Social Indicators Research (2020) 147:621–649
https://doi.org/10.1007/s11205-019-02163-3

ORIGINAL RESEARCH

Catechizing the Environmental-Impression of Urbanization, Financial Development, and Political Institutions: A Circumstance of Ecological Footprints in 110 Developed and Less-Developed Countries

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Accepted: 17 July 2019 / Published online: 22 July 2019

Abstract
This study stabs to probe the impact of financial development, urbanization, trade openness, political institutions, and energy consumption on the ecological footprints (EF), within the framework of EKC, of 110 countries congregated by income levels, over the time span of 1996–2016. The final outcome of cross-sectionally weighted Panel EGLS and multi-step A-B GMM evidently reinforced the existence of EKC hypothesis in case of EF both in developed and less-developed countries. This study finds the destructive environmental impact of composition effect and energy consumption while political institutions, trade openness, and urbanization have constructive environmental effect. Financial development reduces the human demand on nature only in less-developed countries. The ultimate consequences of this study are equipped with several policy recommendations for the concerned authorities.

Keywords Ecological footprints · Urbanization · Financial development · Political institutions · Environmental Kuznets curve · GMM

1 Introduction

Anthropogenic climatic deviations and global warming pose a radical and drastic threat to the affluence of humans and the planet's ecosystem and need to be alleviated as these eco-adverse changes are catastrophically threatening humans' survival on earth (Bello et al. 2018; Charfeddine and Kahia 2019; Solarin and Bello 2018). Though immense literature regarding environment-growth nexus has emerged, but the empirical and pragmatic confirmation to precisely map the ties amidst financial development and environmental quality

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is not adequately enough (Seetanah et al. 2019). Consequently, the associations amongst urbanization, financial development, political institutions, economic growth and environmental degradation, has been the focus of intention of multitude of environmentalists and policy makers (Charfeddine and Kahia 2019).

The role of financial development is vital and vibrant in economic growth (Chang 2002; Jenkıns and Katırcıoglu 2010; Kaushal and Pathak 2015), as it promotes economic growth by encouraging savings, increasing physical capital in both quantity and quality and finally boosting investment (Nazlioglu et al. 2009). Despite the vigorous economic role of financial development, its adverse environmental impact cannot be ignored. There are various studies which have investigated the environmental impact of financial development (Al-Mulali et al. 2015a, b; Katircioğlu and Taşpinar 2017; Pata 2018; Rasoulinezhad and Saboori 2018; Saidi and Mbarek 2017; Tamazian and Rao 2010), but consensus has not been yet done. The environmental impact of financial development may either be positive or negative. Al-Mulali and Sab (2012), Muhammad and Ghulam Fatima (2013), and Pata (2018) explained that financial development deteriorates environmental quality by instigating economic growth which means higher level of production and consumption which increases energy consumption. On the other hand, Omri et al. (2015), Ozturk and Acaravci (2013), and Rasoulinezhad and Saboori (2018) explained that financial development improves environmental quality by facilitating firms in enhancing research and development and implementing cleaner and green technologies.

Despite the incidence of numerous studies probing the environmental impact of urbanization the consensus has not been reached yet (Charfeddine and Khediri 2016). Previous researchers found the conflicting outcomes and made the urban-environment association even more complex. The environmental impression of Urbanization may either be beneficial or harmful. Urbanization brings environmental damage by boosting the demand for fossil fuels due to higher demand of housing, public infrastructure, and transportation (Ali et al. 2019a, b; Dong et al. 2019). Shahbaz and Lean (2012) argued that urbanization increases energy consumption which can cause environmental damage. Contrary to it, urbanization can reduce the environmental damage by promoting efficient use of public infrastructure, urban agglomerations, and efficient use of land area, on the other hand by reducing distance travel, and private vehicles usage (Charfeddine 2017; Chen et al. 2008; Poumanyvong and Kaneko 2010).

Where enhanced political institutional quality is inescapable for unremitting and sustained financial and economic development (Cropper and Griffiths 1994; Culas 2007; North 1991), its dire critical role in in EKC framework cannot be snubbed (Ali et al. 2019a; Panayotou 1997) for diminishing environmental degradation (Apergis and Ozturk 2015). Tamazian and Rao (2010) confirmed that financial development is beneficial to the environmental quality only if it is escorted with resilient institutions. Deacon (2003), Ibrahim and Law (2015), and Panayotou (1996) argued that institutions' quality is the one of the major determinants of environmental quality. Hence, environmental quality is not just improved at higher income levels but this economic growth and environment nexus depends on the governance and institutional quality, as better institutional quality is associated with higher environmental quality (Ibrahim and Law 2016; Panayotou 1997), so the role of enhanced political institutions in determining environmental quality is inevitable.

Where international trade plays its vital role in igniting economic growth (Katircioglu 2010; Katircioglu et al. 2010) its environmental impact can't be over-looked. The environmental impact of trade, has been decomposed into scale, composition and technique effects (Antweiler et al. 1998; López et al. 2007). Scale effect refers to the amplified economic activity due to increased trade intensity (Katircioglu 2009; Katırcıoğlu et al. 2016), which in turn increases pollution emissions due to higher economic activity and higher energy consumption level. Trade may change the composition of country's output i.e. if a country is labor-intensive then trade will allow it to produce environmental friendly goods and vise-versa, so composition effect may be either positive or negative. The technique effect refers to diminutions in emission intensity per unit of output, as trade boosts economic growth and demand for cleaner environment increases with the rise of income level. Hence, the environmental impact of trade depends on the net effect of scale, composition, and technique effects. So, trade may affect the environmental quality either positively or negatively depending on the net effect of scale, technique, and composition effects.

In literature, most of studies capture environmental quality by incorporating CO_2 emissions within the EKC framework. However, CO_2 emission is a week indicator of environmental quality, as it measures only air contamination, and so CO_2-based implications may be deceptive (Ulucak and Lin 2017). Thus, Ecological Footprint (EF) has emerged as an all-inclusive indicator of environmental degradation as it encompasses all three types of pollutions such as air, water, and soil (Solarin and Bello 2018). Explicitly, this study intends to investigate the impact of urbanization, financial development and institutional quality measured by political institutions on the ecological footprints, a concise and thorough measure of environmental degradation, of developed and less-developed countries.

This study contributes to the existing literature by many folds. First of all, in this study we probe the environmental deterioration in fifty-three developed and fifty-seven less developed countries, by incorporating ecological footprint which is more comprehensive and general proxy for environmental damage, as hardly any study has conducted this type of comparative analysis. Secondly, we developed a comprehensive index to capture different aspects of financial development for both group of countries. Thirdly, in order to investigate the role of institutions in determining environmental quality we have also developed another concise index for political institutions for all the countries under consideration. Fourthly, this study endeavor to examine the environmental impression of trade openness by decomposing the net trade impact into scale, composition, and technique effects, as to our knowledge there is hardly any study which has conducted this decomposition analysis for EF in both groups of countries. Lastly, this study probes the comparative analysis of environmental impression of urbanization between both groups of countries, as to our knowledge there is hardly any study which has performed the comparative analysis of impacts financial development, political institutions, and urbanization on the EF of both developed and less-developed countries, by constructing comprehensive indices for both financial development and political institutions.

The rest of the document is purposefully designed as follows: The coming segment exhibits the global ecological footprints and their incidence in both developed and less-developed countries while the third chapter provides the brief review of relevant literature. Fourth section discusses the data and empirical methodology and provides the variables construction as well. Empirical results and discussion has been encompassed in the 5th section. Lastly, Sect. 6 concludes the study and delivers policy implications.

2 Ecological Footprints Incidence in DCs and LDCs

EF is a more exhaustive and principal measure of environmental degradation, along with greenhouse gasses[1] emissions. It was developed by Rees (1992) and extended by Rees and Wackernagel (1996) and Wackernagel and Rees (1998). EF designates human

[1] Greenhouse gasses include CO_2, N_2O, S_2O, CH_4, and anthropogenic Fluorinated gasses.

