Pakistan Journal of Commerce and Social Sciences
2019, Vol. 13 (2), 487-514
Pak J Commer Soc Sci

Financial Development and Ecological Footprint: A Global Panel Data Analysis

Muhammad Tariq Majeed
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: tariq@qau.edu.pk

Maria Mazhar
School of Economics, Quaid-i-Azam University, Islamabad, Pakistan
Email: mariamazhar28@yahoo.com

Abstract

This study examines the environmental effects of financial development using a comprehensive indicator of ecological footprint for a panel of 131 countries from 1971 to 2017. For the empirical analysis, pooled ordinary least squares (OLS), fixed effects model, random effects model, Driscoll-Kraay (DK) standard errors, and system generalized method of moments (GMM) are employed. The findings reveal that all indicators of financial development namely domestic credit to private sector, domestic credit to private sector by banks, and domestic credit provided by financial sector significantly help to improve the environmental quality by reducing the ecological footprint. Comparatively, the effect of domestic credit to private sector is stronger than other measures of financial development. Similarly, urbanization has been accompanied by the significant reduction in ecological footprint. In contrast, energy consumption, foreign direct investment (FDI), and GDP per capita worsen the environmental quality by increasing the ecological footprint. The study also validates the existence of "pollution haven hypothesis" for the global economy. Findings of the study have global implications. In general, financial sector has the potential to support the global efforts towards environmental protection. However, regional or country specific experiences can differ depending upon the financial sector priority towards environmental protection.

Keywords: ecological footprint, environmental quality, environmental degradation, urbanization, financial development, pollution haven hypothesis, energy consumption, green financing

1. Introduction

1.1 Background of the Study

The present world is confronted with two major global challenges: achieving economic development and protecting the earth's environment. The environmental degradation has appeared to the forefront of contemporary issues for all countries mainly as a consequence of accumulation of greenhouse gases (GHGs) in the atmosphere. Over the past 200 years, rapid growth in industrialization has witnessed a substantial rise in energy demand that largely depends on non-renewable fossil fuels. Consequently, policy makers find it increasingly difficult to manage the trade-off between economic development and environmental protection.

Achieving sustainable development has become the fundamental objective of all economies. The role of financial sector is fundamental to achieve sustainable development (Majeed, 2016). In this regard, green financing focuses on new financial blueprint that helps to increase development along with environmental protection. It is based on the notion of "green credit" that financial institutions use to control environmental pressure by financing energy-efficient technology and green investment. Using other instruments such as interest rate can also control environmental pollution by providing loans at low interest rate to the industries adopting clean technology. Similarly, financial institutions also promote research and development (R&D) in new energy resource, emphasizing the ecological agriculture production (Xu, 2013). The countries, around the globe have been promoting "green financing" using financial instruments.

1.2 Financial Development and Environmental Degradation

The literature has highlighted the influential impact of financial development (FD) on environmental degradation (Zhang, 2011; Katircioglu & Taşpinar 2017; Zhang and Zhang 2018; Danish et al., 2018; Destek & Sarkodie 2019; Sarkodie and Strezov, 2019). Zhang (2011) highlighted the beneficial role of well-developed institution in reducing environmental pressure (ecological footprint). Financial development improves environmental quality by attracting and bringing more environmental-friendly projects through research and development. It can also facilitate the investment in clean technologies. For example, investment in renewable energy increases that is more environmental-friendly and helps to reduce ecological footprint (EFP). Similarly, FD can improve economic efficiency by lowering the capital risk and financial cost. In addition, FD can promote R&D activities and investment in clean technology by broadening the FDI inflows, stock market activities and banking activities.

In contrast, FD upsurges the environmental degradation by motivating and facilitating the credit facilities for purchasing mechanical machinery, electrical devices, automobiles, and houses. These facilities help the investors to expand their business horizons and to set up new machinery and new plants that, in turn, increase the carbon emissions concentration in the environment, thereby worsening environmental quality (Zhang and Zhang 2018; Danish et al., 2018). Moreover, rise in foreign direct investment in response to well-developed financial system also contributes to environmental degradation (Sarkodie and Strezov, 2019).

1.3 Significance of Ecological Footprint

Many other studies explore the link between FD, energy, development and emissions to provide better policy solution to manage development and environment simultaneously (Wang et al., 2011; Majeed, 2018). Based on inconclusive results, these studies provide different policy solutions for different countries and regions. A major weakness of these studies is that they rely on CO_2 emissions as an indicator of environmental degradation (Bekhet et al., 2017; Maji et al., 2017; Zakaria & Bibi, 2019). The carbon emissions are, however, just a part of environmental degradation caused by large scale energy consumption (Al-Mulali et al., 2015).

In contrast, the ecological footprint (EFP) is a comprehensive indicator of anthropogenic pressure on the environment. A major advantage of EFP is that it combines environmental data into a single measure, which can be easily compared to the corresponding productive capacity to highlight the fact that how much of the ecosystem' surface we use for sustaining life. The increasing world population is putting pressure on the demand of natural resources. As a consequence, ensuring the sustainable use of natural resources has become a global challenge. Thus, it is very important to know the level of natural resource consumption to preserve them for future generations as well. The EFP is basically the measure of that consumption and many studies consider it more comprehensive and reliable indicator of environmental damage (Bagliani et al., 2008; Wang et al., 2011; Al-Mulali et al., 2015; Uddin et al., 2017). These studies suggest EFP as comprehensive measure of environmental degradation for following reasons.

First, it is not complex and easy to understand (Senbel et al., 2003). Second, it deals with the information of numerous natural resources that are required for the production and support of the overall economy (Katircioglu et al., 2018). Third, it tracks the information about ecological deficit and surplus (Castellani & Sala 2012). Fourth, it provides the information regarding the gap between human demand and regeneration of natural resources. In this way, it provides the efficient measure of depleted natural resource reproduction by capturing the information related to important natural resources such as water and land use for crop cultivation and grazing (Aydin et al., 2019). Thus, EFP clarifies the fact that whether we use resources sustainably or not by providing a set of comprehensive information related to changes in quality of the environment. For instance, the resources are used unsustainably if they are consumed at faster rate and consumption is beyond the mean capacity of ecosystem. Fifth, by providing the information about resource metabolism, it allows the government to compare the economy's resource demand with its actual supply and handle the distributional process efficiently. Lastly, it can build the economy's competitiveness by monitoring resource supply/deficit (Wackernagel et al., 2006).

