top ten international tourism countries	Transportation	CO_2	FMOLS, DOLS	(-)

Note: (+), (-), (X) signs indicate the effect of PCI indicators on environmental degradations. While (+) sign presents positive effect, (-) and (X) represent negative and statistically insignificant impact, respectively. EF, OLS, ARDL, NARDL, DOLS, FMOLS, AMG, DSUR, GMM, VECM, AGE, PMG, CS-ARDL, CS-DL, FGLS, DOLS-MG, DCCE, stand for ecological footprint**,** ordinary least squares, autoregressive distributed lag, nonlinear autoregressive distributed lag method, dynamic ordinary least squares, fully modified ordinary least squares, augmented mean group, iterative seemingly unrelated regression, generalized methods of moments, vector error correction model, applied general equilibrium, and pooled mean group, Cross-sectional autoregressive distributed lag approach, cross-sectional augmented distributed lag, feasible generalized least squares, dynamic ordinary least squares- group-mean, dynamic common correlated effect, respectively.

3. Data and Empirical Methodology

3.1. Data and descriptive statistics

The aim of the present study consists on investigating the dynamic short and long-run interdependence between environmental indicator (CO_2 emissions), economic growth and the productive capacity index using various panel cointegration techniques of estimations for a panel of 38 OECD countries[1] over the period 2000-2018. Also, the study tries to evaluate the validy of the environmental Kuznets curbe (EKC) hypothesis. The data on CO_2 emissions, real GDP are obtained from The World Bank World Development Indicator (WDI, 2021). PCI data are obtained from UNCTADSTAT, (2021).

Our empirical study starts by some descriptive statistics of the underlining variables of the selected sample of OECD countries. The descriptive statistics of CO2 emissions, real GDP and productive capacity index are reported in Table 1.

Table 2. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
CO2	722	331412.5	866300.9	1860	5776410
GDP	722	3.70e+15	6.10e+16	1.06e+10	1.50e+18
PCI	722	39.71749	4.846304	24.70107	52.63663
		CO2	GDP	PCI	
Pairwise correlation	CO2	1.0000			
	GDP	0.2160	1.0000		
	PCI	0.3444	0.0832	1.0000	

Notes: CO2= Carbon dioxide emissions; GDP= Gross Domestic Product; PCI= Productive capacity index

[1] Australia- Austria- Belgium- Canada- Chile- Colombia- Costa Rica- Czech Republic- Denmark- Estonia- Finland- France- Germany- Greece- Hungary- Iceland- Ireland- Israel- Italy- Japan- South Korea- Latvia- Lithuania- Luxembourg- Mexico- Netherlands- New Zealand- Norway- Poland- Portugal- Slovakia- Slovenia- Spain- Sweden- Switzerland- Turkey- United Kingdom- United States.

According to the outcomes reported in Table 1, the biggest value of CO_2 emissions has been recorded in the United States with 5776410 kt in 2000 while the smallest value of CO_2 emissions was in Iceland and equal to 1860 kt (2012). Regarding the real GDP variable, the higher value has been recorded in the United States with 1.50e+18 (in 2018). The smallest real GDP has been observed in Iceland with 1.06e+10 (in 2000). The United States has the highest index of productive capacity with 52.63663 (in 2016), while the lowest index was equal to 24.70107 (in 2000) in Colombia. The pairwise correlation between the analysis variables revealed no problem of correlation.

3.2. Empirical Methodology

The present research follows the study developed by Apergis et al. (2018) which is based on EKC frameworks. The evolution of the environmental quality (CO_2 emissions) is explained by the Gross Domestic Product (GDP) and its square. In addition, the empirical model considers the Productive Capacity Index (PCI) as an explanatory variable representing the productive economic structure. This empirical study does not integrate energy indicators (energy use, energy consumption,...) into the empirical model since the PCI index includes different energy indicators such as GFP per kg of oil consumption, total energy consumption per capita, renewable energy consumption as share of total final energy consumption. Otherwise, it leads to a multicollinearity problem.