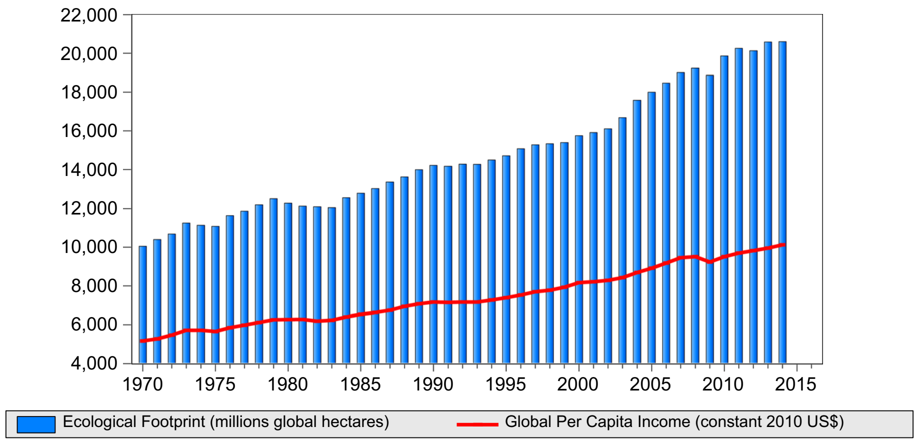

Fig. 1 Global ecological footprint and GDP per capita. *Source*: Developed by the author based upon data extracted from WDI, World Bank and Global Footprint Network

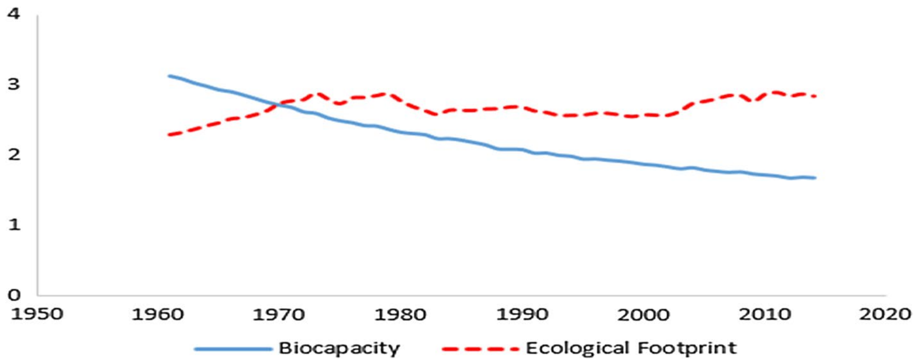

Fig. 2 Global ecological footprints and biocapacity. Vertical axis measures global hectares per person. *Source*: Developed by the author based upon data extracted from Global Footprint Network

demand on nature, as it measures, by incorporating ecological accounting system, all the natural resources required to support an economy. An economy's ecological footprint is the total biologically productive land and aquatic area, measured in global hectares, needed to produce resources that people consume and to absorb pollution generated by human activity; by means of prevalent technology (Bagliani et al. 2008; Charfeddine and Mrabet 2017).

The human demand on nature has been increased substantially during last few decades, as shown in Fig. 1. Global ecological footprint measured in global hectares has shown an increase of over 292% since 1970, while world per capita income has also increased by

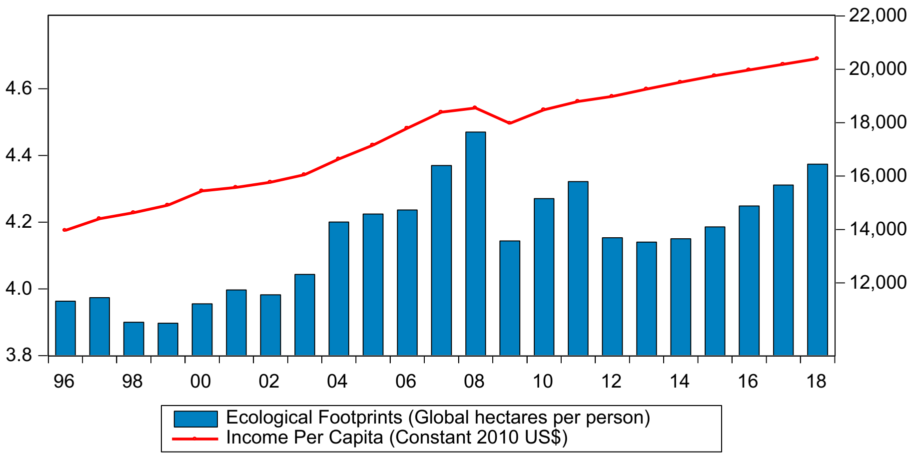

Fig. 3 EcoloGICAL FOOTprints and GDP per capita of DCs. *Source*: Developed by the author based upon data extracted from WDI, World Bank and Global Footprint Network

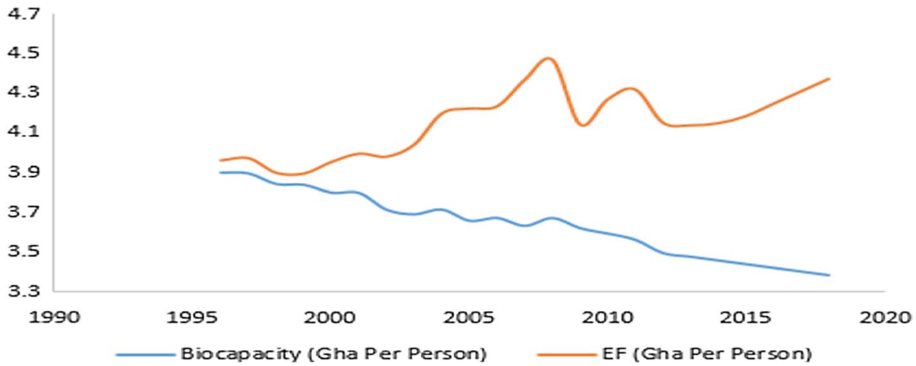

Fig. 4 Ecological Footprints and Biocapacity of DCs. Vertical axis measures global hectares per person. *Source*: Developed by the author based upon data extracted from Global Footprint Network

195% over the same period. This high demand on nature has lead the whole world towards ecological deficit[2] which is continuously shooting up (see Fig. 2).

Ecological footprints global hectares per person rose notably in the developed countries since 1996, while per capita income of these considered countries was also on the rise during the same time span, as exhibited in Fig. 3. Ecological deficit in developed countries is continuously widening due to high demand on nature in these high income nations, shown in Fig. 4. Though human demand on nature in less-developed countries (LDCs) is much lower than developed nations, but still ecological footprints and per person GDP continuously rose in LDCs, over the selected period, see Fig. 5. Rising income levels in LDCs exerted pressure on environment by increasing human demand on nature and not

[2] Ecological deficit indicates that ecological footprints (natural resources consumption) exceeds the biocapacity (biologically productive area).

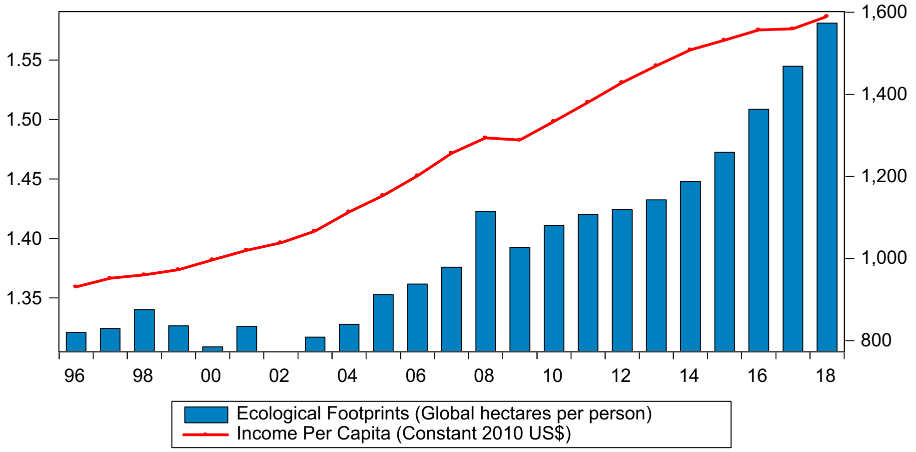

Fig. 5 Ecological footprints and GDP Per capita of LDCs. *Source*: Developed by the author based upon data extracted from WDI, World Bank and Global Footprint Network

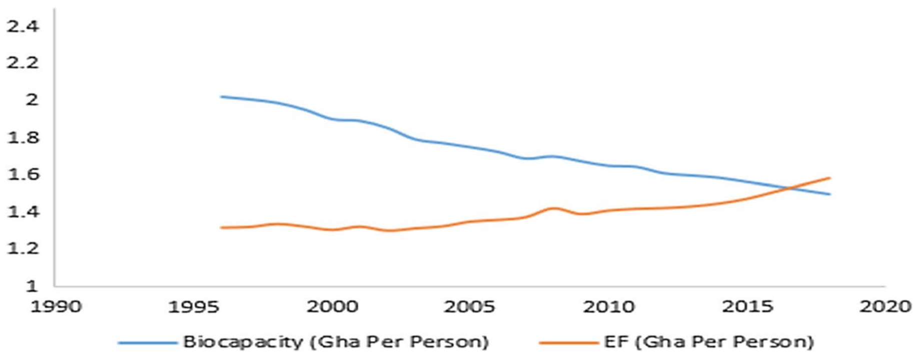

Fig. 6 Ecological footprints and biocapacity of LDCs. Vertical axis measures global hectares per person. *Source*: Developed by the author based upon data extracted from Global Footprint Network

only eroded ecological reserve but also turned it into ecological deficit, which is worsening over time, shown in Fig. 6.

