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RESEARCH ARTICLE

Does national scale economic and environmental indicators spur logistics performance? Evidence from UK

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Abstract The aim of this study is to examine the association between national economic and environmental indicators with green logistics performance in a time series data of UK since 1981 to 2016. The research used autoregressive distributed lag method to understand the long-run and short-run relationships of national scale economic (foreign direct investment (FDI) inflows, per capita income) and environmental indicators (total greenhouse gases, fossil fuel, and renewable energy) on green logistics. In the short run, the research findings indicate that the green logistics and renewable energy have positive relationship, while fossil fuel is negatively correlated with green logistics operations. On the other hand, in the long run, the results show that FDI inflows, renewable energy sources, and per capita income have statistically significant and positive association with green logistics activities, while foreign investments attracted by environmental friendly policies and practices adopted in global logistics operations, which not only increase the environmental sustainability but also enhance economic activities with greater export opportunities in the region.

Keywords Foreign direct investment inflows · Total greenhouse gases · Green logistics performance · Renewable energy sources

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Introduction

In the last couple of decades, global logistics activities have received rising attention in the world due to motivating factors such as economic and environmental reasons (Ayvaz et al. 2015). The driving factors such as economic benefits, image and reputation, customer pressure, and government strict environmental friendly laws influence on firms to adopt appropriate strategies in logistics concerns not only to increase their benefits but also to protect environmental sustainability. The problem of CO_2 emissions and greenhouse gases are continuously affecting global climate change and causing more severe storm activities (Hayami et al. 2015). Heretofore, the government and regulatory authorities totally failed to implement their environmental-sustainability policies and control pollution and global warming. McMichael et al. (2008) warn that we must need to solve environmental and economic issues occurring due to heavy global logistics and transport activities, or we need to be ready for multiplier effect of global warming and pollution in terms of several diseases, including asthma attacks, weakening of lung function, mesothelioma, pulmonary cancer, bronchitis, neurobehavioral disorders (Khasnis and Nettleman 2005), pneumonia, birth defects and immune system defects, and liver and other types of cancer (Grover and Rajeshwari 2009). The polluted system of logistics discourages foreign direct investment (FDI) inflows and also a significant poor economic growth in several low-income countries (Wanzala and Zhihong 2016). A research conducted by (Ayvaz et al. 2015) shows that doubling of freight charges leads to a 0.5% decrease in the rate of economic growth, since transport is a vital element of logistics and supply chain. This figure seems small, but it can cause great variation in gross domestic product (GDP) of countries. In addition, 70% of variations in per capita gross domestic product among different countries were due to transportation costs

(Wanzala and Zhihong 2016) in the logistics and supply chain activities.

The logistics activities play an important role in the development of country economic activities. Rao and Holt (2005) argue that green logistics activities enhance firms' financial benefits and also help to reduce their negative effect on the environmental sustainability. Carter and Rogers (2008) further described that firm logistics activities should be aligned and integrated with environmental and social goal. Zaman and Shamsuddin (2017) conducted the research on panel of selected European countries; the results revealed that GDP per capita income improve logistics activities and greater GDP and strong economic countries dedicate themselves to implement green and environmental friendly logistics activities to further increase economic growth in sustainable way and to attract foreign direct investment (Zhu et al. 2008). Chinese firms are continuously struggling to enhance their environmental image and reputation in the market by adoption of green practices in their activities, including the renewable energy consumption to attract FDI inflows (Zaman and Shamsuddin 2017). The results show that European countries' economic growth and foreign direct investment inflows are stronger than other developed countries in Asian region due to the adoption of renewable energy sources and other green practices in logistics activities and freight transportation.

The key motivation of this study is to address logistics performance by using nationwide economic and environmental indicators, as previously green logistics is analyzed at a firm-level management strategy, which is deemed to be desirable to examine in macro-level settings. The aim of the research is to observe the dynamic associations between logistics performance indicators, environmental factors and economic factors, for a period of 2007 to 2016. The research has competitive advantage over the previous research studies for it utilize a number of promising indicators to test the idea of environmental friendly logistics or green logistics and environmental factors including total greenhouse gases, fossil fuel consumption in logistics and transportation activities, and economic factors, i.e., foreign direct investment inflows and GDP per capita.