1.4 Research Gap and Contribution

This study provides a better understanding of environmental degradation, energy and development using EFP as a measure of environment. This study focuses on FD as a potential predictor of environmental degradation including other factors of environmental degradation. In the FD-environment nexus there is only one study that has used three measures of FD along with ecological footprint as an indicator of environmental damage (Baloch et al., 2019). But this study is only restricted to Belt and Road Initiative (BRI) countries.

Since environmental degradation is the global issue, it is important to analyze the empirical linkages between FD and environmental degradation from the global perspective. The present study identifies increasing FD as one of the major cause of improved environmental quality in a panel of 131 countries. Specifically, FD is a complex and multidimensional concept that requires more than one measures. This study incorporates three measures of financial development namely domestic credit to private sector, domestic credit to private sector by banks, and domestic credit provided by financial sector. In addition, this study exploits the advanced econometric techniques such as system GMM for solving the problem of endogeneity and getting the robust estimates.

1.5 Research Questions and Implication

This study attempts to answer the two crucial questions. First, whether the FD increases the ecological footprint or not? Second, whether the impact of FD varies depending upon the indicators used to measure FD or not? The main implication of the study is that the impact of FD on ecological footprint is negative in a global setting. Regional or country specific experiences can differ depending on the financial sectors' priorities towards environmental protection. That is, if financial institutions provide loans and relaxations to the industry adopting clean technology and promoting environmental-friendly projects then it can reduce overall ecological footprint.

The remaining study is structured as follows: the next Section 2 provides the review of the related literature. Section 3 comprises the discussion on the data, methodology and statistical analysis. The empirical results and their interpretation have been reported in Section 4. Finally, Section 5 concludes the study and offers policy recommendations.

2 Literature Review

Environmental degradation is the outcome of various human activities that led to the worsening of environment quality through depletion of natural resources, species extension, weather variations and the loss of ecosystem (Majeed & Mumtaz, 2017; Majeed & Mazhar, 2019). In the last few decades, environmental degradation has emerged as a central area of academic research. As a result, both environmental theories and empirics have been extensively focused and debated.

The theoretical foundation of this study relies on theories such as Environment Kuznets Curve (EKC), ecological modernization theory, environmental transition theory, intergenerational equity theory, structural human ecological theory, and the compact city theory. EKC explains that in the initial stages of economic development environmental degradation increases, but after a particular level of economic development society commences to improve its relationship with the environment. This was labeled as EKC by Panayotou (1995) on the basis of Grossman and Krueger (1995) work who first pointed out the inverted U-shaped relationship between environmental pollutants and per capita income. The empirical literature largely confirms the presence of EKC in developed and developing countries (Grossman and Krueger, 1995; Majeed, 2018).

According to ecological modernization theory, environmental degradation increases with the transition of economies from low to middle stage of development as priority is given to growth expansion. However, moving to further modernization, priority is changed towards sustainable growth, sustainability of environment, technological innovations, and service base economy, thereby reducing the environmental degradation. Similarly, environmental transition theory postulates that transition of economies towards industrial/manufacturing economy increases environmental pollution by increasing the demand for energy consumption and urban infrastructure. However, as cities or economies become wealthier and achieve high growth then they try to improve their relationship with environment by technological innovations, stricter environmental regulations and structural changes in the economy.

The intergenerational equity theory, in contrast, emphasizes on social justice between generations that is all past, present and future generations have equal relationship with environment. There is no room for preferring present generation over future generation by depleting the natural-resource base for economic gains. This is the individual's responsibility to preserve the natural environment for other species and generations.

The structural human ecological theory contains the interconnected structure of microsystem, mesosystem, exosystem and macrosystem. According to this theory, a child is firstly affected by microsystem (family, peers, school, religious institute, health, and service), then by mesosystem (interaction between family and school) where he/she experiences reality. Then indirectly he is affected by exosystem (neighbors, social services, media and industry) and macrosystem (cultural identities). In this structure, species of the world and natural environment affect each other in a cohesive manner. That is, not only individuals, families, and nations' decisions and actions affect environmental quality, but natural or human created environment also affect individual behavior, health and living standard. The compact city theory sheds light on the benefits of higher urbanization as it leads to the economies of scale for public infrastructure and reduces environmental pressure.

The empirical research on financial development and environment nexus started with the pioneer studies of Aufderheide & Rich (1988), Schmidheiny & Zorraquin (1998). Aufderheide & Rich (1988) highlighted the role of multilateral banks in affecting the environmental quality. They argued that World Bank's financial assistance mechanism often ignores the environmental impacts of the loanable funds and leads to serious environmental concerns. For example, in the case of India, financing the energy capital increased soil erosion, the Grand Bereby rubber project resulted in tropical forestland deterioration and micro-finance for the cotton production led the projected agriculture land useless by exhausting the soil. Schmidheiny & Zorraquin (1998) concluded that more often financial institutions encourage short-term goals and ignore the associated environmental risks, thereby leading to higher natural resource exploitations.

In addition, a number of studies using time series data have found similar conclusion. For example, Moghadam & Dehbashi (2018) for Iran, Sehrawat et al. (2015) for the Indian economy, Mesagan & Nwachukwu (2018) for the Nigerian economy, and Raza and Shah (2018) for Pakistan economy found the detrimental effects of financial development. In the same context, the study by Zakaria & Bibi (2019) used the panel data of South Asian economies, Ganda (2019) employed panel data of OECD economies, and Bloach et al. (2019) used the panel data of BRI countries and found similar findings. According to these studies FD increases carbon emissions by providing credit facilities that induce the customers to buy cars, machinery that put negative consequences on environment. For example, firms by buying new machinery expand their business horizons. Moreover, development in financial sector also attracts FDI which may increase pollutant emissions. Thus, first strand of the literature provides the evidence of unfavorable environmental effects of financial development.