3 Literature Review

The environmental impact of financial development, energy consumption, urbanization, and trade openness has been investigated by large number of researchers under the framework of so-called Environmental Kuznets Curve (EKC) hypothesis. EKC postulates an inverted-U shape association between economic growth and pollution emissions (Grossman and Krueger 1991; Grossman and Krueger 1994; Shafik 1994; Shafik and Bandyopadhyay 1992).

According to EKC hypothesis, pollution emissions surges up due to economic growth at early stages but later on, after a certain income level, effluences start to decline as demand for environmental quality increases at higher income levels (De Bruyn et al.

1998). Overwhelming number of studies have probed the presence of EKC hypothesis (Akbostancı et al. 2009; Coondoo and Dinda 2002; Copeland and Taylor 2004; Dasgupta et al. 2000; Dinda 2004; Gökmenoğlu and Taspinar 2016; Grossman and Krueger 1991; Halicioglu 2009; Lise and Van Montfort 2007; Ozturk and Acaravci 2010; Seker et al. 2015; Stern 2004), but still unison consensus has not been yet made.

Al-Mulali et al. (2015b), Ang (2007), Apergis and Payne (2009), Aslan et al. (2018), Charfeddine and Khediri (2016), Halicioglu (2009), Hamit-Haggar (2012), Jalil and Mahmud (2009), Lean and Smyth (2010), Marrero (2010), Pao and Tsai (2010), Saboori and Sulaiman (2013a, b), Shahbaz et al. (2013b, c) and Wang et al. (2017) confirmed an inverted-U shape association between income and effluence emissions while Akbostancı et al. (2009), Chandran and Tang (2013), He and Richard (2010) and Wang et al. (2013) were incapable to upkeep the professed EKC hypothesis.

Dong et al. (2018) validated EKC hypothesis, for CO_2 emissions, by incorporating panel data of fourteen Asia Pacific countries, over the period of 1970–2016. Olale et al. (2018) employed provincial panel data of Canada, covering time period 1990–2014, and confirmed the presence of EKC hypothesis at country and provincial level while using fixed effect methodology. Katircioglu et al. (2018) investigated the impact of economic growth, urbanization, and population at world level from 1960 to 2013. They confirmed EKC hypothesis only when population is inserted in the model. Balin and Akan (2015) also supported EKC hypothesis by using panel data of 27 developed countries over the time span of 1997–2009.

Farhani et al. (2014) employed FM-OLS and DOLS and confirmed inverted-U shape relationship between CO_2 emissions and per capita income in 10 MENA countries over the period from 1990 to 2010. Osabuohien et al. (2014) established the inverted-U shape association between per capita income and CO_2 by using panel data of 50 African countries from 1995 to 2010. Chiu (2012) used panel data of 52 developing countries from 1972 to 2003 and investigated the impact of economic growth on deforestation. He used panel smooth transition regression (PSTR) and endorsed the EKC hypothesis incidence. Leitao (2010) confirmed the existence of EKC hypothesis for sulfur, using global panel data over the period of 1850–2000. Narayan and Narayan (2010) investigated the EKC hypothesis in 43 developing countries by measuring short and long run elasticities over the period of 1980–2004. They approved that CO_2 emissions fall as income grows in the long run.

Shahiduzzaman and Alam (2012) employed auto-regressive distributed lag (ARDL) estimation technique and confirmed the presence of EKC hypothesis, for CO_2 emissions, in Australia from 1961 to 2009. Saboori et al. (2012) found inverted-U shape linkage between per capita income and CO_2 emissions in Malaysia covering time period 1980–2009. Ahmad et al. (2016) used time series data from 1971 to 2014 and validated EKC for CO_2 in Indian economy using ARDL model.

Hassan et al. (2019) probed the impact of per capita income, natural resources, and urbanization on the EF of Pakistan, over the time span of 1970–2014. They supported EKC and found that natural resources have positive impact on EF. They found that urbanization improves environmental quality by reducing EF. Bello et al. (2018) incorporated time series data of Malaysia covering time span of 1971–2016 to investigate the impact of per capita income, and urbanization on CO_2 emissions, EF, water footprint, and carbon footprint. They found substantial evidence of EKC hypothesis for all measures of environmental damage while they found harmful environmental impact of urbanization in case of CO_2 emissions only.

Charfeddine (2017) employed Markov Switching Equilibrium Correction Model (MS-ECM) and incorporated time series data of Qatar from 1970 to 2015 and found the evidence of EKC hypothesis for EF ecological carbon foot print and CO_2. Mrabet and Alsamara (2017) performed a comparative analysis by determining the impact of per capita income, energy consumption, trade openness, and financial development on both EF and CO_2 emissions, by incorporating time series data of Qatar ranging from 1980 to 2011. They used ARDL model to estimation and supported the EKC hypothesis only in case of EF. They measured financial development by ratio of credit to private sector to GDP and inferred that financial development causes environmental pollution by increasing EF while reduces CO_2 emissions.

Ulucak and Bilgili (2018) got the evidence of inverted-U shape association between per capita income and EF in low, middle, and high income countries. Charfeddine and Mrabet (2017) used Fully Modified OLS (FMOLS) and dynamic OLS (DOLS) and confirmed the inverted-U shape behavior between per capita income and EF in 15 MENA countries, covering time period of 1975–2007. They also confirmed that urbanization improves environmental quality while political institutions do not bring any benefit to the environment. Uddin et al. (2017) examined the environmental impact of economic growth, foreign trade, and financial development in 27 countries with highest figure of ecological footprint from 1991 to 2012. They employed Dynamic-OLS technique and found that foreign trade and financial development reduce EF while real income deteriorates environmental quality by increasing EF.

Ozturk et al. (2016) probed the EKC hypothesis for EF in 144 countries, over the period of 1988–2008 but they were able to support the hypothesis only in upper-middle and high income countries. They also found that urbanization improves environmental quality in more than half of high-income countries but deteriorates in majority of the countries. Al-Mulali et al. (2015b) used panel data of 93 countries, over the period of 1980–2008, to examine EKC hypothesis by using EF as an indicator of environmental degradation. They confirmed the inverted-U shape association between per capita income and EF. Moreover, they found that trade openness, urbanization, and energy consumption causes environmental damage while financial development improves environmental quality. Uddin et al. (2016) used time series data of twenty-two countries to examine the EKC hypothesis for EF but they were able to support the hypothesis only in 10 countries.

Where there are numerous studies supported the EKC hypothesis, in contrast, there are many who could not upkeep the explicit inverted-U shape ties between per capita income and pollution emissions. For instance, Allard et al. (2018) investigated the impact of per capita income on CO_2 emissions using panel data of 74 countries from 1994 to 2012. They confirmed N-shaped association between per capita income and CO_2 emissions. They also found beneficial environmental impact of renewable energy consumption. Alvarez-Herranz et al. (2017) also found N-shaped association between economic growth and CO_2 emissions in 17 OECD countries from 1990 to 2012. Kearsley and Riddel (2010) investigated the EKC in 27 OECD countries but they were incapable to find any significant supporting evidence for the association. Arouri et al. (2012) investigated the impact of economic growth and energy consumption on CO_2 emissions in twelve MENA countries. They affirmed damaging environmental impact of energy consumption but they found diminutive evidence in support of EKC hypothesis. Chandran and Tang (2013) could not find any supporting evidence for EKC hypothesis in five ASEAN countries.

Zoundi (2017) empirically examined the existence of inverted-U shape association between CO_2 emissions and per capita income using panel data set of twenty-five African countries, from 1980 to 2012 but they rejected the existence of EKC hypothesis. Ozcan (2013) investigated the association between CO_2 emissions and economic growth in twelve

Middle East countries, overt the period of 1990–2008, but they were able to affirm the EKC hypothesis in only three countries.

Wang et al. (2013) probed the EKC hypothesis for EF by using cross sectional data of 150 nations for the year of 2005 but they could not get any evidence to support the hypothesis. Caviglia-Harris et al. (2009) employed difference-GMM developed by Arellano and Bond (1991) to inspect the EKC hypothesis by using panel data of 146 countries from 1961 to 2000, in case of EF, but they could not support the hypothesis substantially. They found that energy consumption depreciates the environmental quality by causing EF.

