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Trade Openness, Political Stability and Environmental Performance: What Kind of Long-Run Relationship?

Otwartość w handlu, stabilność polityczna i wydajność środowiskowa: jaki rodzaj długotrwałej relacji?

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Abstract
This paper investigates the long-run relationships among environmental performance, political stability, and trade openness for 126 countries as well as the sub-samples of OECD and non-OECD countries, using the panel cointegration and panel-based error correction models for the period 2002-2014. For the full sample and the non-OECD countries, our results corroborate that there exists a long-term equilibrium cointegrated relationship among the variables. Moreover, the panel fully modified ordinary least square (FMOLS) estimations present that political stability and trade openness have a negative effect on environmental performance in full samples case as well as the non-OECD countries, whereas trade openness exhibits a positive influence on environmental performance in OECD countries. The vector error correction model (VECM) shows a diversified negative causalities running from trade openness and political stability to environmental performance in the long run for both full samples and the sub-samples countries. The policy implication is that pollution haven hypothesis (PHH) is supported and trade regulations can help promote environmental performance; meanwhile, political stability accelerates macroeconomic performance and attracts more foreign investment. Overall, the government can carry on a policy to lower pollution levels, thus further advancing environmental performance.

Key words: political stability, trade openness, Environmental Performance Index, Panel Cointegration, causality

Streszczenie
W niniejszym artykule przeanalizowano długoterminowe relacje pomiędzy wydajnością środowiskową, stabilnością polityczną i otwartością handlu w 126 krajach, a także pod-próbki krajów OECD i spoza OECD, z wykorzystaniem kointegracji panelowej i panelowych modeli korekcji błędów za lata 2002-2014. W przypadku całej próby i krajów spoza OECD nasze wyniki potwierdzają, że między zmiennymi istnieje długookresowa równowagowa zależność. Co więcej, panel FMOLS wskazuje, że stabilność polityczna i otwartość handlu mają negatywny wpływ na wydajność środowiskową w przypadku pełnych próbek, jak również w krajach nienależących do OECD, podczas gdy otwartość handlowa ma pozytywny wpływ na wydajność środowiskowe w krajach OECD. Model VECM pokazuje zróżnicowane negatywne przyczyny, które wynikają z otwartości handlowej i stabilności politycznej na wydajność środowiskową w dłuższej perspektywie, zarówno dla pełnych próbek, jak i dla podpróbek. Konsekwencją polityczną jest to, że hipoteza PHH (pollution haven hypothesis) jest wspierana, a regulacje handlowe mogą pomóc w promowaniu wydajności środowiskowej; tymczasem stabilność polityczna przyspiesza wyniki makroekonomiczne i przyciąga więcej inwestycji zagranicznych. Ogólnie rzecz biorąc, rząd może prowadzić politykę mającą na celu obniżenie poziomu zanieczyszczeń, a tym samym umożliwia dalszy postęp w dziedzinie ochrony środowiska.

Słowa kluczowe: stabilność polityczna, otwartość w handlu, Indeks Wydajności Środowiskowej, Panel Kointegracyjny, przyczynowość

1. Introduction

The coordinated development of the economy and environment has attracted the attention of many scholars recently, with sustainable economic growth being the main goal for countries around the world as the developing countries contribute 50% of global GDP, which is expected to grow to 60% by 2030 (Farhani and Rault, 2014; Ahmed et al., 2017). Generally speaking, the most striking factor in promoting economic growth is trade openness (Sharif, 2011). On account of trade agreements set up through the World Trade Organization (WTO) and the Association of Southeast Asian Nations (ASEAN), the global economy has experienced a historic rapid expansion in the last few decades (Ahmed et al., 2017; Ertugrul and Seker, 2016). Though such trends doubtless have produced great economic performance, increasing social welfare and improved the economic strength of individual countries, but bring the environmental quality to deteriorate at same time (Dogan and Seker, 2016). For example, in terms of global warming, the World Bank recently noted that the global average temperature is four degrees centigrade higher than that during the pre-industrial period (Ozturk and Acaravci, 2013); an extreme heat, rising seas, changing marine ecosystems, and unstable water availability are all projected to be at dangerous levels in the near future.