The rest of study organized as follows: "Literature review and hypothesis development" section provides literature review and hypothesis development. "Methodology" section discussed the research methodology. "Results and discussion" section covers results and discussion part of research. Finally, "Conclusion" section will cover research conclusion and practitioner implications.

Literature review and hypothesis development

The logistics play a vital role in the growth of countries' economy, and also, it is the significant contributor of air pollution, including CO_2 emissions and greenhouse gases. Firms are implementing green practices in their logistics and supply chain activities to reduce the negative affect on environment and build a positive image in the domestic and international market to increase their market share (Zaman and Shamsuddin 2017). The logistics activities heavily depend on energy and fossil fuel consumption, and these both are the killer for sustainable environment Khan et al. (2017) . Since the last couple of decades, regulatory authorities and customer create pressure on firms to adopt green practices and renewable energy sources in business activities (Zaman and Shamsuddin 2017) to mitigate the problem of CO_2 emissions and climate change for sustainable environmental and economic development in the region (Halldorsson and Kovacs 2010). The detailed literature review is presented for each element of green logistics in the following sub-sections.

The world's total energy consumption projected to 2040 demonstrates a continuously growing trend towards renewable energy consumption (REC). Renewable energy source is inexpensive as compared to fossil fuel, while this also reduces the carbon missions and greenhouse gases (Azad et al. 2015). The classification of energy sources and its contribution to global energy consumption is shown in Fig. 1.

The relationship between green logistics and energy demand

The relationship between logistics and energy demand is well discussed under logistics management process, while green practices in the logistics required cleaner energy sources to reduce the harmful effect on the environment, including CO_2 emissions, greenhouse gases, and climate change for healthy environmental and economic growth (Dekker et al. 2012). Wu and Barnes (2016) highlighted the need of renewable energy in logistics and supply chain operations for sustainable environmental growth, while Anable et al. (2012) and Nakamichi et al. (2016) argued that transport activities consumed greater energy in order to perform their logistics operations. Park et al. (2016) claimed that developed countries' environmental economic growth is strong due to adoption of green logistics and renewable energy sources (Park et al. 2016). The results show that investment in cleaner or renewable energy not only maximize the profitability but also mitigate the CO_2 and greenhouse gas (GHG) emissions, while fossil fuel is not only polluting the environmental beauty but also expensive as compared to cleaner energy sources (Gold and Seuring 2011). Bio-energy as green energy option builds many expectation. Mainly, bio-energy is expected to mitigate problem of climate change and carbon emissions to preserve non-renewable resources (Nguyen et al. 2010) to improve regional development by creating employment in usually rural areas and underdeveloped areas (Elghali et al. 2007).