The empirical model can be written as follows:

$$CO_2 = f\left(GDP, GDP^2, PCI\right) \quad (1)$$

The natural logarithmic form of Eq.(1) can be given as follows:

$$LnCO_{2,it} = \beta_0 + \beta_1 LnGDP_{it} + \beta_2 LnGDP_{it}^2 + \beta_3 LnPCI_{it} + \varepsilon_{it} \quad (2)$$

Where $i = 1,...,38$ and $t = 2000,...,2018$; CO_2, GDP, GDP^2 *and* PCI represent CO_2 emissions per capita, income per capita, the square value of income per capita and productive capacity index respectively. *Ln* denotes the natural logarithmic form of each variable.

The study tries to explore the role of the productive capacity index and economic growth on the propagation of the environmental indicators (CO_2 emissions), the analysis of the empirical parts applied various econometric tests. Also, the hypothesis of the environmental Kuznets curve (EKC) is verified for the long-run and the directions of causalities among the variables are discussed for the short and long-run relationships. The investigation considers the following empirical steps: i) examining the degree of cross-sectional dependence in residuals using Pesaran (2004) test; ii) testing the integration order of the variables using either the first or the second generation panel unit root tests (PURT) depending on the cross-sectional dependence results; iii) checking if variables are cointegration using Pedroni (2001) and Westerlund (2004) tests; v) estimating the short and long-run coefficients suing PMG-ARDL approach; and finally, vi) discussing the directions of causalities between the variables.

4. Empirical Results

The first step of the empirics consists of testing the degree of Cross-sectional dependence in residuals (CD) developed by Pesaran (2004). This test statistic is a fairly significant test for the selection of other econometric procedures tests applied in the analysis such as panel unit roots and cointegration tests. The test developed by Pesaran (2004) is applied to check which kind of PURT can be useful. The null assumption assumes the non-existence of CD in residuals. Thus, the first-generation PURT is suitable. However, the alternative assumption suggests the existence of CD in residuals specifying that the second-generation PURT is applicable to identify stationary characteristics. Pesaran (2004) has advanced this test to examine the degree of CD in the data. Detecting cross-sectional dependence can lead to decreasing the efficiency of the data and gives spurious outcomes (Philllips and Sul, 2003). Pesaran (2004)'s statistics uses a simple average of all pairwise correlation coefficients of OLS residuals obtained from the regression of the augmented Dickey-Fuller (ADF, 1979) for each series.

Table 3. Peasan (2004)'s Cross-sectional Dependence Test Result

Variable	CD-test	p-value	corr	abs(corr)
$LnCO_2$	21.03	0.000***	0.182	0.577
LnGDP	94.03	0.000***	0.814	0.814
LnPIC	108.94	0.000***	0.943	0.943

Notes: "***" indicates statistical significance at the 1% level. all of the statistics are computed under the null hypothesis of cross-section independence.

The outcomes of CD test are reported in Table 3 and indicate the rejection of cross-sectional independence in residuals of all underlining variables at the 1% significance level. Thus, the second generation PURT can be applied in this case.

Next, the study applies the cross-sectional augmented IPS (CIPS) PURT developed by Pesaran (2007) to check for the integration order of variables. The null hypothesis assumes that the variable is not stationary, while the alternative hypothesis assumes the stationary of series. The Pesaran test (2007) does not require the calculation of a factor allowing the removal of CD. An advanced ADF regression is taken into account to capture the CD that arises with a single-factor model.

Table 4. CIPS PURT Results

	CIPS unit root test (Pesaran, 2007)			
At Level	t-Statistic	-1.191	-1.786	-1.309

	Prob.	-	-	-
At first difference	t-Statistic	-4.188***	-2.962***	-4.483***
	Prob.	-	-	-

Notes: "***" indicates statistical significance at the 1% level. Pesaran panel unit root test (CIPS) with cross-sectional and first difference means included for each variable. The deterministic chosen is constant. Critical value are -2.03 (10%), -2.11 (5%) and -2.25 (1%).

The CIPS PURT results are reported in Table 4 and show that, at level, all variables contain a unit root. However, after the first difference, they became stationary. Thus, all variables are integrated of order one, I(1) at the 1% significance level.

The stationary tests proved that all variables are I(1) and the long-run cointegration can be checked using numerous cointegration techniques such as Pedroni (2004) and Westerlund (2007). Pedroni (2004) developed two sets of cointegration statistics (within and between dimensions). For the common process (within dimension), Pedroni (2004) has developed four statistics: v, rho, PP, and ADF statistics. For the individual process (between dimension), the test comprises three statistics: rho, PP and ADF statistics., Westerlund (2007) has advanced four cointegration tests which are based on the CD statistic of residuals. The statistics inspired by Westerlund produce an efficient outcome given the presence of CD in residuals.