Hervieux and Darné (2013) explored the impact of per capita income on EF by using time series data of 15 countries over the period of 1961–2007. They found linear positive relationship between EF and per capita income while EKC was evident only in two out of 15 countries. Gill et al. (2018) rejected the incidence of EKC hypothesis in Malaysia during time period 1970–2011.

Financial development stimulates economic growth (Calderón and Liu 2003; Chang 2002; Frankel and Romer 1999; Mazur and Alexander 2001) which can improve environmental quality by attracting green technologies (Frankel and Rose 2002; Katircioğlu and Taşpinar 2017). Contrary to it, Sadorsky (2010), Pata (2018), and Tamazian and Rao (2010) argued that financial development can deteriorate the environmental quality by promoting polluting industry. Despites the presence of several studies which probed the environmental impact of financial development, the association between financial development and environmental degradation is still in mist. For instance, Pata (2018) used domestic credit to private sector as a proxy for financial development and got that financial development causes CO_2 emissions in Turkey, over the period of 1974–2014. Al-Mulali and Sab (2012) confirmed that financial development measured by DCPS and broad money (BM) deteriorates environmental quality by causing CO_2 in thirty Sub-Saharan African countries. Same as, Muhammad and Ghulam Fatima (2013), Zhang (2011), and Sadorsky (2010) found that financial development causes CO_2 in Pakistan, China, and twenty-two emerging economies, respectively.

Mrabet and Alsamara (2017) found that financial development, measured by credit of private sector to GDP ratio, causes CO_2 while it reduces EF in Qatar, over the period of 1980–2011. Charfeddine (2017) found that financial development causes EF while it reduces carbon footprint and CO_2 in Qatar. Al-Mulali et al. (2015b) confirmed that financial development, measured by domestic credit to private sector, has negative impact on EF in ninety-three developing countries. Whereas, Omri et al. (2015) and Ozturk and Acaravci (2013) supported the neutrality hypothesis for the impact of financial development on CO_2 emissions in panel data of 12 MENA countries and Turkey, respectively.

Role of institutions is crucial not only for better financial and economic development (Cropper and Griffiths 1994; Culas 2007; Jones and Manuelli 2001; North 1991), but it is also critical in EKC framework (Bhattarai and Hammig 2001; Panayotou 1997; Torras and Boyce 1998) for diminishing environmental degradation (Apergis and Ozturk 2015). Tamazian and Rao (2010) confirmed that financial development is beneficial to the environmental quality only if it is escorted with resilient institutions. Bhattarai and Hammig (2001) found that strong institutions develop environmental quality in Africa, Asia, and Latin America.

Antweiler et al. (2001) decomposed the trade environmental impact into scale, composition, and technique, effect.[3] The net trade impact on the environmental quality may either

[3] For definitions of scale, technique, and composition effects see Sect. 1.

be positive or negative depending on these three effects. Hossain (2011), Shahbaz et al. (2013a), and Jayanthakumaran and Liu (2012) found that trade improves the environmental quality while Abler et al. (1998), Kasman and Duman (2015), Ozturk and Acaravci (2013), and Suri and Chapman (1998) confirmed the detrimental environmental impact of foreign trade.

The discussion given above confirms that there is a resilient affiliation between environmental quality and economic factors such as economic growth, financial development, political institutions, trade openness, energy consumption, and urbanization within the framework of EKC hypothesis. To the best of the author's knowledge, this study is dissimilar to the preceding research in numerous aspects, such as there is hardly any study which has performed a comparative analysis between developed and less developed countries in case of ecological footprint by incorporating comprehensive indices for financial development and political institutions. Moreover, this study will decompose the net trade effect into scale, composition, and technique effect in case of EF at global level.

4 Data and Empirical Methodology

This study aims to probe the associations among financial development, political institutions, energy consumption, trade openness, urbanization, and ecological footprint for 53 developed and 57 less developed countries within the framework of EKC hypothesis, over the period of 1996–2016. We followed Antweiler et al. (2001), who amalgamated Heckscher-Ohlin model to decompose the net trade effect into scale, composition, and technique effects as follows:

$$\hat{\psi} = \hat{\xi} + \hat{\jmath} + \hat{\tau} \tag{1}$$

In Eq. 1, $\hat{\xi}$ is the scale effect which elucidates that larger economic activity upsurges both production and consumption and deteriorates the environmental condition as more effluences are discharged at higher level of consumption and production, keeping all other things same, while the composition effect ‘ $\hat{\jmath}$ ‘ describes how the industrial structure and output mix of the economy moves the environmental effluences, depending on the extent of trade and the nation's comparative advantage. The technique effect, ‚$\hat{\tau}$‚ explains that pollution emissions starts to decline at higher income levels as demand for environmental excellence surges with the escalation of national income. The pollution emissions, represented by $\hat{\psi}$, hinge on the scale effect, measured as per capita income, which measures the size of the economy, the composition effect (capital-labor ratio), which measures the factor abundance of the country, and the technique effect (measured by square of per capita income).

Finally, in order to reach the foremost objective of the study, we followed Al-Mulali et al. (2015b), Ang (2007, 2009), Apergis and Ozturk (2015), Cole (2006), Ibrahim and Law (2015), Katircioglu et al. (2018), Uddin et al. (2017), and Ozturk and Acaravci (2013) to establish the final empirical model, in logarithmic form, as follows:

$$\ln EF_{it} = \pi_0 + \Omega \ln Y_{it} + \nu \ln Y_{it}^2 + \eta \ln U_{it} + o FD_{it} + \varphi P_{it} + \xi \ln K_{it} + \tau \ln O_{it} + \sigma \ln E_{it} + \varsigma_{it} \tag{2}$$

where $\ln EF_{it}$ is the natural logarithm of per capita ecological footprint, while $\ln Y_{it}$ and $\ln Y_{it}^2$ measure the per capita income and square of per capita income, whereas $\ln U_{it}$ represents the natural log of urbanization. Financial development has been indicated by FD_{it}, while P_{it} indicates the independent variable political institutions. Stern (2004) and Lean and Smyth (2010) argued that most of the EKC literature suffer from omitted variable bias so in order to avoid the omitted variable bias we added trade openness, energy consumption, and the composition effect, as well. Here in Eq. 2, composition effect measured by capital-labor ratio has been represented by $\ln K_{it}$. Finally, $\ln O_{it}$ and $\ln E_{it}$ measure natural log of trade openness and energy consumption, respectively.

4.1 Model Specification

In this study we are intended to probe the impact of financial development, political institutions, trade openness, and urbanization on the ecological footprint of 110 countries. In order to investigate the linkages amid the series we incorporated A-B multi-step Generalized Method of Moments (A-B GMM) estimators by Arellano and Bond (1991). We opted for the GMM estimators for many reasons. First, Roodman (2006) argued that GMM best suits when number of years (T) is less than number of countries (N) which is a case in our study as number of years, T (21), is lower than number of countries, N (53 and 57). Second, GMM resolve the potential endogeneity issues in regressors by introducing instrumental variables (Omri and Chaibi 2014). Third, this approach does not eradicates cross-country variations. Fourth, ordinary estimation techniques such as least-square regressions may suffer from dynamic panel bias e.g. country-specific heterogeneities which can be easily eradicated by GMM. Lastly, B-B GMM is preferred if there is a finite-sample bias (Baltagi 2008; Blundell and Bond 1998) which is not a case in this study so we proceeded with A-B GMM.

Finally, we specified our empirical model as follows, in Eq. 3:

$$\ln \mathrm{EF}_{\mathrm{it}} = \gamma_i + \Omega \ln \mathrm{Y}_{\mathrm{it}} + \nu \ln \mathrm{Y}_{it}^2 + \eta \ln \mathrm{U}_{\mathrm{it}} + \mathrm{oFD}_{\mathrm{it}} + \varphi \mathrm{P}_{\mathrm{it}} + \xi \ln \mathrm{K}_{\mathrm{it}} + \tau \ln \mathrm{O}_{\mathrm{it}} + \sigma \ln \mathrm{E}_{\mathrm{it}} + \Psi_{\mathrm{i}} + \alpha_{\mathrm{t}} + \varsigma_{\mathrm{it}} \tag{3}$$

where the subscript "i" denotes the designated, individual, countries (i = 1…53 for Panel A and i = 1……57 for Panel B), while, the subscript "t" specifies the time period (t = 1996–2016). The panel model specified in Eq. 3 captures all the country-specific unobserved heterogeneity by Ψ_i and time-fixed effects by α_t while ς_{it} is a time-varying idiosyncratic error term. Besides, Hao and Liu (2015) and Leitao (2010) argued that country-specific time-invariant diverse features may affect the pollution emissions, consequently to capture these country-specific diverse characteristics we have reported panel fixed effect estimators.