From different viewpoints, the stable political environments generally enhanced regional mutual trusts not only increase a great deal of environmental performance, but also contribute to a decrease in environmental problems among nations. A rapidly expanding literature has investigated the relationship between institutional failure and environmental regulation and finds that corruption has a negative influence on environmental performance (see, for example, Fredriksson and Svenson, 2003; Damania et al., 2003). Closely related studies empirically document as Fredriksson and Svenson (2003), they develop a theoretical framework and predict that the degree of political instability play the main element in formulating an environmental policy and has an effect on corruption. In their empirical investigation, an interaction variable between instability and corruption is added to their models to test this contention. Using the degree of environmental regulations in 1990 as the dependent variable, the authors find that corruption lowers the degree of environmental regulations significantly, but the impact lessens when the degree of political instability rises. More recent work as Damania et al. (2003), who investigate the relationships among environmental policy, corruption, and trade liberalization by developing an endogenous model of environmental policy determination. Their framework predicts that more trade openness leads to stricter environmental regulations. Governmental institutions also affect environmental performance. There are 5 theories showing that democracy can promote environmental quality. First, political rights and free flow of information should accelerate the causes of environmental interest groups. Second, compared to autocracies, electoral accountability and ability of groups to mobilize socially make democracies more responsive to the environmental needs of the public. Third, democracies respect the rule of law and human life and thus positively influence the environment. Fourth, compared to autocracies, democracies face a lower cost when environmental regulation reduces production and consumption. Fifth and lastly, autocracies distribute more resources toward oppressive actions when they are faced with the possibility of regime change (Hosseini et al., 2013). It means that environmental performance is affected by political institutions; because of the spatiality the environmental performance can influence neighboring countries. In a word, political stability plays a key determinant of environmental performance (Hosseini et al., 2013).

There are several international political conflicts that are linked with environmental shocks. For example, during the Iraq-Kuwait war in 1991, the Iraqi army destroyed Kuwaiti oil sources, resulting in a half a ton of air pollution, smog formation, and acid rain. This war also damaged dams and sewage water treatment plants, meanwhile brought about many environmental problems like haze and acid rain in the region. Previous scholars agree that regional political instability can weaken environmental regulations at a certain degree. For instance, Al-Mulali and Ozturk (2015) investigate 14 Middle East and North African (MENA) countries during the period 1996-2012, with the conclusion that political instability and ecological footprints are cointegrated in the long run, while political stability lessens environmental damage based on the panel VECM analysis. Such result shows that institutional instability actually weakens environmental regulations, while political stability shows its potential shocks on environmental performance. However, previous research mostly ignores the political stability, international trade and environment performance nexus. In this paper, we look to fill in this gap in the literature and test whether political stability is a core factor for environmental performance under consider the international trade.

Table 1 summaries the previous literature has separately studied how trade openness and political stability affects environmental performance. In accordance with Table 1, we first notice that most studies utilize CO_2 or SO_2 emissions as an indicator of environmental performance. Hence, many scholars use empirical methods to test how trade openness (TR) affects environmental quality, but the conclusions present differences due to the different samples, time period and empirical approaches. Third, it is rare works on how political stability (PS) impacts environmental performance except for the findings proposed by Al-Mulali (2015). Fourth and finally, governments formulate environmental policy and pro-

Table 1. Summary of the relationship among environmental performance, trade openness, and political stability

Author(s)	Environmental variable	Period	Sample	Methodology	Empirical finding
Cole (2004)	pollutant	1980-1997	OECD countries	Hypothesis Test	Trade openness $\xrightarrow{-}$ pollutant
Halicioglu (2009)	CO2 emissions per capita	1960-2005	Turkey	ARDL	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Jalil and Feridun (2011)	CO2 emissions per capita	1953-2006	China	ARDL	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Sharif Hossain (2011)	CO2 emissions per capita	1971-2007	Newly industrialized countries (NIC)	GMM	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Sharma (2011)	CO2 emissions per capita	1985-2005	69 countries	GMM	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Shahbaz et al. (2012)	CO2 emissions per capita	1971-2009	Pakistan	VECM	Trade openness $\xrightarrow{-}$ CO2 emissions per capita
Kohler (2013)	CO2 emissions per capita	1960-2009	South Africa	ARDL	Trade openness $\xrightarrow{-}$ CO2 emissions per capita
Ozturk and Acaravci (2013)	CO2 emissions per capita	1960-2007	Turkey	ARDL	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Shahbaz et al. (2013)	CO2 emissions per capita	1965-2008	South Africa	ARDL	Trade openness $\xrightarrow{-}$ CO2 emissions per capita
Al-mulali and Sheau-Ting (2014)	CO2 emissions per capita	1990-2011	189 countries	FMOLS	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Farhani et al. (2014)	CO2 emissions per capita	1971-2008	Tunisia	ARDL	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Shahbaz et al. (2014)	CO2 emissions per capita	1975-2010	Bangladesh	ARDL	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Al-Mulali and Ozturk (2015)	Ecological footprint	1996-2012	14 countries in MENA (Middle East and North African) region	FMOLS	Trade openness $\xrightarrow{+}$ CO2 emissions percapita
					Political stability $\xrightarrow{-}$ CO2 emissions percapita
Dogan and Seker (2016)	CO2 emissions per capita	1985-2011	Top countries listed in the Renewable Energy Country	FMOLS	Trade openness $\xrightarrow{-}$ CO2 emissions per capita
Ertugru et al. (2016)	CO2 emissions per capita	1971-2011	China, India, South Korea, Brazil, Mexico, Indonesia, South Africa, Turkey, Thailand, and Malaysia	ARDL	Trade openness $\xrightarrow{+}$ CO2 emissions percapita
Le et al. (2016)	PM10	1980-2013	98 countries	GLS	Trade openness $\xrightarrow{+}$ CO2 emissions per capita
Ahmed (2017)	CO2 emissions per capita	1971-2013	South Asian countries	FMOLS	Trade openness $\xrightarrow{+}$ CO2 emissions per capita