Apart from detrimental effects of FD on environmental quality, another strand of the literature identified the favorable effects of financial development on environmental quality. A group of panel studies in this strand of the literature uses CO_2 emissions as an indicator of environmental degradation and finds the similar findings. For example, Tadesse (2007) for the industries of thirty-eight countries, Tamazian et al. (2009) for the BRIC economies, Xiong & Qi (2018) for 30 Chinese provinces, and Hamdan et al. (2018) for 5 ASIAN economies namely, Indonesia, Malaysia, Philippines, Singapore, and Thailand, Seetanah et al. (2019) for selected 12 Island developing economies found the favorable effects of financial development on environment. Likewise, dealing with the time series analysis the study by Dar & Asif (2018) for Turkey, Shahbaz et al. (2016) for Portugal, and Mohammed et al. (2019) for Venezuela reported the similar findings. According to these studies financial development improves environmental quality by improving information asymmetries, technological innovations in the energy sector, FDI inflows and R&D expenditures on energy efficient technology. Taking into consideration the above discussion, from the theoretical context it can be summarized that environmental quality is affected by human's decisions and actions, economy's level of modernization and the knowledge about environmental protection. Regarding the empirical literature it is highlighted that FD plays a crucial role in influencing the environmental quality. However, the overall literature analysis shows that the results of FD on environmental quality are inconclusive depending on the indictor used to measure environmental degradation and the econometric methodology.

The empirical literature, however, mainly emphasized the importance of FD in influencing CO_2 emissions, which captures only the information on carbon emissions and presents just one component of whole environmental damage. Ecological footprint is considered as more useful and reliable measure of environmental degradation. According to Wackernagel et al. (2002) "It is an important instrument used to track human requirements on the biosphere's regenerative capacity and human dependence on ecosystems."

Ecological footprint depends on the given area population, living standard, income level, consumption pattern and ecosystem efficiency (Wackernagel et al., 1999) and provides a better understating regarding the ecosystem deficit and surplus by capturing the information regarding important natural resource base utilized in the production process. For example, EFP includes the information regarding carbon emissions, residential and grazing land, fishing grounds, and forest products. All these resources provide an extensive base for economic growth. However, deterioration in these resources puts the economy's growth into slumps. Therefore, it is crucial to include the comprehensive indicator of environmental degradation to represent the overall environmental loss.

This study contributes in the existing literature by exploiting the more comprehensive indicator of environmental degradation (ecological footprint). Moreover, it investigates the impact of FD on ecological footprint from global perspective by taking the large panel data of 131 economies. In addition, this study also uses three measures of financial development for understating the clear picture of the relationship. Lastly, this study uses the larger time span from 1971-2017 and exploits the modern econometric technique of system GMM along with the traditional panel data models to resolve the endogeneity problem.

3 Data and Methodology

3.1. The Data

To estimate the impact of financial development on ecological footprint, the panel data for all countries is selected over the period 1971-2017. The data series for ecological footprint were missing for most of the countries and, therefore, final sample size is limited to 131 countries. The data on all indicators used for the analysis is taken from World Bank (2018) except ecological footprint, which is collected from Global Footprint Network (2018).

3.2. Econometric Model

The relationship between FD and environmental degradation is empirically tested by many studies (Katircioglu & Taşpinar, 2017; Destek & Sarkodie, 2019). The present study follows the standard empirical model by considering ecological footprint as a comprehensive indicator of environmental degradation, which is consistent with Bloach et al. (2019). Econometric model is given as follows:

$$EFP_{it} = \beta_0 + \beta_1 FD_{it} + \beta_2 LEC_{it} + \beta_3 LGDP_{it} + \beta_4 URB_{it} + \beta_5 FDI_{it} + \nu_i + \mu_t + \varepsilon_{it} .(1)$$

Where, 'i' represents the cross sections and 't' shows the time period covered for empirical analysis. The parameter β_0 represents the intercept term. EFP_{it} shows ecological footprint. FD_{it} represents the financial development. The parameter β_1 is the slope coefficient, which measures the marginal effect of FD_{it} on ecological footprint. All other variables LEC_{it}, $LGDP_{it}$, URB_{it} and FDI_{it} are used as explanatory variables. The term ν_i captures the country specific unobservable effects while μ_t captures the temporal effects. The term ε_{it} is the error term.

3.3. Construction of the Variables

3.3.1 Ecological Footprint (EPF)

The dependent variable EFP is measured in global hectares (GHA) per person (see Charfeddine & Mrabet, 2017; Katircioglu et al., 2018; Bloach et al., 2019). It is proposed to highlight the natural resource consumption and the productive capacity of the ecosystem (Aydin et al., 2019). "Ecological Footprint accounts act as balance sheets by documenting for a given population – a household, a district, a city, a region or humanity as a whole – the area of biologically productive land and sea required to produce the renewable resources this population consumes and assimilate the waste it generates, using prevailing technology. It documents the extent to which human economies stay within the regenerative capacity of the biosphere. Overall, it is the sum of built-up land, carbon, cropland, fishing grounds, forest products and grazing land."

3.3.2 Financial Development (FD)

This study employs three measures of FD to identify the clear picture of the relationship between FD and environment. First is the domestic credit by the private sector measured as percentage of GDP (FDP). "It refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment." The second proxy for the financial development is domestic credit to private sector by banks as percentage of GDP (FDB). "It refers to the financial resources provided to the private sector by other depository corporations (deposit taking corporations except central banks), such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment." Finally, the last proxy for the financial development is the domestic credit to private sector provided by the financial sector (FDF). "It includes all credit to various sectors on a gross basis, with the exception of credit to the central government, which is net."

3.3.3 Energy Consumption

To account the role of energy consumption we use the log of energy consumption in the regression model measured in terms of kg of oil equivalent per capita. "It refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport." Its effect on environmental degradation depends on the way that how and for what purpose it is used. If energy is efficiently utilized in green technologies then it will help to reduce the harmful environmental effects (Stern et al. 2006). While the higher amount of energy consumption in terms of higher demand for gas, oil and coal contributes to the pollutant emissions along with the resource degradation that deteriorates the overall environment (Mirza & Kanwal, 2017).