Table 5. Panel Cointegration Tests Results

Westerlund cointegration tests				
Statistic	Value	Z-value	P-value	Robust P-value
Gt	-3.052	-2.466	0.007***	0.063*
Ga	-7.336	6.283	1.000	0.397
Pt	-17.931	-2.918	0.002***	0.040**
Pa	-7.311	3.930	1.000	0.247

Pedroni cointegration tests

Alternative hypothesis: common AR coefs. (within-dimension)				
			Weighted	
	Statistic	Prob.	Statistic	Prob.
Panel v-Statistic	0.086119	0.4657	0.123294	0.4509
Panel rho-Statistic	0.368554	0.6438	-0.855053	0.1963
Panel PP-Statistic	-2.140036	0.0162**	-4.395778	0.0000***
Panel ADF-Statistic	-2.282922	0.0112**	-4.709156	0.0000***
Alternative hypothesis: individual AR coefs. (between-dimension)				
	Statistic	Prob.		
Group rho-Statistic	1.380753	0.9163		
Group PP-Statistic	-3.800751	0.0001***		
Group ADF-Statistic	-3.935883	0.0000***		

Notes: "***", "**", and "*" indicate statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5 shows the outcomes of cointegration tests and suggests that two statistics among four from Westerlund cointegration tests confirm the presence of a long-run relationship among the variables. Pedroni outcomes reveal that four statistics among seven reject the null of no cointegration. Thus, according to these tests consequences, the long-run cointegration among the variables can be confirmed.

In this step, the study could investigate the structural long-run interdependence between CO_2 emissions, economic growth, and productive capacity index using the PMG ARDL approach. Pesaran et al. (1999) developed a transitional econometric estimator (PMG estimator) which imposes the similarity of long-rum coefficients while allowing the short-run coefficients to vary between country groups using the ARDL approach was further used to estimate both the short and long-run coefficients in addition to causalities among the variables. The PMG estimator may inspect the long-run coefficients to be constant across individual country groups. However, it permits the variation of the short-run coefficients, the residuals variance, and the intercepts. The ARDL model developed by Pesran et al. (2001) has been widely applied due to its econometric advantages. The ARDL technique is used in numerous empirical studies since it can be applied regardless of whether the series is I(1) or I(0). In addition, this technique simultaneously generates the long-term and short-term coefficients in the same model and gives good outcomes with a small sample.

Table 6. PMG-ARDL Estimates (LnCO_2 dependent variable)

Variable	Coefficient	Std. Error	t-Statistic	Prob.*
	Long Run Equation			
LnGDP	9.493406	1.102707	8.609181	0.0000***
LnGDP_2	-0.167496	0.020882	-8.021023	0.0000***
LnPCI	-1.030800	0.123126	-8.371933	0.0000***
	Short Run Equation			
ECT	-0.344033	0.062134	-5.536951	0.0000***
D(LnCO_2)	51.20099	83.60371	0.612425	0.5406
D(LnCO_2(-1))	142.8724	65.94581	2.166512	0.0308**
D(LnGDP^2)	-0.929726	1.540782	-0.603412	0.5466
D(LnGDP^2(-1))	-2.721465	1.200791	-2.266393	0.0239**
D(LnPCI)	1.545381	0.359766	4.295518	0.0000***
D(LnPCI(-1))	1.034886	0.437662	2.364576	0.0185**
C	-40.89130	7.357215	-5.557985	0.0000***

Notes: "***" and "**" indicate statistical significance at 1% and 5%, respectively. ECT denotes the error correction term. D(.) indicates the first difference.

The outcomes of PMG-ARDL are reported in Table 6 and show that all estimated coefficients are statistically significant at the 1% level. The estimated coefficients can be interpreted as elasticities given the logarithmic form. According to these results, the EKC assumption can be confirmed due to the sign of estimated coefficients of real GDP and its square. A 1% increase in real GDP leads to an increase in CO_2 emissions by 9.49%, while a 1% increase in the square of real GDP leads to decreasing CO_2 emissions by 0.17%. This findings confirm our expectations because in the developing process, the environmental issiues has secondary importance for countries. During that time, the economic parameters such as income, growth, employment are important for a society. However, after a certain threshold point, the environmental awaness of the society increases. Thus, while income level increases, the environmental degradation will decrease. These findings are in the line with the studies of (S. Khan et al., 2022). Interestingly, the productive capacity index coefficient is found to be negative and statistically significant to affect environmental indicators (CO_2). A 1% increase in the index of productive capacity will decrease emissions of CO2 by 1.03%. To our knowledge, this consequence is new and has not been previously investigated. The finding somewhat supports the research of Can & Gozgor (2017) who used the economic complexity index as a proxy of productive economic structure. We can conclude that the productive capacity of a country may a potential parameter that increase environmental quality.