Notes: Pollutant is estimated from a mixture of ten air and water pollutants. CO_2 represents carbon dioxide emissions; PM10 represents emissions of particulate matter; ARDL represents Autoregressive-Distributed Lag Model; FMOLS: Fully Modified Ordinary Least Square; VECM: Panel Vector Error Correction Model; GMM: Generalized Method of Moments; GLS: Generalized Least Squares Method. Arrow means independent variable impacts on dependent variable, the "+" means a positive impacts whereas"-" means a negative shocks.

moting trade openness, political stability therefore influences the formulation and execution of these two policies. For these reasons, it is necessary to study the relationships among trade openness, political stability, and environmental performance.

The motivation of this paper is to study the impacts of trade openness and political stability on environmental performance, utilizing econometric methodologies such as panel cointegration, the Fully Modified Ordinary Least Square (FMOLS), and Vector Error Correction Model (VECM) in 126 countries for the period 2002-2014. We target to solve these 4 problems from previous studies. Therefore, this paper investigates the main factors that contribute to environmental quality so as to provide specific suggestions to policymakers to reduce environmental pollution.

This paper consists of 4 sections. Part 2 introduces a brief presentation of the panel cointegration test. Part 3 shows the empirical findings. Finally, part 4 offers the conclusions.

2. Econometric methodology and model

To study the panel cointegrated relationships among EPI, PS, and TR, we adopt the panel cointegration test proposed by Pedroni (2004), which follows the fixed effect panel model:

$$y_{it} = \alpha_i + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + u_{it}, \quad i = 1,...,N, \quad t = 1,...,T, \quad (1)$$

where y_{it} represents the dependent variable to measure EPI. To ensure robustness of our study, $x_{1i,t}$ denotes TR to measure trade openness, while $x_{2i,t}$ represents PS to measure political stability.

EPI has the dimensions $(N*T)\times 1$, while the TR and PS have the dimensions $(N*T)\times M$, where N represents the number of sample countries in the estimated panel, T is the observation periods, M reflects the regression variables, and u_{it} is the residual. The parameter α_i refers to the country-specific fixed effects. Heterogeneity exists within different economic growth rates, which is the same as TR and PS in those cross-country differences also present important econometric problems. The tests consider heterogeneity between individual members of the panel, covering heterogeneity in the long-run cointegrating vectors.

Once the variables exhibit a cointegrated relationship, we next estimate the cointegrated vectors. The process u_{it} in equation (1) can be written as:

$$u_{it} = \sum_{j=-\infty}^{\infty} \varphi_{ij} \varepsilon_{it+j} + v_{it} \ , \quad (2)$$

Where v_{it} is stationary with zero mean, φ_{it} is smaller than infinity, and v_{it} and ε_{it} are uncorrelated contemporaneously with all lags and leads. We now adopt a FMOLS estimator that uses the past and future values of independent variable x_{it} as additional regressors. The FMOLS technique not only has the benefit of correcting for bias that is induced by serial correlation and endogeneity among regressors from the traditional OLS estimation, especially for the cointegration model (Pedroni, 2000; Lee and Chang, 2006; Westerlund, 2007), but it also provides a modification of the heterogeneous dynamic in the cointegrated process when the residuals from the regression are transformed by non-parametric techniques (Philips and Hanson, 1990; Gaure, 2013).

Pedroni (2000) also emphasizes that such a technique is combined with the most beneficial factor of capturing small observations when the number of panels is less than the number of years. We then substitute equation (2) into equation (1) to get:

$$y_{it} = \alpha_i + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \sum_{j=-q}^{q} \varphi_{ij} \Delta x_{it+j} + \dot{v}_{it},$$

where $\dot{v}_{it} = v_{it} + \sum_{|j|>q} \varphi_{ij} \varepsilon_{it+j}$. (3)

We therefore obtain the estimator's FMOLS by running the following regression:

$$y_{it} = \alpha_i + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \sum_{j=-q}^{q} \varphi_{ij} \Delta x_{it+j} + \dot{v}_{it}. \quad (4)$$

Hence, in the empirical model we would like to introduce y_{it} as EPI. x_{it} as TR and PS.