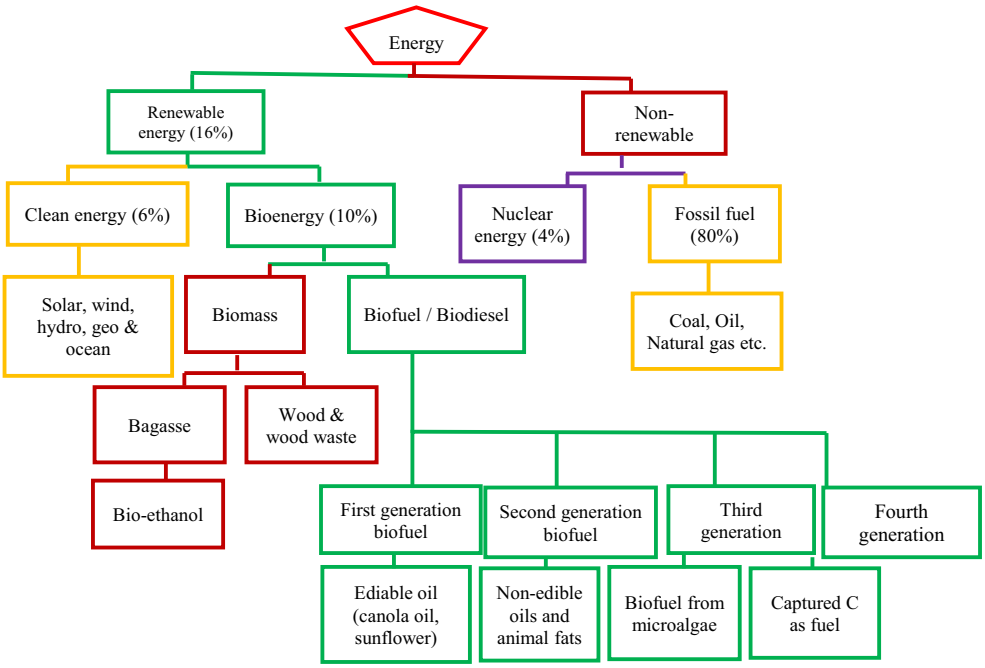

Fig. 1 Energy sources and its contribution in global consumption. *Source*: Azad et al. (2015)

Khan et al. (2016) conducted the research on the renewable energy and green growth, and researchers have used data of World Bank Indicators. The results show that the renewable energy sources are still lagging behind in most of the developed and developing countries; however, the appropriate energy portfolios required substantial knowledge information regarding the environment and health effects for green growth.

The German government target is to fulfill to the 80% of energy demand from renewable energy sources by the end of 2050 (Rahbauer et al. 2016), while customer will play vital role to achieve this target by purchasing clean electricity. However, the demand for green electricity is still low in small manufacturing enterprises, which represent biggest electricity customer group. The government policies and customer awareness create pressure on firms to adopt environmental friendly practices in their business activities, while firms more strictly follow environmental policies to maintain their image and reputation in the domestic and international market. According to the United States Energy Information Administration (USEIA), the world energy consumption expected to 2040 indicates a growing trend towards renewable energy (Azad et al. 2015). The clean energy and bioenergy not only reduce the carbon emissions and harmful effect on the environment but also increase the positive image and profitability of the firms. Saba et al. (2015) and Azad et al. (2015) highlighted that regulatory authority and customers can create pressure on firms to adopt renewable energy in logistics and supply chain activities to mitigate the problem of air pollution and climate change.

The government strict sustainable development policies can influence on firms to replace their fossil fuel consumption by different sources of renewable energy (Gold and Seuring 2011). The results show that bio-energy manufacturing would be helpful to reduce the negative affect on the environmental, as it is reliable option to encourage green agenda in energy policy framework. Bhattacharya et al. (2016) conducted the study to find the relationship between renewable energy sources and economic growth. The results revealed that renewable energy sources have positive and significant impact on countries' economic growth. Shahbaz et al. (2015) collected the data from World Bank; the results show that renewable energy enhanced clean economic growth and also prompt green logistics operations. Bhattacharya et al. (2016) argued that renewable energy is the promising solution for green logistics and economic development which may be enlarged with the government-regulated bodies to promote cleaner technologies across the countries. On the basis of above cited research papers, we present the following hypothesis:

H1: Renewable energy positively correlated with the green logistics.

The relationship between green logistics and economic growth

Economic health is correlated with green logistics operations, while practices under logistics management are helpful to encourage economic growth of country (Zaman and Shamsuddin 2017; Zhang and Zhao 2012). During twentieth century, firm's aim was to reduce the waste for economic benefits rather than environmental sustainability, but in twenty-first century, firms and government policies are very clear towards environmental sustainability (Park et al. 2016).

Green logistics and supply chain has emerged as a significant important firm philosophy for mitigating harmful effect on the environment and also enhancing economic growth (Diabat and Govindan 2011). Wanzala and Zhihong (2016) argue that polluted logistics systems are discourage investments, including FDI inflows, and also incur a huge cost in the logistics operations in terms of delayed custom clearance, reducing export opportunities in a number of European countries due to polluted logistics and freight operations. Zaman and Shamsuddin (2017) conducted the research on green logistics and economic indicators and researchers used World Bank Indicators (WDI). The results of research confirmed that green logistics operations attract FDI inflows and greater FDI inflow also is a driver of sustainable environment in the European region. The results show that FDI inflows and renewable energy sources are positively and significantly associated with green logistics management, while CO_2 emissions and fossil fuel consumptions are negatively correlated with performance of green logistics. Hartmann and Germain (2015) highlighted that ecological product design and green logistics activities are not only protecting the environment but also increasing firm profitability in terms of reduction of waste, implementing green technologies, and adopting renewable energy sources. Khan et al. (2017) conducted the research on 15 panel-selected countries; researchers used WDI data and the results revealed that GDP, FDI inflows, and manufacturing value added activities are significantly affected by CO_2 and GHG emissions, while green logistics activities reduce CO_2 and GHG emissions and also have positive affect on countries' economic growth in terms of GDP and FDI inflows. Furthermore, the greater economic activities and green logistics performance have bidirectional causality in a panel of European countries (Khan et al. 2017).