3.3.4 Economic Growth

Economic growth is regarded as the most important determinant of environmental degradation. It is measured using the log of GDP per capita (constant 2010 US dollars). It can affect the environmental quality through three channels. First, it increases the environmental degradation as inputs utilization increases for the higher production (scale effect). Second, with the composite change of growth path from agriculture to the industrial sector environmental deterioration increases initially and then declines in the later stage with the expansion of service sector (composite effect). Lastly, technological advancement helps to curb the pollutant emissions by introducing the green technology (technique effect) (Stern, 1998; Stokey, 1998). Regarding its linear effect it is identified that expansion in economic growth causes the development in the major economic sectors such as agriculture, industrial and services sectors that in turn leads to higher investment, and consumption, thereby reducing the environmental quality (Bloach et al., 2019).

3.3.5 Urbanization

The effect of urbanization on ecological footprint is also incorporated in the present study measured through the urban population as a percentage of total population (URB). "It refers to people living in urban areas as defined by national statistical offices." Wang et al. (2016) claimed that urbanization increases the environmental degradation by increasing the energy and resource demand and their consumption. However, it can improve the environmental quality for the high-income economies Chikaraishi et al. (2015). Moreover, it helps the efficient use of space and transportation and increases the economies of scale. It also increases the productivity and boosts the green technology over the longer period that reduces the resource inefficiency and improves the environmental quality (Arouri et al., 2013; Majeed & Gillani, 2017).

3.3.6 Foreign Direct Investment

Lastly, we have used FDI as an important determinant of environmental degradation measured through FDI inflows as a percentage of GDP. “These are the net inflows of investment to acquire a lasting management interest in an enterprise operating in an economy other than that of the investor. It is the sum of equity capital, reinvestment of earnings, other long-term capital, and short-term capital as shown in the balance of payments.” Foreign enterprises use cleaner technologies following the environmental protection laws and promote R&D in the energy-efficient technology, thereby leading to higher environmental quality (Zarsky, 1999; Asghari, 2013). This relationship is also justified by the pollution halo hypothesis that higher FDI inflows offer advance energy efficient technologies and promote efficient environmental management system. FDI can also increase greenhouse gas emissions and air pollution in the economies which have weak environmental protection laws, poor infrastructure and weak institutional framework (Solarin et al., 2018). This positive link between FDI and environmental degradation is also known as the pollution haven hypothesis which states that FDI increases investment in the high pollutant industries and deteriorates the environmental quality.

3.4. Estimation Methods

Initially, we used the traditional panel data estimation techniques pooled OLS, fixed effects, and random effects for analyzing the empirical relationship between financial development and ecological footprint. Moreover, we used Driscoll and Kraay (1998) (DK) standard errors technique for obtaining the best robust estimates as it provides robust estimates in the presence of heteroskedasticity, cross-sectional and serial dependence (Sarkodie and Strezov 2019). In addition, for assessing the causal relationship among the concerned variables panel Granger causality test is used. Lastly, the system GMM is also exploited, which provides robust estimates in the presence of heteroscedasticity, endogeneity and first order autocorrelation.

3.5. Statistical Methodology

3.5.1 Descriptive Statistics

Table 1 reports the descriptive statistics of the variables incorporated in the present study.

The statistics show that the minimum value of ecological footprint is 0.0313 that belongs to Haiti while the economy of Bahamas has the maximum value 5.487. Regarding the financial sector development, Guyana’s financial sector by the banking sector has the highest contribution 88.297, while the lowest contribution of financial sector by the banking sector is 3.194 in Timor-Leste economy. Moreover, the maximum value for the financial sector by the banking sector and private sector is 68.363 and 63.587, respectively for Denmark. Likewise, the minimum value of financial sector by both the banking sector and private sector is 1.306 for Yemen.

Table 1: Descriptive Statistics

Variables	Observations	Mean	Median	Maximum	Minimum	Standard Deviation
Ecological Footprint	3441	3.350	2.393	5.487 (Bahamas, The)	0.0313 (Haiti)	2.734
FDP	3441	44.97	30.64	63.583 (Denmark)	1.306 (Yemen, Rep)	40.02
FDB	3441	41.49	29.22	68.363 (Denmark)	1.306 (Yemen, Rep)	36.02
FDF	3441	58.92	43.97	88.297 (Guyana)	3.194 (Timor-Leste)	52.28
Energy Consumption	3441	2100.4	936.90	4418.3 (Trinidad and Tobago)	0.870 (Timor-Leste)	2584.1
GDP	3441	12487.8	4094.0	26903.3 (Luxembourg)	27.17 (Gambia, The)	17894.8
Urbanization	3441	56.884	57.309	19.936 (Botswana)	100 Singapore	22.294
FDI	3441	3.636	1.6111	98.423 (Malta)	0.176 (Japan)	13.907

3.5.2 Correlation Matrix

Table 2 shows the correlation between ecological footprint and FD along with other explanatory variables. All indictors of financial development have positive correlation with ecological footprint. However, the correlation between financial development by the private sector and ecological footprint is relatively high (0.474).

Table 2: Correlation Matrix

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Ecological Footprint	1							
FDP	0.474*** (0.00)	1						
FDB	0.442*** (0.00)	0.945*** (0.00)	1					
FDF	0.394*** (0.00)	0.907*** (0.00)	0.845*** (0.00)	1				
Energy Consumption	0.879*** (0.00)	0.385*** (0.00)	0.346*** (0.00)	0.304*** (0.00)	1			
GDP	0.813*** (0.00)	0.584*** (0.00)	0.580*** (0.00)	0.538*** (0.00)	0.730*** (0.00)	1		
Urbanization	0.686*** (0.00)	0.456*** (0.00)	0.450*** (0.00)	0.390*** (0.00)	0.593*** (0.00)	0.610*** (0.00)	1	
FDI	0.107*** (0.00)	0.103*** (0.00)	0.127*** (0.00)	0.104*** (0.00)	0.052*** (0.00)	0.096*** (0.00)	0.123*** (0.00)	1

4. Empirical Results

4.1. Results of Pooled OLS

Table 3 presents the regression results of pooled OLS. All measures of FD contribute negatively to ecological footprint implying that FD improves quality of environment. The estimated values of the coefficients infer that 1 percent increase in FDP, FDB, and FDF will bring about 0.0039, 0.0061 and 0.0021 percent decline in ecological footprint, respectively. This effect is statistically significant at 1 percent level of significance. These results are consistent with the findings of Zhang (2011), Shahbaz et al. (2016) and Mohammed et al. (2019) who argue that well-developed financial institutions facilitate the funds for energy-saving and environmental-friendly projects. Moreover, financial institutions provide incentives to the firms that adopt energy efficient technology that, in turn, reduces the business cost and in turn improves the environmental quality. Moreover, it can also improve the environmental quality by attracting higher FDI inflows that also boost the productivity, R&D activities, and investment in green technologies (Hamdan et al. 2018). Therefore, the strong financial institution and corporation between capital markets and banks provide a promising path towards the improved environmental quality.