2. Empirical results

Annual data for TR and PS come from World Development Indicator (WDI), and EPI is prepared jointly by the Yale Center for Environmental Law and Policy (YCELP) and the Center for International Earth Science Information Network (CIESIN) at Columbia University as a comprehensive assessment for various countries' environmental governance. The empirical period covering 2002-2014 is based on data that can be acquired[1]. In a word, EPI as an estimate is more reasonable than CO_2 emissions, because it can reveal the effect of a country or a nation on the environment in terms of air, soil, and water. Thus, the main contribution of this study to the literature is using EPI as a sophisticated evaluation indicator for environmental quality in a region.

3.1. Results of panel unit root and panel cointegration

For the empirical process, we first test the cointegrated relationships among EPI, PS and TR. Hence, when these variables are structurally cointegrated, we adopt the panel fully modified ordinary least squares (FMOLS) to explore the long-term relationship. Next, we employ the panel-based vector error

[1] In 2014, the EPI index included 178 economies, covering 99% of the global population, 98% of land, and 97% of global GDP.

correction model (VECM), which discovers the causality in our sample countries in long term. Finally, we discuss different group topics that contain OECD and non-OECD cases, which allow us to study the issuer more in-depth so as to establish a better environmental policy.

Table 2 shows the results of the panel unit root test, and the LLC and ADF tests, implying that EPI, PS, and TR have a unit root in the level statistics. At the same time, the results exhibit stationary behavior in all variables' first-differences at the 5% significance level and follow the I (1) process.

Table 2. Panel unit root tests

	LLC	ADF
EPI	3.88(0.96)	88.28(1.00)
PS	3.09(0.97)	93.37(1.00)
TR	-1.25(0.10)	274.60(0.13)
∆ *EPI*	-5.54(0.00)**	323.83(0.00)**
∆ *PS*	-19.12(0.00)**	465.08(0.00)**
∆ *TR*	-8.06(0.00)**	418.65(0.00)**

Notes: LLC and ADF tests are under the null of without a unit root. ∆ denotes first differences. All variables are in natural logarithms. ** indicates statistical significance at the 5% level. Values in brackets are the probability value.

Table 3 exhibits Pedroni's (2004) panel cointegration test of the basic model. In Table 3, when the dependent variable is EPI, except for panel variance, panel ρ, and group ρ statistics, all other statistics reject the null hypothesis of no significant cointegration. Given these tests' results, we believe that the 126 countries' EPI has a long-run cointegration relationship with PS and TR.[2]

Table 3. Pedroni's panel cointegration tests – Full sample: dependent variable is EPI

Independent variables: PS and TR	
Panel *v*-statistic	-4.94
Panel ρ	-0.67
Panel PP	-25.32**
Panel ADF	-16.93**
Group ρ	4.02
Group PP	-24.70**
Group ADF	-15.62**

Notes: Statistics are asymptotically distributed as normal. The variance ratio test is right-sided, while the others are left-sided. **and * denote rejecting the null of no cointegration at the 5% and 10% significance levels, respectively.

3.2. Results of panel FMOLS estimation

When the cointegrated relationship between variables exists, we next adopt the panel FMOLS estimation method offered by Kao and Chiang (2000) to calculate the individual and panel estimators, which are seen at the bottom of Table 4. In Table 4, when EPI is still considered as the dependent variable, as shown in the bottom column, the coefficients in the full sample of PS and TR are statistically significant at the 5% level, the effects are negative, and the panel estimators are -0.42 and -2.89, respectively. Why does PS show a negative impact on EPI? One possible reason is that in the full samples, most countries have a stable political society, which leads to a relaxation on environmental regulations for business purposely, because economic development usually creates environmental problems (Shahbaz et al., 2013). Another reason is that stability in politics will attract foreign investment, and in order to maintain these investments over the long term, governments will protect production, and based on this they may relax environmental protection (Tabassam and Hashmi, 2016).

TR has a negative impact on EPI, which is similar to the results in Halicioglu (2009) and Sharif (2011). It is simple to understand that more trade openness results in more carbon emissions and greenhouse effect, which bring more pollution and create environmental problems. From the PHH, the trade openness has a technology effect, scale effect, and composition effect on the environment. For the technology effect, when trade openness increases, it helps to promote technology and environmental performance and decreases carbon emissions. For the scale effect, trade openness adds trade volume and output, which subsequently result in environmental degradation. For the composition effect, developing countries attract pollution intensive industries from developed countries, leading to environmental problems. This means that scale and composition effects have a negative influence on environmental performance; however, the technology effect has a positive effect. The net impact hinges upon which effect is dominant among the three (Shahzad et al., 2017). In this paper we find that TR has a negative impact on EPI, which supports the conculsion that scale and composition effects are dominant on the environment.

When the cointegration of EPI, PS, and TR is found, we next establish VECM, which uses the two-step procedure from Engle and Granger (1987), so as to estimate the long-run causalities between EPI, PS, and TR. equation (5) is the model, as the first step, which can obtain the estimated residuals ε_{it}. They are identified as country, and time fixed effects and shown as α and δ, respectively.

$$EPI_{it} = \alpha_i + \delta_i t + \beta_{1i} PS_{it} + \beta_{i2} TR_{it} + \varepsilon_{it}, \quad (5)$$

According to the previous finding, we next estimate Granger causality as:

[2] The critical values of the panel cointegration tests are tabulated by Pedroni (1999, 2004).