In many countries, governments and regulatory authorities impose heavy taxes on fossil fuel in order to encourage renewable energy. Mafakheri and Nasiri (2014) argue that heavy taxes only impose on transport industry and do not provide as such support to biomass projects. In this situation, this could backfire and elevate the cost of transportation activities in biomass supply chains. Rehman Khan et al. (2017) conducted the empirical study in a panel of 19 well-famous tourist countries; the results show that transportation facilities and economic growth are interdependent with each other, while sustainable transportation in countries attracts international tourists and FDI inflows (Rehman Khan et al. 2017). This research confirmed the causality between sustainable transportation, international tourism, and healthy economic growth in terms of greater GDP and FDI inflows (Prajogo et al. 2012). The results show that green logistics and transportation activities enhance firms' positive image and reputation in domestic and international market, while green logistics operations also avail the tax exemptions and less delay in custom clearance in a number of European countries. Renewable energy and green practices in logistics and freight transportation attract foreign investments and build strong economic growth (Prajogo et al. 2012). On the basis of above cited research papers, we present the following hypothesis:

> H2: Economic growth is positively associated with green logistics operations.

The relationship between green logistics and environmental factors

Undeniably, environmental sustainability is significantly comprised by logistics and transportation activities if the suitable policy is lacking behind towards green logistics operations (Murphy and Poist 2000). Firms in USA are well-adopted green practices in their logistics operations and the environmental friendly practices are very helpful to reduce CO_2 and GHG emissions, while maintaining environmental sustainability in long term. Srivastava (2007) argue that green practices in order to increase green logistics practices are ignored in global logistics operations and freight transportation, while government regulations need to enforce environmental friendly policy framework. Zaman and Shamsuddin (2017) conducted the research on 27 panel-selected European countries and data downloaded from World Bank; the results indicate that green practices are the key desirable policy to encourage implementation of green logistics across the region. The environmental friendly initiatives need to be taken by firms and government should impulse to environmental laws. Green logistics in broad idea also covers green marketing, green consumption, green packaging, green distribution, green transportation, green production, and reverse logistics, which further lead to economic performance and environmental performance. Green manufacturing and green logistics both are working for mitigating the negative affect of business activities on the environment, and green practices in logistics activities enhance firm profitability (Prajogo et al. 2012) along with an improved firm image and market share (Porter and Van der Linde 1995).

In the last couple of decades, environmental sustainability is seriously compromised due to industrializations across the globe. Nakamichi et al. (2016) argue that total CO_2 carbon emissions per vehicle in Thailand and Laos are greater as compared to other nearest countries, while greater carbon emissions are badly damaging tourism industry in Thailand. Further, the results revealed that firms need to build their production facilities close to the customer in order to reduce CO_2 emissions by shrinking lead time, and also adopt renewable energy sources in their logistics operations for long-term environmental sustainability. Khan et al. (2017) conducted the research on European countries, and researchers used the WDI