4.2 Data Source and Variable Construction

In this study we exploited annual panel data of 110 countries (53 developed and 57 developing countries), covering time span of 1996–2016, to sightsee the influence of financial development (FD), political institutions (P), trade openness (O), energy consumption (E), and urbanization (U) on the ecological footprints (EF), within the framework of EKC.

We acquired the annual data of ecological footprint, measured in global hectors, from Global Footprint Network.[4] The yearly data for GDP per capita (constant 2010 US$), energy consumption (kg of oil equivalent per capita), trade openness (ratio of exports plus imports to GDP), urbanization (total number of people living in urban areas) are fetched from World Development Indicators (WDI), World Bank. We measured composition effect by capital-labor ratio, where we used gross fixed capital formation (GFCF, constant 2010

[4] https://www.footprintnetwork.org.

US$) as a proxy for capital stock. We combed WDI, World Bank for both GFCF and labor force (total labor force). In this study, financial development (FD) is a composite index of domestic credit to private sector (DCPS), domestic credit by banking sector (DC), broad money (BM), and liquid liabilities (LL). The data for all these constituent elements except liquid liabilities has also been extracted from WDI, World Bank, while the data for liquid liabilities has been extracted from Global Financial Development, World Bank.

We used Voice and Accountability (VA), Political Stability and Absences of Violence (PSAV), Government Effectiveness (GE), Regulatory Quality (RQ), Rule of Law (RL) and Control of Corruption (CC) to construct a comprehensive index to capture institutional quality. We collected data of all these regressors, which are contributing to the edifice of political institutional index from Worldwide Governance Indicators (WGI), World Bank.[5] We have shown the variables names, their symbols, measures, and the expected signs, as per economic rationale and previous studies' findings, in Table 1.

GDP per capita (Y) captures the scale effect so it is expected to increase the environmental degradation so per capita income is expected to have positive sign. EKC hypothesis assumes that technique effect captured by square of per capita income reduces environmental degradation at higher income levels so square of per capita income (Y^2) is expected to be negative signed (Grossman and Krueger 1991). Urbanization can improve environmental quality if urban population have access to green technologies and it is properly planned (Charfeddine and Mrabet 2017) and opposite otherwise.

Financial development may have negative sign if it attracts green technologies (Katircioğlu and Taşpinar 2017) and positive otherwise (Pata 2018). Political institutions can improves the environmental quality if they are sufficiently strong enough to curb the pollution emissions, and opposite otherwise (Charfeddine and Mrabet 2017; Ibrahim and Law 2015).

Composition effect (K) may either be positive or negative depending on the environmental regulation strength and resource abundance of the nation (Abler et al. 1998). Trade openness may also have either of the symbols depending on the net effect of scale, composition, and technique effects (Antweiler et al. 2001). Energy consumption is expected to have positive sign as it reduces environmental quality by causing pollution emissions. Summary of descriptive statistics of both panel A (DCs) and panel B (LDCs) are presented in Tables 10 and 11, given in "Appendix". Correlations amid the series, given in Table 2 for DCs and Table 3 for LDCs, exhibit that none of group has any problem raised by high correlations.

4.2.1 Principal Component Analysis

Composite financial development and political institutions indices have been constructed using Principal Component Analysis (PCA). PCA is a statistical technique which is used to construct single weighted index from different; but correlated variables. The transformation of original variables into uncorrelated variables has been given below:

In order to capture different aspects of financial development and political institutions, we opted PCA to construct comprehensive indices for these variables. PCA is engaged to condense a large set of extremely correlated series into a reduced set of uncorrelated indicators which characterize a substantial variations of the original dataset (Feridun and

[5] Accessed on 15th March, 2018.

Table 1 Variables description, symbols, and expected signs

Variables	Symbol	Variables measure	Expected sign
Ecological Footprint	*EF*	It is measured in global hectors	
Real GDP per capita	*Y*	It is measured in constant 2010 US$	+
Real GDP per capita squared	Y^2	It is equal to square of Y	–
Urbanization	*U*	Urban population refers to people living in urban areas	±
Financial Development Index	*FD*	It is a composite Index of DCPS, DC, LL and BM[a], constructed by PCA	±
Political Institutions Index	*P*	PI is a composite Index of VA, SAV, GE, RQ, RL, and CC[b], constructed by PCA	±
Capital-Labor Ratio	*K*	Capital Measured by Gross Fixed Capital Formation (GFCF) in constant 2010 US$ and Labor by total labor force	±
Trade Openness	*O*	Trade openness is a ratio of sum of exports and imports and GDP	±
Total Energy Consumption per capita	*E*	It is measured in Kg of oil equivalent per capita	+

Ecological Footprint is a dependent variables so it does not have expected sign

[a]For details of DCPS, DC, and BM, see Sect. 4.2.1

[b]For details of VA, PSAV, GE, RQ, RL, and CC, see Sect. 4.2

Table 2 Correlation matrix of panel a (developed countries)

	ln EF	ln Y	ln UR	FD	P	ln K	ln O	ln E
ln EF	1.0000							
ln Y	0.4012	1.0000						
ln UR	0.1865	0.5547	1.0000					
FD	0.2164	0.5700	0.4709	1.0000				
P	−0.1218	0.1771	−0.1519	0.0641	1.0000			
ln K	0.5392	0.7767	0.4285	0.4984	0.1131	1.0000		
ln O	0.0913	0.2814	0.1708	0.2516	0.0277	0.3199	1.0000	
ln E	0.6339	0.5793	0.4422	0.2753	−0.0549	0.5648	0.1302	1.0000

Table 3 Correlation matrix of panel B (less-developed countries)

	ln EF	ln Y	ln UR	FD	P	ln K	ln O	ln E
ln EF	1.0000							
ln Y	0.4264	1.0000						
ln UR	0.0736	0.6026	1.0000					
FD	0.3532	0.5999	0.4419	1.0000				
P	0.1160	0.0745	-0.0134	0.0479	1.0000			
ln K	0.2389	0.5514	0.4714	0.4491	0.1058	1.0000		
ln O	0.0244	0.0961	0.2701	0.2199	0.0669	0.2557	1.0000	
ln E	0.3556	0.3995	0.2250	0.4252	0.0390	0.2922	0.1723	1.0000

Sezgin 2008; Katircioğlu and Taşpinar 2017). This transformation can be symbolized as follows:

$$Ultimate_{Index=W_1CI_1+W_2CI_2+\ldots+W_mCI_m=\sum_i^m W_i*CI_i} \tag{4}$$

In Eq. 4, the $Ultimate_{Index}$ represents the concluding composite index established, whereas CI_i characterizes factor scores of respective constructing indicators and W_i symbolizes the allocated weights find by each of the contributing indicators. The apportioned weights are measured as follows:

$$W_i = \left(\frac{\theta_i}{\sum_i^n \theta_i}\right) \times 100 \tag{5}$$

where W_i denotes the apportioned weight allotted to the ith factor and θ_i is the variance of the ith factor (Chen 2010; Katircioğlu and Taşpinar 2017).

4.2.1.1 Financial Development Index Adu et al. (2013) argued that there is not any exact and precise measure of financial development due to the diverse and multifaceted structure of financial development across the economies. Plentiful proxies, such as domestic credit to private sector by financial corporations, domestic credit to private sector by depository corporations, broad money, liquid liabilities, bank assets, stock market capitalization, etc., have been employed by researchers to measure financial development, but these proxies are not

Table 4 Principal component analysis for financial development index

Component	Eigenvalue	Difference	Proportion	Cumulative
Panel A (Developed countries)				
1	3.341570	2.821240	0.8354	0.8354
2	0.520338	0.420193	0.1301	0.9655
3	0.100145	0.062200	0.0250	0.9905
4	0.037944	.	0.0095	1.0000
FD indicators	Factor loadings	Unexplained	FD indicators	KMO
DCPS	0.4940	0.1846	Overall	0.7020
DC	0.4956	0.1794		
BM	0.5081	0.1373		
LL	0.5022	0.1571		
Bartlett's test for sphericity: 5570.931 (0.000)				
Component	Eigenvalue	Difference	Proportion	Cumulative
Panel B (Less-developed countries)				
1	2.678670	1.694140	0.6697	0.6697
2	0.98453	0.653007	0.2461	0.9158
3	0.33152	0.326247	0.0829	0.9987
4	0.00527	.	0.0013	1.0000
FD indicators	Factor loadings	Unexplained	FD indicators	KMO
DCPS	0.5875	0.07605	Overall	0.6264
DC	0.5903	0.06792		
BM	0.1528	0.93110		
LL	0.5320	0.24180		
Bartlett's test for sphericity: 6421.327 (0.000)				

One principal component is extracted. KMO is a Kaiser–Meyer–Olkin measure of sampling adequacy

problem free (Tyavambiza and Nyangara 2015). Although, Domestic credit to private sector is a widely used measure of financial development but it is not a direct measure of transaction costs and endowment of financial services information. Moreover, Adusei (2012) argued that domestic credit by banking sector is a better measure of financial development, for developing countries, than domestic credit to private sector.[6]

King and Levine (1993) suggested broad money (M2) as a proxy for financial development but it better represents monetization rather than financial development as it, largely, consists of currency (Jalil and Feridun 2011; Shahbaz et al. 2017). Although, Liquid

[6] Governments in less developed countries are compelled to borrow, for economic development, from depository corporations. So, credit by banking sector is a better measure of financial intermediation in less developed countries, than credit to private sector.