Table 4. FMOLS estimates: EPI, TR, and PS - Full samples(Dependent variable is EPI)

country	PS	TR	country	PS	TR	country	PS	TR	country	PS	TR
Albania	0.17(7.66)**	-0.12(-0.96)	Gabon	0.02(0.25)	-0.25(-0.25)	Spain	-0.01(-0.02)	-0.21(-0.73)	Panama	0.18(1.31)	-0.08(-0.25)
Algeria	0.22(4.24)**	-2.10(-5.37)**	Georgia	0.02(0.20)	0.49(2.37)**	Sudan	0.05(0.69)	-1.04(-5.81)**	Paraguay	0.28(4.06)**	-0.70(-1.35)
Azerbaijan	-0.17(-2.40)**	-1.07(-3.74)**	Gambia	-0.63(-4.86)**	0.73(1.59)	Suriname	0.32(3.96)**	0.55(3.97)**	Peru	0.39(4.04)**	-0.65(-2.00)**
Argentina	-0.02(-0.36)	-0.89(-4.28)**	Ghana	-0.78(-1.85)*	0.60(1.14)	Sweden	0.18(1.49)	0.69(1.38)	Philippines	0.21(4.96)**	-0.28(-1.83)*
Australia	0.12(5.22)**	0.10(1.54)	Greece	-0.01(-0.37)	0.18(1.47)	Switzerland	-0.08(-1.29)	0.01(0.03)	Poland	-0.02(-0.93)	0.34(2.92)**
Austria	0.04(0.85)	0.24(1.14)	Guatemala	0.21(2.68)**	-0.79(-3.17)**	Tajikistan	0.15(0.70)	-0.65(-1.47)	Portugal	-0.01(-0.39)	0.33(2.95)**
Bangladesh	0.15(0.88)	0.70(1.47)	Honduras	-0.11(-1.03)	-0.18(-0.75)	Thailand	0.03(1.45)	0.29(0.93)	Qatar	-0.03(-0.73)	0.19(1.57)
Armenia	-0.11(-1.37)	0.20(0.82)	Hungary	0.05(0.59)	0.45(2.04)**	Togo	0.06(1.34)	2.10(5.59)**	Romania	-0.39(-1.39)	0.21(0.29)
Belgium	-0.17(-3.32)**	0.50(3.68)**	Iceland	-0.01(-0.25)	0.14(1.26)	Trinidad	0.18(2.34)**	-0.43(-1.62)	Russia	-0.06(-0.46)	-1.37(-1.67)*
Bolivia	0.13(1.93)*	0.21(0.97)	India	0.18(0.77)	0.01(0.02)	Tunisia	-0.08(-5.33)**	0.01(0.02)	Saudi Arabia	0.03(0.29)	0.38(0.63)
Bosnia	0.17(2.64)**	-0.63(-2.23)**	Indonesia	0.05(1.85)*	0.05(0.17)	Turkey	-0.04(-1.28)	0.73(4.82)**	Senegal	0.12(0.47)	2.19(2.34)**
Botswana	-0.25(-1.49)	0.48(2.41)**	Iran	0.09(4.15)**	-0.93(-6.10)**	Turkmenistan	0.01(1.59)	0.01(2.55)**	Serbia	0.07(1.67)*	0.22(1.07)
Brazil	-0.05(-0.35)	-0.44(-0.63)	Ireland	0.29(3.67)**	0.62(3.16)**	Ukraine	-0.12(-8.92)**	-0.89(-3.50)**	Singapore	0.01(0.65)	-0.12(-1.94)*
Brunei	-0.01(-0.15)	0.23(1.83)*	Italy	-0.16(-2.33)**	0.46(3.07)**	Macedonia	0.17(2.62)**	-0.16(-0.43)	Slovakia	-0.09(-0.72)	-0.44(-1.12)
Bulgaria	-0.19(-3.66)**	0.54(5.23)**	Cote d'Ivoire	0.05(2.32)**	-0.45(-1.78)*	Egypt	-0.03(-1.15)	0.01(0.05)	Viet Nam	-0.23(-1.57)	0.77(2.20)**
Myanmar	-0.24(-2.08)**	0.11(7.83)**	Jamaica	0.19(4.86)**	-0.17(-0.96)	Kingdom	-0.02(-0.46)	-0.03(-0.15)	Slovenia	0.03(0.40)	0.23(1.78)*
Belarus	-0.04(-1.54)	-0.19(-1.68)*	Japan	-0.05(-0.88)	0.05(1.07)	Tanzania	-0.11(-1.40)	0.81(1.60)	South Africa	-0.08(-1.07)	0.32(1.46)
Cambodia	0.35(5.54)**	-0.46(-1.60)	Kazakhstan	-0.01(-1.74)*	0.11(2.66)**	America	0.01(0.12)	0.42(1.18)	Zimbabwe	0.13(7.34)**	-0.05(-1.16)
Cameroon	-0.21(-2.04)**	0.86(1.88)*	Jordan	-0.01(-0.31)	-0.39(-3.74)**	Uruguay	0.26(1.96)**	-1.22(-3.31)**	Norway	-0.25(-1.29)	1.14(1.21)
Canada	0.08(0.61)	0.38(0.77)	Kenya	0.18(0.70)	-2.19(-2.61)**	Uzbekistan	0.03(0.86)	-0.87(-2.87)**	Estonia	-0.30(-2.39)**	-0.26(-1.17)
Chile	0.06(1.31)	0.44(1.76)*	South Korea	4.49(53.52)**	-104.30(-53.68)**	Venezuela	0.13(2.50)**	-0.04(-0.24)	Finland	0.18(1.39)	0.18(0.37)
China	-0.02(-0.13)	-0.39(-1.75)*	Kyrgyzstan	0.16(0.94)	-0.11(-0.23)	Yemen	0.09(1.96)**	-1.56(-5.28)**	France	-0.17(-4.11)**	1.29(6.28)**
Colombia	0.06(2.08)**	-0.09(-0.14)	Lebanon	-0.01(-0.14)	-0.03(-0.21)	Niger	-0.27(-4.29)**	-0.87(-2.61)**	Nicaragua	0.18(1.48)	0.31(1.73)*
Congo	0.15(2.23)**	1.02(1.52)	Latvia	-0.01(-0.14)	0.43(3.07)**	Mozambique	-0.08(-2.22)**	0.29(2.37)**	Ethiopia	-58.68(-36.96)**	-262.90(-36.89)**
Costa Rica	-0.13(-1.59)	0.68(1.68)*	Lithuania	0.29(1.57)	-0.05(-0.33)	Oman	0.04(1.01)	0.66(5.08)**	Eritrea	-0.04(-2.53)**	-0.14(-12.13)**
Croatia	0.40(2.17)**	0.68(1.68)*	Luxembourg	0.39(2.27)**	-0.42(-1.72)*	Namibia	-0.22(-1.23)	0.84(1.31)	Niger	-0.27(-4.29)**	-0.87(-2.61)**
Cuba	-0.13(-0.85)	0.29(2.15)**	Malaysia	0.13(2.18)**	-0.72(-4.39)**	Nepal	0.11(3.37)**	1.08(1.95)*	El Salvador	-0.06(-0.19)	0.02(0.01)
Cyprus	0.03(0.45)	0.90(2.95)**	Malta	-0.01(-0.01)	0.01(0.02)	Netherlands	-0.08(-1.48)	-0.14(-1.04)	Morocco	0.16(0.80)	0.10(0.33)
Czech Republic	-0.01(-0.11)	0.04(0.56)	Mauritius	-0.11(-2.39)**	0.51(1.85)*	New Zealand	-0.06(-1.25)	0.20(0.54)	Zambia	-0.10(-1.40)	0.71(3.32)**
Benin	-0.06(-0.95)	0.38(2.59)**	Mexico	0.03(0.42)	1.10(2.87)**	Dominican	0.16(1.72)*	0.11(0.40)	Moldova	0.21(2.64)**	-1.38(-3.24)**
Denmark	0.35(1.48)	-0.15(-0.31)	Mongolia	0.09(0.91)	-0.16(-0.41)	Ecuador	0.08(33.13)**	-0.01(-0.83)	Montenegro	-0.17(-3.29)**	-0.72(-3.16)**
Panel Group	**-0.42(7.71)****	**-2.89(-6.49)****	Norway	-0.25(-1.29)	1.14(1.21)	Pakistan	-0.07(-1.24)	-1.20(-1.09)			