data. The results revealed that economic growth, country reputation in international arena, export opportunities, and FDI inflows are seriously affected due to greater CO_2 emissions and GHG emissions in the region. Further, the study suggests that government needs to strictly enforce environmental sustainability policies in their country to maintain economic growth activities and foreign investment inflows (Khan et al. 2017; Wanzala and Zhihong 2016; Facanha and Horvath 2005). The results conclude that logistics has a profound impact in the end-to-end business activities, as firms are greening their logistics activities and adopt renewable energy sources in their logistics operations; it significantly reduces CO_2 emission and GHG emission. Hausman et al. (2005) argued that logistics operations greatly contribute in economic and financial variables in order to achieve maximum financial target from trade. On the other hand, Meyer et al. (2007) claimed that climate change is badly affected by logistics operations around the globe, as an increase in the number of vehicles significantly increases CO_2 and GHG emissions. In simple words, a number of vehicles are increasing, which means that a number of polluters are increasing on yearly basis around the globe. Lai and Wong (2012) concluded that green practices in logistics activities enhance economic and environmental performance. The results confirm that green logistics have a positive contribution in greater environmental quality and firm financial performance, while government and customer pressure encourage the green logistics and renewable energy sources to achieve environmental profitability. A number of researchers used World Bank Indicators for conducting their research to identify the relationship between green logistics operations and carbon emissions and FDI. Zaman and Shamsuddin (2017) also used WDI data for conducting research on green logistics association with FDI and trade openness. On the basis of above cited research papers, we hypothesis that greater environmental consideration in logistics activities is significantly and positively correlated with green logistics. Greater environmental sustainability is based on governmental policies enforced on firms to adopt green practices in their logistics operations for reducing carbon emissions and footprints.

H3: Greater environmental sustainability is positively associated with green logistics.

Methodology

This research paper draws the association between renewable energy, environmental elements, economic health factors, and green logistics operation performance. Undeniably, logistics operations are heavily dependent on energy demand, and logistics and supply chain activities are the backbone of country economic growth. On the other hand, logistics activities are significant contributor of carbon emissions and global warming. In a number of developed countries, economic growth is strong due to focus on environmental sustainability (Khan et al. 2017). Table 1 shows the definition of constructs.

Government and customer pressure can influence on firms to adopt renewable energy sources and green practices in their business activities. The main purpose of this research is to connect logistics operations with renewable energy sources, environmental and economic indicators. The given below equation will be used to calculate the green logistics operation performance in the UK.

$$\mathrm{GLP}_t = \beta_0 + \mathrm{FDI}_t\beta_1 + \mathrm{REC}_t\beta_2 + Fossil_t\beta_3 + TGHG_t\beta_4 + \mathrm{GDP}_t\beta_5 + \varepsilon_t \quad (1)$$

where GLP shows the overall green logistics operations, FDI indicates the foreign direct investment net inflows, REC indicates the renewable energy consumption (percent of total final energy consumption), Fossil shows the fossil fuel energy

Table 1 Definition of constructs

Constructs	Definitions
Green logistics performance (GLP)	The logistics green practices have been adopted by regulatory authority to reduce emissions, while GLP has been calculated by efficiency of custom clearance process to reduce carbon emissions, quality of trade and transport-related infrastructure, and competence and quality of logistics services with minimum possible emissions
Foreign direct investment (FDI)	Foreign direct investment inflow is a leading indicator of handsome economic activities
REC	REC is the renewable energy (percent of total final energy consumptions) used and prompted by government for protecting environment
Fossil	Fossil is the fossil fuel energy consumption (percent of total); mainly, fossil fuel is the key contributor of emissions
TGHG	TGHGs indicate the total greenhouse gas emissions (kt of CO_2 equivalent)
GDP	GDP is the gross domestic product per capita in the UK (annual growth)

consumption (percent of total), TGHG indicates the total greenhouse gas emissions (kt of CO_2 equivalent), and GDP indicates the gross domestic product per capita in the UK. The basic objective of the research is to examine the effect of explanatory variables (REC, FDI, TGHG, Fossil, and GDP) on logistics operation performance, while the study does not used pooled least square method, as all the variables are not stationary at level and Bond test suggests the long-run relationship between the variables; for that reason, pooled least square seems to be not suitable (Imran et al. 2015), so autoregressive distributed lag (ARDL) approach is the most appropriate statistical method to test our research hypothesis, while ARDL method is proposed by Pesara and Shin (1998) and Pesaran et al. (2001). In our research, it is hypothesized that with greater consumption of renewable energy, FDI net inflow, GDP per capita will improve the performance in green logistics operations and total greenhouse emissions and fossil fuel consumption are negatively correlated with performance of green logistics in the perspective of UK. This research collected the sample data from WDI during the period of 1981 to 2016. A number of researchers have used WDI data for testing correlation between green logistics performance and environmental performance (Kim and Min 2011; Zaman and Shamsuddin 2017). Figure 2 shows the plots of level data since 1981 to 2016 for ready reference.