The effect of energy consumption on EFP is significant and positive implying that 1 percent increase in energy consumption leads to 1.5044 (column 1) to 1.4872 (column 3) percent rise in ecological footprint. This finding is in line with the study of Al-Mulali & Ozturk (2015). The argument behind this relationship is that the energy consumption increases the environmental degradation by increasing the demand and consumption for fossil fuels like oil, gas, and coal. It can also increase the pollutant emissions by processing, manufacturing and installation of manufacturing goods because energy intensive industries use pollution intensive inputs in the production process (Suri & Chapman, 1998).

The result reveals that higher pace of economic growth (GDP) contributes to ecological footprint. The coefficient of GDP is positive and significant in all estimated models. The studies of Suri & Chapman (1998), Moghadam & Dehbashi (2018), and Bloach et al. (2019) also found the similar results that rapid increase in economic growth opens the opportunities for higher economic activities such as investment, production and consumption that increase the air, water and soil pollution.

The results documented in columns (1-3) of Table 3 reveal that urbanization results in lower level of ecological footprint. This finding supports the compact city theory that higher urbanization improves the environmental quality by increasing the productivity, efficiency and economies of scale in public infrastructure. This finding is consistent with Effiong (2016) who argued that urbanization improves environmental quality by increasing the economies of scale that, in turn, promote resource productivity, employment and efficient use of natural resources. However, in the presence of inadequate public infrastructure and higher poor migrant it can also increase environmental pressure. Lastly, the estimated effect of FDI on ecological footprint turned out to be positive and statistically significant. This relationship is supported by the empirical literature (Solarin et al., 2018).

Table 3: Financial Development and Ecological Footprint (Pooled OLS)

Dependent Variable: Ecological Footprint			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0039***		
	(0.000)		
FDB		-0.0061***	
		(0.000)	
FDF			-0.0021***
			(0.000)
Energy Consumption	1.5044***	1.4895***	1.4872***
	(0.000)	(0.000)	(0.000)
GDP	0.7311***	0.7748***	0.7098***
	(0.000)	(0.000)	(0.000)
Urbanization	-0.0122***	-0.0129***	-0.0115***
	(0.000)	(0.000)	(0.000)
FDI	0.0071***	0.0077***	0.0070***
	(0.000)	(0.000)	(0.000)
Constant	-12.5824***	-12.7274***	-12.3648***
	(0.000)	(0.000)	(0.000)
Observations	3454	3450	3459
R-squared	0.7592	0.7612	0.7587
F-Statistics	2174.63***	2195.41***	2171.43***
	(0.000)	(0.000)	(0.000)
Results of Post-Estimation Tests			
VIF	3.80	3.84	3.71
Wooldridge's Test	29.364	29.318	29.395
	(0.000)	(0.000)	(0.000)
BPG Test	1001.03	993.28	1029.33
	(0.000)	(0.000)	(0.000)

(*** p<0.01, ** p<0.05, * p<0.1)

Furthermore, the results show that R^2 takes the value of 0.75 (column 1 & 3) to 0.76 (column 2) indicating that around 76 percent variation in ecological footprint is explained by the independent variables. The probability value of F test is also significant providing the evidence of the best model fit. In un-tabulated results VIF remains less than 10 in all models indicating that the data is free from multicollinearity problem. Moreover, the problem of first order autocorrelation is detected in all models by the Wooldridge's test. Likewise, Breusch-Pagan-Godfrey (BPG) test indicates the presence of heteroskedasticity, which is addressed using robust regressions. Moreover, system GMM is used to resolve the problem of heteroskedasticity.

4.2. Results of Fixed Effects

Pooled OLS or the common effect model treats all cross sections as homogeneous and ignores the significant temporal and country specific effects. Therefore, it often suppresses the true picture of the relationship behind concerned variables. To capture these unobserved country specific effects, fixed and random effects methods of estimation are used. Fixed effects model assumes that each country has its own intercept (fixed effect) that varies across cross-sectional units. The results of fixed effects estimation are reported in Table 4. The findings show that all measures of financial development increase environmental quality. In addition, all other explanatory variables carry the correct signs and remain significant providing the evidence that our main findings are not sensitive to country specific effects.

Table 4: Financial Development and Ecological Footprint (Fixed Effects)

Dependent Variable: Ecological Footprint			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0052***		
	(0.000)		
FDB		-0.0042***	
		(0.000)	
FDF			-0.0046***
			(0.000)
Energy Consumption	2.0021***	2.0257***	1.9738***
	(0.000)	(0.000)	(0.000)
GDP	0.2319***	0.1714***	0.1980***
	(0.000)	(0.000)	(0.000)
Urbanization	-0.0239***	-0.0250***	-0.0222***
	(0.000)	(0.000)	(0.000)
FDI	0.0015*	0.0015***	0.0015***
	(0.087)	(0.000)	(0.000)
Constant	-11.1282***	-10.7806***	-10.7015***
	(0.000)	(0.000)	(0.000)
Observations	3454	3450	3459
R-squared	0.7257	0.7213	0.7200
Hausman Test	44.99	41.11	62.52
	(0.000)	(0.000)	(0.000)
F Test	340.00***	328.66***	350.86***
	(0.000)	(0.000)	(0.000)

(*** p<0.01, ** p<0.05, * p<0.1)

4.3. Results of Random Effects

The random effects model assumes that error terms (random effects) vary across cross-sectional units. The results of random effects estimation are reported in Table 5.

According to the findings all measures of FD help to improve the environmental quality by lowering the ecological footprint. The coefficients are statistically significant at 1 percent level of significance. The results are in favor of ecological modernization theory and environmental transition theory suggesting that moving towards modernization increases the capability of adopting clean technology and improves the information related to environmental protection.