Conclusion and Policy Directions

Many economic parameters may affect environmental degradation. The productive economic structure is one of the main indicators that may impact environmental quality. Thus, in this research, we attempted to inspect the impact of productive capacity on CO2 emission based on EKC frameworks in the sample of 38 OECD countries over the period 2000 and 2018. We employed Westerlund and Pedroni cointegration tests, PMG-ARDL approaches, and Granger causality tests to obtain the empirical findings. The cointegration analysis reveals that series are cointegrated in the long run. The outcomes gained from the PMG-ARDL approach confirmed the validity of the EKC hypothesis. Besides, the empirical findings provide evidence that productive capacity has significant and a negative impact on CO_2 emissions.

Emissions that lead to climate change are one of the biggest problems of today's world. This situation is also one of the important obstacles to sustainable development. In this direction, reducing CO_2 emissions has become one of the strategic goals at the national and international levels. Since environmental pollution is a very comprehensive and almost entirely human-induced problem, there is no easy solution. Based on the empirical findings mentioned above, it is understood that the increase in the productive capacity of the countries is a very strong factor in reducing CO_2 emissions. First of all, since the PCI index is a composite index consisting of eight main headings, improvements to be made in each heading will have important results in reducing CO_2 emissions as a whole. Thus, the current research proposes the following policies.

The widespread use of ICT increases the use of smart devices and networks, enabling optimization in the management planning and supply chain of goods, freight transportation. The widespread use of the internet allows the globalization of information and enables trading for manufacturers. Thus, it increases energy efficiency, limits time loss, increases efficiency, and limits environmental pollution. In this respect, it is of great importance for policymakers to support ICT investments. The commitment of countries to reduce greenhouse gases with the Paris Agreement allows making regulations on a global scale, especially in transport. Clean technologies need to be supported by taxes and subsidies to be competitive in the process of decarbonizing the transport sector and switching to relatively expensive alternatives. To do that, governments share a budget to support the transportation sector.

The environmental effects of the transformation of economic structures are also very important. During the transformation process, to meet the increasing energy demand, the use of renewable energy sources should be encouraged, and it should be possible to obtain the total energy consumption from renewable resources at an increasing rate. Increasing the quality of regulatory and supervisory institutions and ensuring institutional reliability in these countries will facilitate compliance with environmental regulations to be made in the long term. Another addressee of the regulations is the private sector. The public and private sectors should work together to reduce and prevent environmental pollution. A set of reliable indicators must be agreed upon to establish environmental targets, share social responsibility, and conduct monitoring and evaluation by establishing autonomous institutions in public-private partnerships.

To increase the environmental awareness of human capital, the content of education should be updated in a way that will increase environmental awareness. In this direction, Earth Overshoot Day should be reminded every year with events, and individuals should be raised awareness by showing how many months the natural resource produced by each country is consumed throughout the year. All human activities are more or less dependent on natural capital. Therefore, rather than seeing sustainability as an ethical problem, it should be acted from a risk management perspective, natural capital should be conserved and enhanced, and its productive capacity should be increased.

In this study, we intentended the explore Productive Capacity Index on environmental on CO2 emissions in the sample of OECD countries. Thus, our study is limited only OECD countries. We suggest that researcher can test the impact of PCI on various environmental indicators such as ecological footprint, carbon footprint, Sulphur Oxides (SO_X), Nitrogen Oxides (NOx), Carbon Monoxide (CO) and non-methane Volatile Organic Compounds (VOC) for different country groups. In this study, we used EKC hypothesis. For future research, scholars can test the effect of PCI on environment by using Stochastic Impacts by Regression on Population, Affluence, and Technology) (STIRPAT) model. Finally, the sub-components of PCI can be used as an explanatory variable for various country groups.

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