Notes: ** and * denote rejecting the null of no cointegration at the 5% and 10% significance levels, respectively.

Table 5. Panel causality tests – full sample

Dependent variable	Source of causation (EPI, PS, TR)			
	λ	$\lambda / \Delta EPI$	$\lambda / \Delta PS$	$\lambda / \Delta TR$
Δ EPI	-3.90**	--	5.67**	8.87**

Note: ** and * indicate significance at the 5% and 10% levels, respectively.

$$\Delta EPI_{it} = \chi_{1i} + \lambda_1 ECM_{it-1} + \sum_k \theta_{11k} \Delta EPI_{it-k} + \sum_k \theta_{12k} \Delta PS_{it-k} + \sum_k \theta_{13k} \Delta TR_{it-k} + u_{1it}, \quad (6)$$

where t denotes the time period 2002-2014, i denotes the cross sections (126 countries), u_{it} is the error term, ECT is the lagged error correction term, k is the lag length, and χ represents the fixed country effects. The error correction model represents the equilibrium error λ_1, implying a long-run relationship in the process of cointegration and also that co-movements with this path are permanent. In addition, For long-run causality, we can test $H_0 : \lambda_1 = 0$ in eq. (6). Thus, we carry on the joint test to check for any existing causality, where variables usually face the burden of adjusting from the short-run equilibrium to the long-run equilibrium.