Table 5: Financial Development and Ecological Footprint (Random Effects)

Dependent Variable: Ecological Footprint			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0054***		
	(0.000)		
FDB		-0.0044***	
		(0.000)	
FDF			-0.0047***
			(0.000)
Energy Consumption	1.9155***	1.9362***	1.8917***
	(0.000)	(0.000)	(0.000)
GDP	0.3027***	0.2503***	0.2675***
	(0.000)	(0.000)	(0.000)
Urbanization	-0.0221***	-0.0231***	-0.0205***
	(0.000)	(0.000)	(0.000)
FDI	0.0017*	0.0017*	0.0017*
	(0.055)	(0.060)	(0.063)
Constant	-11.0949***	-10.7994***	10.6801***
	(0.000)	(0.000)	(0.000)
Observations	3454	3450	3459
R-squared	0.7346	0.7325	0.7295
Wald Test	1974.64***	1916.06***	2022.71***
	(0.000)	(0.000)	(0.000)

(*** p<0.01, ** p<0.05, * p<0.1)

4.4. Results of Driscoll-Kraay Standard Errors

Table 6 illustrates the regression results of DK standard errors approach for pooled OLS that deals with the issue of temporal and cross-sectional dependence. The findings confirm that 1 percent increase in FDP, FDB and FDF will reduce ecological footprint by 0.0039, 0.0061 and 0.0021 percent, respectively. All measures of financial development are significant at 1 percent level of significance. Thus, overall results indicate that financial development is beneficial for environmental quality as it promotes the use of energy-efficient technology and reduces resource degradation. The results are consistent with the findings of Zhang (2011). Moreover, findings imply that the use of green financing is much reliable for the economies to control environmental pressure (ecological footprint). Similarly, urbanization also plays affirmative role in affecting environmental quality while higher use of energy, economic development and FDI puts devastating effects on ecosystem.

Table 6: Results of Driscoll-Kraay Standard Errors

Dependent Variable: Ecological Footprint			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0039***		
	(0.001)		
FDB		-0.0061***	
		(0.000)	
FDF			-0.0021***
			(0.007)
Energy Consumption	1.5044***	1.4895***	1.4872***
	(0.000)	(0.000)	(0.000)
GDP	0.7311***	0.7748***	0.7098***
	(0.000)	(0.000)	(0.000)
Urbanization	-0.0122***	-0.0129***	-0.0115***
	(0.000)	(0.000)	(0.000)
FDI	0.0071*	0.0077*	0.0070*
	(0.062)	(0.047)	(0.071)
Constant	-12.5824***	-12.7274***	-12.3648***
	(0.000)	(0.000)	(0.000)
Observations	3454	3450	3459
R-squared	0.7592	0.7612	0.7587
F-Statistics	5311.67***	5631.82***	6211.06***
	(0.000)	(0.000)	(0.000)
RSME	1.3410	1.3358	1.3418

(*** p<0.01, ** p<0.05, * p<0.1)

4.5. Results of Panel Granger Causality Test

The stacked causality test of Granger (1969) is used to detect the direction of causality between FD and ecological footprint. The results are displayed in Table 7. The null hypothesis of panel Granger causality test is that FDP, FDB, and FDF do not cause EFP. The null hypothesis for all measures of financial development is not accepted, suggesting that all measures of financial development cause EFP. Overall, results provide the evidence of bidirectional or the reverse causality, which gives rise to the problem of endogeneity.

Table 7: Results of Penal Granger Causality Test

Null Hypothesis	F-Statistic	Probability	Decision	Conclusion
FDP does not Granger Cause EFP	2.449	0.0089	FDP→EFP	FDP↔EFP
EFP does not Granger Cause FDP	7.211	0.0000	EFP→FDP	
FDB does not Granger Cause EFP	1.689	0.0859	FDB→EFP	FDB↔EFP
EFP does not Granger Cause FDB	6.066	0.0000	EFP→FDB	
FDF does not Granger Cause EFP	5.002	0.0000	FDF→EFP	FDF↔EFP
EFP does not Granger Cause FDF	2.170	0.0213	EFP→FDE	

4.6. Results of System GMM

The problem of endogeneity is resolved by including the instruments in specified model and applying the system GMM approach of estimation. We take the lag of dependent variable as endogenous instrument along with the lag values of explanatory variables and time dummies as exogenous instruments. The results reported in Table 8 indicate that all indictors of FD have a negative relationship with ecological footprint that is statistically significant in all estimated specifications. It implies that 1 percent rise in FD indictors will lead to 0.0140 to 0.0175 percent decline in ecological footprint. These empirical findings are similar to the conclusion drawn by Xiong & Qi (2018) and Dar and Asif (2018). The findings support the theory of intergenerational equity which emphasizes on fair use of resources. Hence, with the increase in financial development the use of clean technology increases which reduces the EFP. The decline in EFP implies that resources are efficiently used, pollutant emissions are controlled, and economies move towards environmental substantiality and the environmental goods are preserved for future generations. Regarding the specification Hansen test confirms the overall validity of instruments. Moreover, the insignificant values of AR (2) indicate that error term is uncorrelated and problem of serial correlation does not arise.

Table 8: Financial Development and Ecological Footprint (System GMM)

Dependent Variable: Ecological Footprint			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0140***		
	(0.000)		
FDB		-0.0175***	
		(0.000)	
FDF			-0.0117***
			(0.000)
Energy Consumption	2.2827***	2.2972***	2.0491***
	(0.000)	(0.000)	(0.000)
GDP	0.8235***	0.8029***	1.0273***
	(0.000)	(0.000)	(0.000)
Urbanization	-0.0298***	-0.0262***	-0.0330***
	(0.000)	(0.000)	(0.000)
FDI	0.0103***	0.0123***	0.0109***
	(0.000)	(0.000)	(0.000)
Constant	-17.3917***	-17.4399***	-17.2420***
	(0.000)	(0.000)	(0.000)
Observations	3380	3376	3384
Groups	131	131	131
Instruments	130	130	130
AR (1) Pr> z	0.040	0.049	0.020
AR (2) Pr> z	0.669	0.497	0.473
Hansen Test	0.493	0.471	0.447

(*** p<0.01, ** p<0.05, * p<0.1)

4.7. Pollution Haven Hypothesis (PHH)

The positive relationship between FDI and pollution is known as pollution haven hypothesis (PHH). The empirical results of this study consistently validate PHH as the estimated effect of FDI on ecological footprint is robustly positive and statistically significant in all models. Higher FDI inflows increase the investment and economic activities in pollutant-intensive industries. These industries contribute to water pollution, air pollution, and deforestation. Over all the intensity of all pollutant emissions such as CO_2, NO_X, SO_2, and GHG increase in the atmosphere, which adversely affects the environmental quality.