Results and discussion

Table 2 displays the descriptive statistics of the endogenous and exogenous variables. The statistics show that all of the endogenous and exogenous variables have a positive mean value and have a substantial peak of the distribution, which confirm the strong logistics support in the UK with healthier economic and trade liberalization policies.

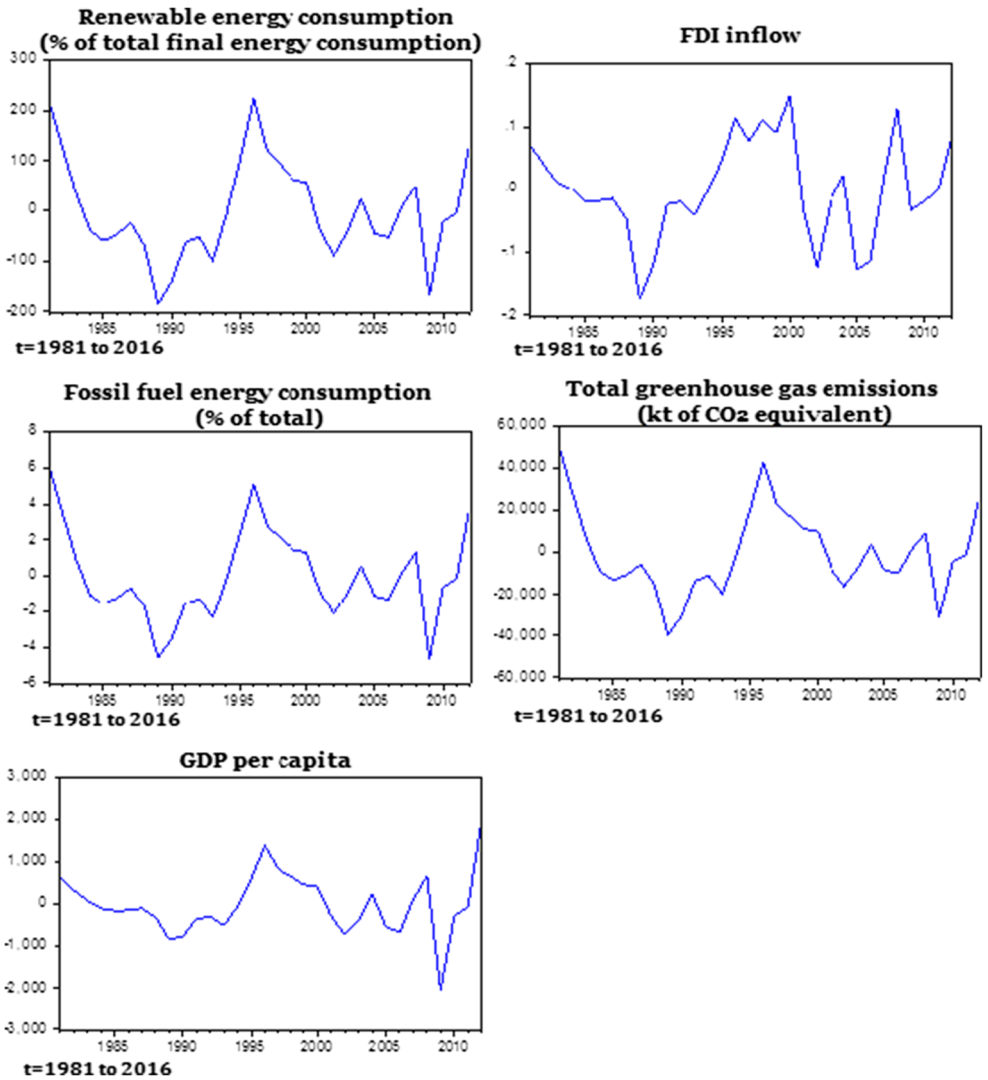

Fig. 2 Graph of level data since 1981 to 2016. *Source*: World Bank (2016)