The test results from our panel VECM are in Table 5, which presents evidence that λ exhibits long-run causality from both PS and TR to EPI at the 5% significant level. Consequently, in the long run, evidence exists for causalities running from trade openness and political stability to environmental performance in the 126 countries. Moreover, these causalities have a negative effect, meaning that when TR and PS increase, this leads to environmental degradation in our samples countries.

Our results for the relationship between TR and EPI are similar to most previous finding, which note that greater TR leads to environmental degradation. However, the conclusion of the relationship between PS and EPI is different from previous literature.comparing with previous finding, Al-Mulali and Ozturk (2015) presenting that PS has a negative effect on CO_2 emissions per capita. It means that better PS portends to better environmental performance, which is opposite to our paper's result. We believe the primary reason for this is the different samples that have been adopted. While they use 14 countries in Middle East and North African (MENA), our paper utilizes 126 countries, including those in MENA.

3.3. Results of the panel cointegration test and panel long-run estimate for the sub-samples

Given that most samples for individual countries exhibit differences in level of development, environmental protection attitude, and environmental awareness (Cole, 2004), pooling these samples simultaneously into the models may lead to errors in the estimations. Based on this, we divide the full sample into two subsamples of OECD and non-OECD countries to determine variables' relationships. Accordingly, the panel data subsamples from 31 OECD countries and 95 non-OECD countries are utilized[3]. We first make sure that the two series are of the I (1) process with statistical significance. Next, we turn to test whether a cointegrated relationship exists. Table 6 shows the findings of Pedroni's (2004) panel cointegration test; most of the statistics again significantly reject the null of no cointegration. As a result, we can predict that the variables present long-run cointegration, no matter for OECD or non-OECD countries. Next, we use the panel FMOLS estimation to determine the influence of EPI, PS, and TR in the long run, with results shown in Table 7.

Table 6. Pedroni's panel cointegration tests for the subsamples

	EPI, PS, TR	
Models	OECD(31)	Non-OECD(95)
Panel *v*-statistic	-3.81	-3.27
Panel ρ	-0.52	-0.86
Panel PP	-15.78**	-22.59**
Panel ADF	-11.14**	-15.68**
Group ρ	1.64	3.68
Group PP	-17.09**	-21.32**
Group ADF	-11.83**	-13.30**

Notes: Statistics are asymptotically distributed as normal. The variance ratio test is right-sided, while the others are left-sided.**and*indicate rejection of the null of no cointegration at the 5% and 10% significance levels, respectively.

[3] 31 OECD countries are Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Estonia, Finland, France, Greece, Hungary, Iceland, Ireland, Japan, Latvia, Luxembourg, Mexico, Netherlands, New ealand, Norway, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States of America..
95 Non-OECD countries are Albania, Georgia, Oman, Algeria, Ghana, Pakistan, Angola, Guatemala, Panama, Armenia, Haiti, Paraguay, Azerbaijan, Honduras, Peru, Bahrain, India, Philippines, Bangladesh, Indonesia, Qatar, Belarus, Iran, Romania, Benin, Iraq, Russia, Bolivia, Jamaica, Saudi Arabia, Bosnia and Herzegovina, Jordan, Senegal, Botswana, Kazakhstan, Singapore, Brazil, Kenya, South Africa, Brunei, Kuwait, Sri Lanka, Bulgaria, Kyrgyzstan, Sudan, Cambodia, LebaNon, Tajikistan, Cameroon, Libya, Tanzania, China, Lithuania, Thailand, Colombia, Macedonia, Togo, Congo, Malaysia, Trinidad and Tobago, Costa Rica, Malta, Tunisia, Cote d'Ivoire, Mauritius, Turkmenistan, Croatia, Moldova, Ukraine, Cuba, Mongolia, United Arab Emirates, Cyprus, Montenegro, Uruguay, Dominican Republic, Morocco, Uzbekistan, Ecuador, Mozambique, Venezuela, Egypt, Namibia, Yemen, El Salvador, Nepal, Zambia, Eritrea, Nicaragua, Zimbabwe, Ethiopia, Viet Nam, Gabon, Niger, Nigeria.

Table 7. FMOLS long-run estimates for the sub-samples (Dependent variable is EPI)

OECD(31)		NON-OECD(95)	
PS	TR	PS	TR
1.27(-0.20)	0.31(8.14)**	-81.30(5.83)**	-4.28(-8.53)**

Note: Same as in Table 3.