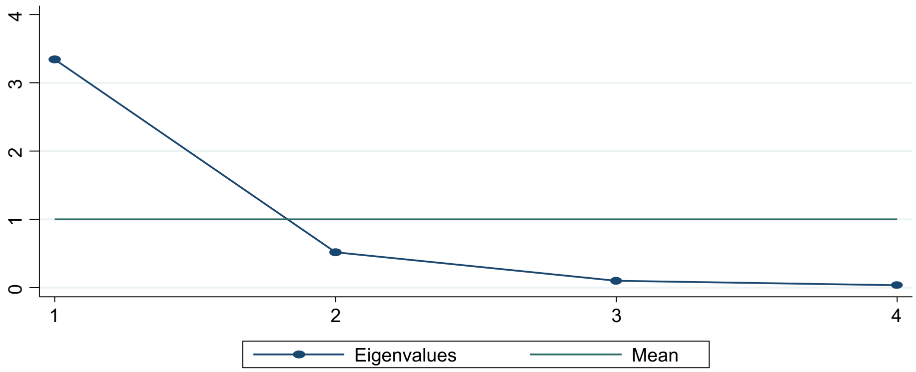

Fig. 7 Scree plot of eigenvalues after PCA for financial development index of DCs

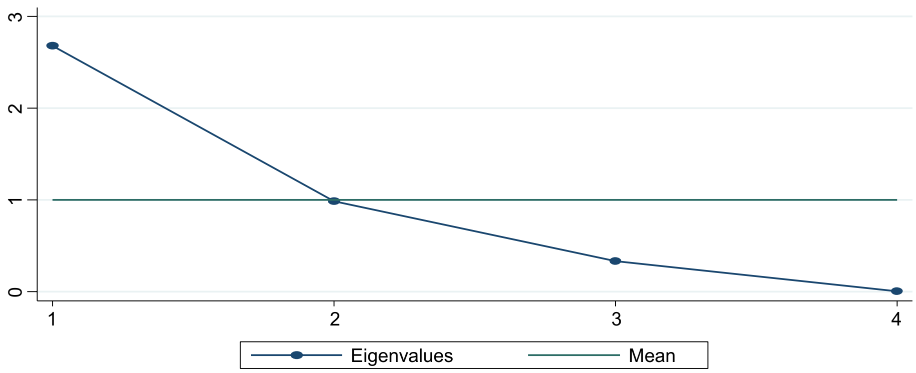

Fig. 8 Scree plot of eigenvalues after PCA for financial development index of LDCs

liabilities[7] are also used as a proxy for financial development but liquid liabilities are better measure of financial depth rather than financial development (Creane et al. 2006). Moreover, it's also not a good proxy for financial intermediation because it does not take into account the savings allocations.

These different financial development proxies cannot be used simultaneously due to high correlations amid the series. These high correlations may distort the ordinary least square (OLS) consequences due to multicollinearity caused by the high correlations. We incorporated principle component analysis (PCA) with the intention to resolve the potential issue of multicollinearity, because PCA develop a composite index of large number of correlated series while holding most of the actual information (Feridun and Sezgin 2008; Katircioğlu and Taşpinar 2017). In order to capture different aspects of financial development we applied PCA technique to domestic credit to private sector (DCPS), domestic credit by banking sector (DC), broad money (BM), and liquid liabilities (LL) to construct a comprehensive index for FD. The outcomes of PCA analysis to construct the

[7] Liquid liabilities measures the debt obligations payable within a year. It measures the liabilities provision to the economy.

Table 5 Principal component analysis for political institutions index

Component	Eigenvalue	Difference	Proportion	Cumulative
Panel A (Developed countries)				
1	5.054640	4.656390	0.8424	0.8424
2	0.398257	0.080145	0.0664	0.9088
3	0.318111	0.207335	0.0530	0.9618
4	0.110776	0.032316	0.0185	0.9803
5	0.078459	0.038705	0.0131	0.9934
6	0.039754		0.0066	1.0000
FD indicators	Factor loadings	Unexplained	PI indicators	KMO
CC	0.4270	0.0784	Overall	0.8850
GE	0.4144	0.1320		
PSAV	0.3692	0.3111		
RQ	0.4194	0.1108		
RL	0.4337	0.0493		
VA	0.3817	0.2637		
Bartlett's test for sphericity: 9334.930 (0.000)				
Component	Eigenvalue	Difference	Proportion	Cumulative
Panel B (Less-Developed Countries)				
1	3.873670	3.099990	0.6456	0.6456
2	0.773674	0.161271	0.1289	0.7746
3	0.612403	0.201762	0.1021	0.8766
4	0.410641	0.234264	0.0684	0.9451
5	0.176377	0.0231405	0.0294	0.9745
6	0.153237		0.0255	1.0000
FD indicators	Factor loadings	Unexplained	PI indicators	KMO
CC	0.4111	0.3455	Overall	0.8282
GE	0.4508	0.2127		
PSAV	0.3502	0.5250		
RQ	0.4173	0.3256		
RL	0.4706	0.1421		
VA	0.3310	0.5755		
Bartlett's test for sphericity: 4645.840 (0.000)				

One principal component is extracted. KMO is a Kaiser–Meyer–Olkin measure of sampling adequacy

comprehensive, composite indices for both Panel A and Panel B are exhibited in Table 4. We reserved only one component by following Kaiser (1974) and scree plot criteria, shown in Figs. 7 and 8 for DCs and LDCs respectively, which designate to hold only that factors whose eigenvalues exceed one. It is obvious in Table 4 that, in Panel A, there is merely single component whose eigenvalue, 3.341570, exceeds one and, likewise, Panel B also exhibited only one component with eigenvalue, 2.678670, greater than one. Overall Kaiser–Meyer–Olkin (KMO) statistics shows that sample is adequately enough to perform the

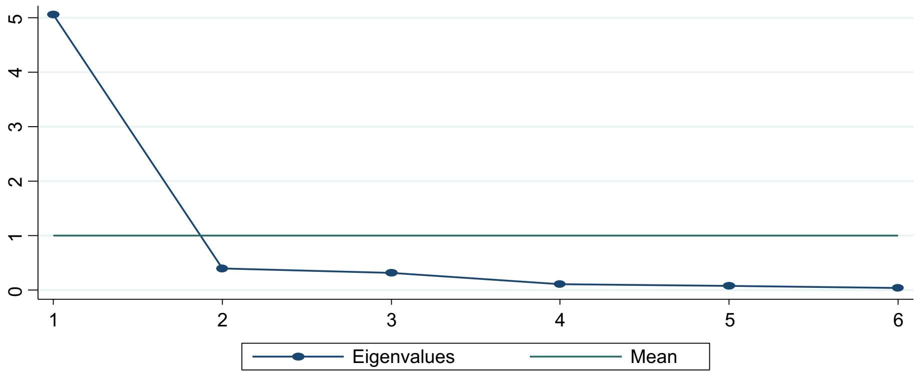

Fig. 9 Scree plot of eigenvalues after PCA for political institutions index of DCs

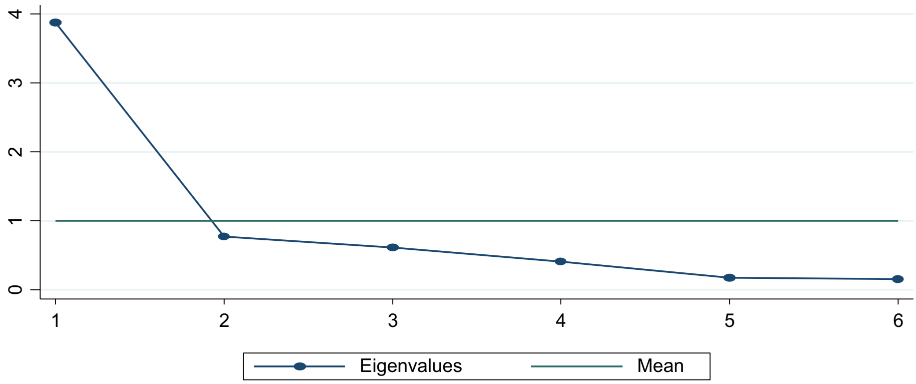

Fig. 10 Scree plot of eigenvalues after PCA for political institutions index of LDCs

analysis. Moreover, Bartlett's test for sphericity indicates that the constructing indicators are also sufficiently correlated.