Table 2 Descriptive statistics

	GLP	TGHG	FDI	REC	Fossil	GDP
Mean	3.95500	706,745.4016	3.0891	3,504.7234	88.6584	27,415.2488
Median	3.93000	722,260.7850	2.0429	3,619.0773	88.0833	27,284.2240
Maximum	4.04508	789,385.0600	10.0735	3,879.8228	94.6628	49,949.1549
Minimum	3.92000	568,061.8289	−0.0753	2,763.9801	80.7120	8,179.1944
Standard deviation	0.03876	66,808.0451	2.6557	301.6715	3.0269	13,122.6647
Skewness	0.94206	−0.4502	1.4406	−1.1011	−0.3079	0.0735
Kurtosis	2.54604	2.1024	4.0990	3.1753	3.3086	1.6988

Authors' estimation based on data set available on World Bank (2016)

There is no doubt that greater and positive mean value of total greenhouse gas (TGHG) and fossil fuel consumption have negative effect on long-term environmental sustainability. On the other hand, REC is significantly reducing harmful effects of logistics and supply chain operations. Finally, county economic growth is measured by GDP per capita income and foreign direct investment inflows, and these both are playing motivating role to adopt green logistics operations in the UK (Khan et al. 2017). FDI inflows and green logistics operations have bidirectional causality; in simple words, renewable energy sources and green logistics practices in the country attract foreign investors. Green logistics operations have positive and significant effect on country economic growth due to renewable energy consumptions in logistics operations. Khan et al. (2016) not only spur sustainable economic growth but also attract foreign investments.

Table 3 shows the correlation matrix and found that renewable energy and economic indicators, including FDI and GDP, are positively and significantly correlated with green logistics operations. On the other hand, environmental factors containing TGHG emissions and fossil fuel consumptions are negatively correlated with green logistics operations. Undeniably, global logistics activities and industrialization are creating alarming situations such as world warming and climate change with air pollutions, while renewable energy sources and green practices in logistics and supply chain operations are best options to mitigate multiple environmental problems, including carbon emissions and climate change.

Table 3 Correlation matrix

	GLP	TGHG	FDI	REC	Fossil	GDP
GLP	1					
TGHG	−0.5104	1				
FDI	0.7268	−0.3505	1			
REC	0.1425	0.4853	0.2436	1		
Fossil	−0.2472	0.7038	−0.2204	−0.0453	1	
GDP	0.7131	−0.8738	0.5762	−0.2389	−0.6754	1

Authors' estimation based on data set available on World Bank (2016)

FDI inflows have significantly and positive relationship with green logistics operations. In simple words, green logistics operations and government policies regarding environmental sustainability attract foreign investments. Fossil fuel consumptions and total greenhouse emissions are negatively correlated with green logistics practices, while as renewable energy consumptions are increasing total greenhouse emissions and fossil fuel consumptions are decreasing, which is the healthy sign for green practices in logistics operations. GDP per capita income is an economic indicator which plays motivating role in operations of green logistics, while green logistics and greater consumption of renewable energy are healthy signs of strong economy and sustainable environmental development. Finally, foreign investments attracted by governmental policies and commitments towards long-term environmental sustainability (Zaman et al. 2016) and renewable energy sources is a leading step towards greening country economy and protect long-term environmental sustainability.

Table 4 shows the estimation of Phillips-Perron test and augmented Dickey-Fuller test to check the stationarity in our time series data and to select the most appropriate statistical technique for robust results. The results of ADF and Phillips-Perron test confirm that data is not stationary on level and the order of integration among variables is I(0) and I(1). On the basis of unit root test results, we have decided to apply ARDL method for testing our research paper hypothesis. ARDL approach was found by Pesaran et al. (2001); the ARDL method allows that exogenous and endogenous variables may be stationary in I(0), I(1), or mix-up of I(0) and I(1) (Bölük and Mert 2015). Due to this reason, ARDL method was frequently adopted by several researchers and also in the current study.