4.8. Sensitivity Analysis

To assess the strength of the empirical findings the sensitivity analysis is also conducted using further input indicators that are life expectancy, population growth, household consumption and gross fixed capital formation. The results are reported Table 9. The effect of FD measures remains highly significant and negative in all estimated models. Thus, sensitivity analysis also confirms the robustness of results.

Table 9: Sensitivity Analysis of Variables

Sensitivity Variables				
Variables	**Life Expectancy**	**Population Growth**	**Household Consumption**	**Gross Fixed Capital Formation**
Dependent Variable: Volatility of Output (1971-2017)				
FDP	-0.0030***	-0.0019***	-0.0029***	-0.0017**
	(0.000)	(0.005)	(0.000)	(0.011)
R-Squared	0.7606	0.7831	0.7695	0.7722
FDB	-0.0051***	-0.0040***	-0.0059***	-0.0042***
	(0.000)	(0.000)	(0.000)	(0.000)
R-Squared	0.7620	0.7845	0.7723	0.7743
FDF	-0.0014***	-0.0008*	-0.0013***	-0.0009*
	(0.000)	(0.098)	(0.000)	(0.061)
R-Squared	0.7604	0.7833	0.7690	0.7726

(*** p<0.01, ** p<0.05, * p<0.1)

4.9. Analysis with CO_2 Emissions

To check the robustness of the findings, the most commonly used measure of environmental degradation CO2 is also used. The results are reported in Table 10. Findings are consistent and robust as coefficient on FD remains highly significant across all specification indicating that financial development significantly reduces environmental degradation. Comparatively, the effect of FDF is stronger than FDB and FDP.

Table 10: Analysis with CO_2 Emissions

Dependent Variable: CO_2 Emissions			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0012***		
	(0.001)		
FDB		-0.0016***	
		(0.000)	
FDF			-0.0011***
			(0.007)
Energy Consumption	0.7115***	0.7034***	0.7097***
	(0.000)	(0.000)	(0.000)
GDP	0.3957***	0.4069***	0.3970***
	(0.000)	(0.000)	(0.000)
Urbanization	0.0066***	0.0067***	0.0066***
	(0.000)	(0.000)	(0.000)
FDI	-0.0001	0.0003	0.0001
	(0.798)	(0.962)	(0.848)
Constant	-7.9583***	-7.9857***	-7.9432***
	(0.000)	(0.000)	(0.000)
Observations	4103	3099	4104
R-squared	0.8537	0.8545	0.8539
F-Statistics	4782.6***	4814.3***	4789.7***
	(0.000)	(0.000)	(0.000)

(*** p<0.01, ** p<0.05, * p<0.1)

4.10. Comparative Analysis of OECD and BRICS Economies

Finally a comparative analysis is conducted for OECD and BRICS economies. The OECD helps the nations to identify and implement better policies for catering environmental issues through various reforms including financial sector reforms. The OECD has established the 'Center of Green Finance and Investment' that works for the environmental protection by establishing green investment banks and using innovative financing instruments such as green investment, green bonds. In this way the financial development helps these economies to control their pollution emissions to some extent (Gurría, 2018). The results reported in Table 11 indicate that all measures of FD help to reduce ecological footprint in OECD economies.

Table 11: Analysis of OECD Economies

Dependent Variable: Ecological Footprint			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0086***		
	(0.000)		
FDB		-0.0133***	
		(0.000)	
FDF			-0.0060***
			(0.000)
Energy Consumption	3.1001***	2.7795***	3.0380***
	(0.000)	(0.000)	(0.000)
GDP	0.5721***	0.8823***	0.5488***
	(0.000)	(0.000)	(0.000)
Urbanization	0.0051	0.0035	0.0067
	(0.254)	(0.414)	(0.135)
FDI	0.0135***	0.0151***	0.0166***
	(0.000)	(0.000)	(0.000)
Constant	-24.730***	-24.888***	-24.184***
	(0.000)	(0.000)	(0.000)
Observations	884	884	884
R-squared	0.7222	0.7401	0.7192
F-Statistics	456.4***	499.9***	499.8***
	(0.000)	(0.000)	(0.000)

(*** p<0.01, ** p<0.05, * p<0.1)

Table 12 reports the results for BRICs economies. The results indicate that an increase in financial development decreases the environmental pressures. These economies are fast growing (Majeed and Ayub, 2018) and are responsible for high environmental pollution. For instance, China is considered at the top among these economies for creating high environmental problems. However, it also takes a lead in clean technologies and technological invocations through FD. Similarly, Brazil has started taking initiatives for environmental protection through better policy enforcement, including financial sector polices (Abdou & El Adawy, 2018).

Table 12: Analysis of BRICs Economies

Dependent Variable: Ecological Footprint			
Variables	**(1)**	**(2)**	**(3)**
FDP	-0.0053***		
	(0.000)		
FDB		-0.0030***	
		(0.005)	
FDF			-0.0049***
			(0.000)
Energy Consumption	1.4147***	1.3461***	1.3442***
	(0.000)	(0.000)	(0.000)
GDP	0.1616**	0.0479	0.1908**
	(0.046)	(0.618)	(0.011)
Urbanization	0.0058	0.0127***	0.0071**
	(0.113)	(0.003)	(0.029)
FDI	-0.0030	-0.0127	-0.0099
	(0.838)	(0.676)	(0.462)
Constant	-8.5749***	-7.7132***	-8.2982***
	(0.000)	(0.000)	(0.000)
Observations	167	166	167
R-squared	0.9594	0.9459	0.9649
F-Statistics	761.3***	559.7***	884.4***
	(0.000)	(0.000)	(0.000)

(*** p<0.01, ** p<0.05, * p<0.1)

5. Conclusion

This study explores the link between financial development and ecological footprint along with other explanatory variables economic growth, urbanization, energy consumption, and FDI. To achieve this objective the study exploits the larger panel of 131 countries covering the period from 1971 to 2017. Financial development is measured through three indicators namely, domestic credit by the private sector, domestic credit by the banking sector, and domestic credit by the financial sector. For the empirical investigation traditional panel data models including pooled OLS, random and fixed effects models along with the Driscoll-Kraay standard errors techniques are employed.