4.2.1.2 Political Institutions Index We incorporated the data of Political Stability and Absences of Violence (PSAV), Voice and Accountability (VA), Government Effectiveness (GE), Control of Corruption (CC), Regulatory Quality (RQ), and Rule of Law (RL) to construct a comprehensive composite index for political institutions in both Panels A and B, by following Apergis and Ozturk (2015), Deacon (2003), Dutt (2009), and Ibrahim and Law (2015). The PCA results for the construction of political institutions indices are shown in Table 5. Following scree plot, shown in Figs. 9 and 10 for DCs and LDCs respectively, and Kaiser (1974) criteria, we held simply one component each in Panel A and Panel B. The sample size is adequate and sufficient to perform the analysis, as indicated by the KMO statistics in both of the panels. Additionally, Bartlett's test for sphericity refuses the presences of any non-collinear variables and any type of sampling error.

Table 6 Panel cross sectional dependence analysis

	ln EF	ln Y	ln Y^2	ln U	FD	P	ln K	ln O	ln E
Panel A (Developed countries)									
Breusch Pagan LM	6409*	21473*	21480*	21936*	13508*	7023.5*	13496*	7647*	9122.7*
Pesaran Scaled LM	95.84*	382.78*	382.91*	391.60*	231.07*	107.53*	230.83*	119.41*	147.52*
Bias-corrected scaled LM	94.51*	381.54*	381.59*	390.28*	229.74*	106.21*	229.51*	118.09*	146.20*
Pesaran CD	9.135*	140.16*	140.16*	78.494*	84.962*	3.0069*	88.070*	38.710*	18.070*
Panel B (Less developed countries)									
Breusch Pagan LM	10496*	19949*	19985*	32729*	15992*	8067.8*	14543*	8260.5*	12962*
Pesaran Scaled LM	157.53*	324.84*	325.48*	551.05*	254.81*	114.55*	229.15*	117.96*	196.40*
Bias-corrected scaled LM	156.10*	323.42*	324.05*	549.62*	253.38*	113.12*	227.73*	116.53*	194.98*
Pesaran CD	4.0650*	103.17*	103.46*	145.79*	84.781*	4.6170*	64.021*	19.551*	8.4700*

*Indicates 1% level of significance

Table 7 Panel unit root analysis

CIPS									
	ln EF	ln Y	ln Y^2	ln U	FD	P	ln K	ln O	ln E
Panel A (Developed countries)									
Level	– 1.997	– 2.129[c]	– 2.098[c]	– 2.938[a]	– 1.136	– 1.514	– 2.124[c]	– 1.734	– 1.690
Δ	– 4.293[a]	– 3.086[a]	– 3.114[a]	– 2.303[b]	– 2.922[a]	– 3.855[a]	– 3.186[a]	– 3.603[a]	– 4.016[a]
Panel B (Less developed countries)									
Level	– 1.690	– 1.990	– 1.910	– 2.018	– 1.599	– 1.841	– 1.937	– 2.080	– 1.701
Δ	– 3.955[a]	– 3.598[a]	– 3.521[a]	– 3.591[a]	– 3.549[a]	– 3.528[a]	– 3.688[a]	– 3.973[a]	– 3.825[a]

Unit root tests were conducted with individual trends and intercepts for each variable. The optimal lag length was selected automatically using Schwarz information criteria (SIC). The asterisks a, b and c indicate statistical significance at the 1%, 5% and 10% levels, respectively

4.3 Panel Cross-Sectional Dependence and Unit Root Analysis

In order to achieve the aforementioned aim we applied panel cointegration technique to look for the linkages among the variables. Before moving towards the unit root analysis, we, initially, incorporated Pesaran (2004)'s CD test for cross-sectional dependence (CSD) as ordinary first generation unit root techniques such as LLC by Levin and Lin (2002), IPS by Im et al. (2003), and Fischer-ADF and PP proposed by Maddala and Wu (1999) turn out to be ineffectual due to low power in the presence of CSD. So as to overcome the issues caused by CSD, we employed second generation CIPS[8] panel unit root test by Pesaran (2007) which accounts for cross-sectional dependence while testing for order of integration of variables. The CIPS panel unit root test can be symbolized as follows:

[8] CIPS is cross-section augmented IPS Im et al. (2003) unit root test for heterogeneous panels by Pesaran (2007).

Table 8 Kao residual cointegration test

	Panel A		Panel B	
	ADF t-statistics	*P* Value	ADF t-statistics	P-Value
Kao Test	− 1.712733	0.0434	3.947725	0.0000

Automatic lag length has been selected on the basis of modified-AIC (MAIC)

$$CIPS(N, T) = \frac{1}{N}\sum_{i=1}^{N} t_i(N, T) \tag{6}$$

where N and T are number of cross sections and number of years respectively. The left hand side of Eq. 6 is unit root test for heterogeneous panels while on the right hand side the term t_i is the ordinary least square (OLS) t-ratios employed in cross-sectionally averaged augmented dickey-fuller (ADF) regression.

5 Empirical Results and Discussion

In this study we intend to investigate the impact of financial development, political institutions, trade openness, energy consumption and urbanization on the EF in panel data of 110 countries, over the time span of 1996–2016. Firstly, we employed Pesaran (2004)'s CD test to probe the presence of cross-sectional dependence in the panel data. For the sake of robustness we have also incorporated other CD tests such as Breusch and Pagan (1980)'s LM test, Pesaran (2004) scaled LM test, and Baltagi et al. (2012). All the CD tests authenticated the presence of cross-sectional dependence amid the series, see Table 6.

Subsequently, we incorporated the 2nd generation CIPS panel stationarity test by Pesaran (2007). The CIPS test, shown in Table 7, confirmed that all the series, in the both panels A and B, become stationary at their first difference. Additionally, Kao (1999)'s residual based panel cointegration test, Table 8, exhibit the existence of long run associations amid the series, in the both panels.

We estimated and stated the concluding outcomes of weighted Panel Estimated generalized Least Square (Panel-EGLS) with fixed effects in Table 9, for the both panels A and B. Where we assigned cross-section weights to control for undesired associations amid the series. We incorporated Hausman test to check whether fixed effect or random effect is appropriate. We selected optimally the fixed effect specification as the Hausman Chi square statistic is significant even at 1% significance level. Though fixed effect models are suitable to capture the country-specific time-invariant diverse characteristics but these models might be misleading due to their weaker control over serial-correlations and heterogeneity. Finally, we reported the final outcomes of AB-GMM for the sake of robustness and comparison with fixed effect Panel-EGLS results. Moreover, in order to control for contemporaneous correlations amid cross-sections, we assigned modified weights and computed Arellano and Bond (1991) Multistep AB-GMM (AB-GMM).

Table 9 Panel fixed effect and A-B GMM results

Dependent variable $\ln EF_t$				
	Panel A (DCs)		Panel B (LDCs)	
	Fixed effect	AB-GMM	Fixed effect	AB-GMM
$\ln Y_t$	0.3458[a]	2.1413[a]	0.2727[a]	0.4526[a]
$\ln Y_t^2$	− 0.0169[a]	− 0.1266[a]	− 0.0178[a]	− 0.0284[a]
$\ln U_t$	− 0.2897[a]	− 0.1618[c]	− 0.0475[a]	− 0.0380[b]
FD_t	0.0038	0.0291[a]	− 0.0044[b]	− 0.0205[a]
P_t	− 0.0384[a]	− 0.0140[a]	− 0.0017	− 0.0012
$\ln K_t$	0.1016[a]	0.1614[a]	0.0134[a]	0.0226[a]
$\ln O_t$	− 0.0492[a]	− 0.0378[b]	0.0030	− 0.0374[a]
$\ln E_t$	0.5930[a]	0.4882[a]	0.0324[a]	0.1529[a]
c	− 1.2061[b]		− 0.5464[c]	
Diagnostic tests				
R^2	0.9851		0.9908	
Adj. R^2	0.9842		0.9902	
Obs.	1113	1113	1197	1197
Red. FE Test	131.91[a]		2.9713[a]	
Hausman	84.481[a]		95.587[a]	
$AR(1)$		0.0871		0.0008
$AR(2)$		0.1243		0.7831
Sargan		0.5650		0.7681

[a], [b] and [c] indicate 1%, 5% and 10% statistical significance levels respectively. Red. FE Test is a redundant fixed effect test. P-values have been quoted in AR (1), AR (2), and Sargan tests

The AB-GMM and fixed effect results indorse the existence of Environmental Kuznets Curve (EKC) in the both panels as the coefficients for $\ln Y_t$ and $\ln Y_t^2$ are positive and negative, respectively, and significant even at 1% level of significance. These results are in line with Bello et al. (2018), Ulucak and Bilgili (2018) and Charfeddine and Mrabet (2017) but opposing Al-Mulali et al. (2015b).