Table 8. Panel causality tests for the sub-samples

	OECD(31)				Non-OECD(95)			
Dependent variable	Source of causation (EPI, PS, TR)							
	λ	$\lambda/\Delta EPI$	$\lambda/\Delta PS$	$\lambda/\Delta TR$	λ	$\lambda/\Delta EPI$	$\lambda/\Delta PS$	$\lambda/\Delta TR$
ΔEPI	-2.79**	--	3.33**	4.87**	-1.71*	--	3.33**	3.08**

Note: Same as in Table 4.

Table 7 reports the panel FMOLS estimators, in which the OECD countries' PS has no long-run relationship on EPI. TR gets a positive impact on EPI, as the panel coefficient is 0.31. However, similar to the full sample, all the non-OECD countries' variables have a long-run negative relationship on EPI with a statistical significance at the 5% level, as the panel coefficients are -81.30 and -4.28, respectively. Finally, the empirical results imply that all cases have a clearer cointegrated relationship among these variables in non-OECD countries.

The full sample has the same result as the subsample of non-OECD countries. Because there are 95 non-OECD countries versus 31 OECD countries, we believe the number of former is the main factor. PS does not affect EPI in OECD countries, and we think the reason is that OECD countries are composed of developed economies, and most of these developed countries have already placed greater emphasis on environmental protection and their environmental quality has improved. Some potential reasons for PS and EPI have a negative co-movement both in the full sample and the subsample of non-OECD countries are as follows. First, non-OECD countries consist of developing countries, which have political stability that leads to high-speed economic development (Uddin and Masih, 2017), and they get their welfare from economic growth. However, high-speed economic development usually leads to the greenhouse effect, which creates environmental problems. Since most non-OECD countries ignore these environmental problems, they thus give rise to bad environmental performance (Álvarez-Herránz, 2017). The second reason is that political stability attracts foreign investment. In order to maintain these investments over the long run, governments will protect production, and based on this, they may relax environmental protection (Tabassam and Hashmi, 2016).

We also look that EPI and TR have a negative co-movement both in the full sample and the subsample of non-OECD countries. It means that better TR leads to bad EPI, which is the same result as in Halicioglu (2009) and Sharif Hossain (2011). The reason is more trade openness brings about more carbon emissions and a greater greenhouse effect, which create environmental problems. Different from the results of full sample and the subsample of non-OECD countries, TR has a positive effect on EPI at the 5% significant level in OECD countries. It means that more trade openness makes for better EPI. We think the reason is that OECD countries transfer production plants to developing countries(Shahzad et al., 2017, Le et al., 2016). The waste following the production transfer then appears in these developing countries, but the value of trade is given over to developed countries (Sharma, 2011; Jayanthakumaran and Liu, 2012).

Table 8 reports the findings of VECM for a panel causality test among EPI, PS, and TR. For both subsamples of OECD and non-OECD countries, the results show that the EPI equation is significant at the 5% level in the former, while the EPI equation is significant at the 10% level in the latter. It means the causalities run from trade openness and political stability to environmental performance in the long run for non-OECD countries, and it shows a negative relationship from trade openness and political stability to environmental performance.

3. Concluding remarks and policy suggestions

By using panel cointegration tests, this paper examines the co-movement and causality among EPI, PS, and TR, by employing data of 126 countries from 2002 to 2014. To avoid heterogeneous problems in our samples and to carry out a robust investigation, we also divide the countries into two subsamples of OECD and non-OECD countries. Our results indicate that there is a clear cointegration relationship among EPI, PS, and TR in our sample countries, and that the panel FMOLS estimations confirm both TR and PS have a negative impact on EPI in the full sample and the subsample of non-OECD countries. However, for the subsample of OECD countries, only TR has positive impact on EPI. In accordance with our panel VECM estimation, PS and TR impact EPI in the long run for the full sample and the two sub-samples.

According to the results obtained, we conclude that both political stability and trade openness impact environmental performance. First, we recommend that the countries under investigation should conduct trade-related policies to promote environmental protection through trade. Political stability accelerates macroeconomic performance and attracts more foreign investment. Thus, policymakers need to target some select projects that have little pollution in order to protect the environment. At the same time, governments can carry out policies that lower pollution levels and formulate minimum environmental standards in order to decrease the emissions of hazardous substances. Second, trade agreements can strengthen the capacity for governments to deal with environmental issues by, for example, incorporating environmental provisions into the agreement. It is a very effective way to protect the global environment. Reducing the trade barriers on environmental goods should lead to greater access to green technologies at a lower cost. For instance, the Trans-Pacific Partnership (TPP) agreement is expected to help developing countries change pollution industries into cleaner industries and transition into low-carbon channels by offering access to green goods, services, and investments (Ertugrul et al., 2016). Third and lastly, developing countries should promote the reduced use of fossil energy and instead employ clean energy that does not harm the economy. It is another effective way to avoid environmental degradation (Niu et al., 2017).

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