The findings reveal that development in the financial sector affects environmental quality favorably by lowering the ecological footprint. The findings are consistent in all estimated models and coefficients on FD remain highly significant. This ensures the affirmative role of green financing in controlling environmental pollution. Moreover, these findings support the results of pervious literature and theoretical outlook.

The study also finds the evidence of bidirectional causal relationship between financial development indictors and ecological footprint. This causes the issue of reserve causality that gives rise to the endogeneity problem in the model which is tackled using system

GMM. In addition, the inclusion of additional control variables under sensitivity analysis and analysis with CO_2 emissions also confirms the robustness of the findings. The findings of the study also validate the pollution haven hypothesis and compact city theory by ensuring positive relationship between FDI and ecological footprint and negative relationship between urbanization and ecological footprint, respectively.

5.1 Contribution of the Study

The empirical research on financial development and environment nexus has become the part of academic literature in the recent decades. However, this literature broadly uses CO_2 emissions as a measure of environmental degradation (see Bekhet *et al.*, 2017; Zakaria & Bibi, 2019) which captures only a part of the total environmental damage. Moreover, the empirical analysis is also limited to the use of smaller sample which cannot be generalized at global level. This study aids to the existing literature in a number of ways. First, it uses the comprehensive measure of environmental quality (ecological footprint) that is highly recommended by the literature (Bagliani *et al.*, 2008; Wang *et al.*, 2011; Uddin *et al.*, 2017).

Second, the studies on the relationship between the financial development and ecological footprint are limited. To date, we found only one study by Baloch et al. (2019), which is similar to our study but their analysis is limited to BRI countries. The present study uses three indicators of financial development along with the ecological footprint and extends the analysis from the global perspectives. Thus, to our knowledge, this is the first empirical study that investigates the associations between three measures of financial development and comprehensive environmental indicator (ecological footprint) using a large panel of 131 countries. Furthermore, this study tackles the issue of endogeneity using the system GMM estimates that is generally ignored in the literature. Third, the study provides the clear picture of relationship among the concerned variables by highlighting the theories of environment and linking it with financial development. That is, ecological modernization theory, environmental transition theory, intergenerational equity theory, and structural human ecological theory are contextualized in the analysis.

5.2 Theoretical and Practical Implications

Empirical findings support the favorable effects of financial development on ecological footprint. In this context, important practical implications can be drawn. That is, if financial institutions will provide loans and relaxation to the industries which are adopting clean technologies, then quality of environment will improve. Moreover, they can also assist the funding for the R&D of green technologies that, in turn, help to improve the environmental quality.

Findings of the study are consistent with ‘ecological modernization’ and ‘environmental transition’ theories, which suggest that modernization and technological innovations help to improve environmental quality. Financial sector can control environmental pollution by promoting technological innovations such as energy-saving technology. Likewise, in the light of ‘structural human ecological’ theory the study has implication for government, financial institutions, entrepreneurs, and individual that is their decisions about money lending for investment will have an effect on ecological footprint. The notion of ‘intergeneration equity’ theory is also supported by the findings as financial development helps in preserving the natural resources for the future generation and ensures equity among generations by controlling the environmental pollution.

5.3 Limitations of the Study and Future Directions

This study contains some research limitations and suggests some directions for future research. First, it incorporates three measures of financial development and does not incorporate financial development index. The future research may exert more accurate picture of the relationship by using a comprehensive index of financial development. Moreover, different indictors of financial sector may be included for a comprehensive analysis. Second, this study is restricted to the limited sample size because of the data availability. Third, this study conducts an analysis for only two group of countries, whereas, future studies can extend this study for a comparative empirical analysis of other groups of countries.

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Appendix

Table A1: List of Countries in Ecological Footprint Analysis

Albania	Cameroon	Gambia	Kyrgyz Rep.	Nigeria	Sudan
Algeria	Canada	Georgia	Latvia	Norway	Suriname
Angola	Chile	Germany	Lebanon	Oman	Sweden
Argentina	China	Ghana	Lesotho	Pakistan	Switzerland
Armenia	Colombia	Greece	Libya	Panama	Tajikistan
Australia	Congo, D. Rep.	Guatemala	Lithuania	Paraguay	Tanzania
Austria	Congo, Rep.	Guinea-Bissau	Luxembourg	Peru	Thailand
Azerbaijan	Costa Rica	Guyana	Macedonia	Philippines	Timor-Leste
Bahamas	Cote d'Ivoire	Haiti	Malaysia	Poland	Togo
Bahrain	Croatia	Hungary	Malta	Portugal	Trin & Tobago
Bangladesh	Czech Rep.	India	Mexico	Qatar	Tunisia
Barbados	Denmark	Indonesia	Moldova	Romania	Turkey
Belarus	Dominican Rep.	Iran	Mongolia	Russian Fed.	Ukraine
Belgium	El Salvador	Ireland	Montenegro	Senegal	UAE
Benin	Equat. Guinea	Israel	Morocco	Serbia	UK
Bhutan	Eritrea	Italy	Mozambique	Singapore	United States
Bolivia	Estonia	Japan	Myanmar	Slovak Rep.	Venezuela
Bosnia	Eswatini	Jordan	Nepal	Slovenia	Vietnam
Botswana	Ethiopia	Kazakhstan	Netherlands	South Africa	Yemen
Brazil	Fiji	Kenya	New Zealand	Spain	Zambia
Brunei	France	Korea, Rep.	Nicaragua	Sri Lanka	Zimbabwe
Bulgaria	Gabon	Kuwait	Niger	St. Lucia	