The coefficient on the variable, urbanization, is negative and significant i.e. it mends environmental quality by shrinking EF in the both panels i.e. panel-A and panel-B. The EF diminishes by 2.8% and 1.6% in panel A and by 0.4% and 0.3% in panel B, if urbanization upsurges by 10%, this outcome is in line with Bello et al. (2018) and Charfeddine and Mrabet (2017). The advantageous environmental impacts of urbanization which offsets its harmful effects, might be due to numerous reasons. Such as, urbanization is accompanied with higher income levels which not only boosts the environment-friendly services sector but also intensifies the demand for environmental quality which reduces EF. Secondly, urbanization also reduces EF due to better facilities and improved living standards as compared to rural areas. Thirdly, urbanization may lead towards the research and development and innovation which reduces EF ultimately (Charfeddine and Mrabet 2017).

The coefficient of financial development for higher income countries is insignificant in case of fixed effect while it is positive and significant in AB-GMM model. In high income countries, EF increases by 0.29%, if financial development increases by 10%, this verdict endorses the results of Charfeddine (2017) while it opposes Al-Mulali et al. (2015b). For lower-income countries, panel B, EF diminishes by 0.04% and 0. 2% in fixed effect and AB-GMM specifications, respectively, if financial development upsurges by 10%. The adverse effect of financial development might be due to higher financial development, in higher income countries, which fallouts as greater use of natural resources and so the higher EF. In less-developed countries, the beneficial environmental impact might also be due to the adverse (De Gregorio and Guidotti 1995) or neutral (Jenkıns and Katırcıoglu 2010) economic effect of financial development. Political institutions have beneficial environmental impact in both of the panels but it is significant only in developed countries. Political institutions reduce the adverse effect of ecological footprint by 0.38% and 0.14% in fixed effect and AB-GMM models, respectively, if they are improved by 10% in developed countries.

The coefficient of $\ln K_t$ is positive and significant in both of the panels. The fixed effects and AB-GMM results indicates that 10% rise in capital-labor ratio increases environmental degradation by 1% and 1.6% respectively for developed countries. In panel B, less developed countries, a 10% increase in capital-labor ration will bring environmental damage of 0.13% and 0.28% respectively. We found the environmental friendly impact of trade openness, for developed countries, Panel-A, implying that a 10% increase in trade openness will diminish EF by 0.49% and 0.38%, in case of fixed-effects and AB-GMM, respectively. In case of Panel B, the effect of trade openness is insignificant in fixed effect model while the coefficient, − 0.0374, is negative and significant in AB-GMM model, which indicates that EF will be reduced by 0.037% if trade openness increase by 10%. The environmental friendly impact of trade openness is due to the strong beneficial technique effect which overcomes the harmful scale and composition effects. Trade boosts economic growth and upsurges income levels which promote green and advanced technology and improves environmental quality by cutting on pollution emissions (Charfeddine and Khediri 2016; Shahbaz et al. 2013c). The positive and significant coefficient of energy consumption indicates that this variable reparations environmental quality by increasing EF. The results indicate that a 10% rise in energy consumption will increase EF by 5.9% and 4.8% in panel A while 0.3% and 1.5% in panel B for fixed effect and AB-GMM, respectively. These results support the findings of Charfeddine and Mrabet (2017).

6 Conclusion and Policy Implications

This study probed the impact of urbanization, financial development, political institutions, trade openness and energy consumption on the ecological footprints of 110 countries, over the time span of 1996–2016, within the framework of EKC. We divided these countries into two groups based on their income levels i.e. developed countries (higher-income countries) and less-developed countries (lower-income countries). In this study we incorporated ecological footprint as a proxy for environmental destruction to overcome the weakness of majority of the past studies which used CO_2 emissions to capture the environmental damage. We developed comprehensive measures of financial development and political institutions by incorporating PCA.

We employed cross-section augmented IPS (CIPS) unit root test and Kao (1999)'s residual based panel cointegration test to check for the presence of stationarity and long-run associations amidst the series. Finally, to inspect the connotations amid the series we employed panel data and augmented the Panel EGLS with fixed effects and Multistep AB-GMM models. Our empirical consequence established the robust bonds among the series in both of the panels. The final outcomes of the study confirmed the presence of EKC hypothesis i.e. inverted-U shape interactions between ecological footprints per capita income in both of the panels. This outcome explains that ecological footprints escalate initially with climbing income levels and starts to diminish at upper income levels, after reaching the turning point. This study exposed the devastating environmental effect of energy consumption and the composition effect as they increase ecological footprint in both of the panels. Additionally, the empirical consequence exhibited that financial development deteriorates the environmental quality by causing ecological footprint in developed countries, which is because developed countries have higher level of financial development which boosts the human demand on nature. Furthermore, we established that trade openness, urbanization, and political institutions are beneficial for the environmental quality in both of the panels as they reduce the ecological footprint by cutting on human demand on nature. Furthermore, this study applauds investigation of above mentioned and other prospective determining factors of EF, such as renewable energy consumption, innovation, and tourism at regional and country levels.

This study curiously implied that both economic and social policies must be devised to mitigate the human demand on nature. The current study vigorously recommend that governments in both developed and less-developed countries can help to reduce the devastating environmental impact of EF by establishing buoyant institutional structures that can alleviate EF to help endorse green growth. Besides, governments of the explored countries should reinforce the environmental guidelines to put green-controls on the polluting industries and energy consumption. Moreover, policymakers should upkeep and encourage the urbanization process as it is supportive in refining environmental excellence. No doubt, financial development is indispensable for development and economic growth, but the concerned anxious authorities should systematically assimilate environmental quality concerns in their financial reforms and macroeconomic policies to help alleviate the human demand on nature and attain persistent economic growth.

Appendix

See Tables 10 and 11.

Table 10 Descriptive statistics of panel A (developed countries)

	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis	Obs.
EF	1.298319	1.250193	2.792829	– 0.64908	0.492343	0.023416	2.814452	1113
Y	9.263672	9.048417	11.42537	7.106204	0.952958	0.530376	2.358602	1113
Y2	86.72294	81.87386	130.5392	50.49813	18.16167	0.688154	2.461617	1113
U	16.01462	15.79977	20.47836	11.64397	1.663260	0.055563	3.026458	1113
FD	0.008530	– 0.51497	6.252158	– 2.39756	1.722141	0.964249	3.222971	1113
P	0.033680	– 0.27977	4.172303	– 4.78979	2.233706	0.238637	2.017186	1113
K	8.506096	8.345598	10.60885	5.145160	0.952946	0.129334	2.610708	1113
O	– 0.34059	– 0.31799	1.485243	– 1.85562	0.517613	0.152874	4.045691	1113
E	7.632294	7.609357	9.623058	5.952191	0.733465	0.186917	2.376576	1113

All the variables are in their logarithmic form except FD and PI

Table 11 Descriptive statistics of panel B (less-developed countries)

	Mean	Median	Maximum	Minimum	SD	Skewness	Kurtosis	Obs.
EF	0.228416	0.187558	2.295116	− 0.89492	0.459738	0.973985	5.320091	1197
Y	6.854306	6.764987	8.358285	4.608487	0.753664	0.138996	2.083453	1197
Y^2	47.54904	45.76504	69.86092	21.23815	10.42706	0.309030	2.080412	1197
U	15.22616	15.07873	19.89950	11.62104	1.556981	0.345269	3.292739	1197
FD	− 0.04376	− 0.55066	9.190833	− 2.25689	1.606907	1.419621	5.731140	1197
P	− 0.03684	0.213120	4.682986	− 6.22525	1.948630	− 0.38059	2.612729	1197
K	6.080869	6.135345	8.277247	− 0.21671	1.108739	− 0.90015	5.154798	1197
O	− 0.40478	− 0.41503	1.135764	− 1.93459	0.469122	0.041710	2.739267	1197
E	5.761231	5.909040	8.017368	1.423493	0.879419	− 1.06457	6.590808	1197

All the variables are in their logarithmic form except FD and PI

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