Before applying ARDL cointegration approach to test our research study hypothesis, we need to confirm presence of long-run relationship between variables. In order to explore long-run relationship among endogenous and exogenous variables in the system, the ARDL bound test approach was developed by Pesaran et al. (2001). This test is based on the F statistics and follows a non-standard distribution, while the null hypothesis of no cointegration $X_1 = X_2 = X_3 = X_4 = 0$ is tested against the alternative hypothesis of cointegration $X_1 \neq X_2 \neq X_3 \neq X_4 \neq 0$. The bound tests show two sets of critical

Table 4 Unit root tests

Variables	Augmented Dickey-Fuller				Phillips-Perron test			
	At level		First difference		At level		First difference	
	t Statistics	Prob.	*t* Statistics	Prob.	*t* Statistics	Prob.	*t* Statistics	Prob.
GLP	−1.738583	0.7057	−2.755394	0.0078	−1.89442	0.6361	−2.95535	0.0042
FDI	−1.863014	0.0603	−8.38418	0.0000	−3.15855	0.0316	−9.363585	0.0000
REC	0.324418	0.9980	−9.246853	0.0000	0.02736	0.9950	−9.513939	0.0000
TGHG	−2.240539	0.0264	−7.313114	0.0000	−2.67698	0.0009	−13.73646	0.0000
Fossil	−2.511577	0.0136	−5.591945	0.0001	−2.42700	0.0168	−4.888483	0.0000
GDP	−2.952494	0.1602	−3.906595	0.0003	−2.18542	0.4821	−3.906595	0.0003

values in which upper bound assumes that all exogenous and endogenous variables in the ARDL model are I(1), and the lower bound assumes I(0). If the *F* statistics value is greater than the upper bound critical value, the null hypothesis is totally rejected, indicating cointegration. On the other hand, if *F* statistics value is smaller than lower bound critical value, it simply rejected alternative hypothesis, meaning that there is no cointegration (Attari et al. 2016). Table 5 shows the results of bound tests; *F* statistics value is greater than upper bound critical value, which shows that there is significant cointegration. After founding the cointegration among variables, the lag orders of the variables are selected by using the suitable Schwarz Bayesian and Akaike information criteria.

Table 6 shows the results of optimal lag order selection criteria; the results of Akaike information criterion (AIC), Schwarz information criterion (SC), and Hannan-Quinn (HQ) information criterion are similar for the model, while we have selected optimal lag length and reported for the ARDL equation (2) with no auto serial correlation or serial correlation problem.

Table 7 indicates the ARDL short-run results; the finding shows that CointEq coefficient is negative and statistically significant, while it also indicates the reliability of our results. The ARDL short-run estimates indicate that "REC" (0.003, $p < 0.05$) reflects a statistically significant and positive effect on green logistics performance (GLP) in the context of UK, while "Fossil" (−0.011, $p < 0.1$) is negatively correlated with green logistics operation performance. On the other hand, in the short run, "FDI," "TGHG," and "GDP" have insignificant association with green logistics performance.

Table 8 shows the ARDL long-run results; the coefficient of parameter estimates suggests that the REC (0.009, $p < 0.01$), GDP (0.003, $p < 0.01$), and "FDI inflow" (0.012, $p < 0.1$) reflect a statistically significant and positive impact on green logistics operation performance. On the other hand, TGHG (−0.031, $p < 0.05$) and Fossil (−0.011, $p < 0.01$) have indicated a significantly negative impact on green logistics operation performance. Therefore, in the long-run ARDL results, our hypotheses (H1, H2, and H3) were accepted at the different level of confidence; the results of ARDL long-run estimates revealed that REC, FDI inflow, and economic activities are positively correlated with green logistics performance but the TGH (total greenhouse emissions) and Fossil (fossil fuel consumptions) are significantly and negatively correlated with green logistics operations.

Table 9 shows the diagnostics tests including serial correlation, heteroskedasticity, Ramsey RESET, and normality tests. The results show that there is no serial correlation; in simple words, the disturbance term connecting to any variable in the model has not been influenced by the disturbance (Attari et al. 2016) term relating to another variable of the model. The RESET defines the model linearity; if the residuals from a linear model are exogenous, they should not be associated with the predictors used in the equation (Attari et al. 2016). Therefore, a regression of the residuals (Egli 2004) on these values should not be significant. Table 8 indicates that

Table 5 ARDL bond test for cointegration

Variables	*F* statistics	Cointegration
F (GLP, FDI, REC, Fossil, GDP, TGHG)	9.786868***	Cointegration
Critical value	Lower bound	Upper bound
1%	3.41	4.68
5%	2.62	3.79
10%	2.26	3.35

***Significant at 1%, **significant at 5%, *significant at 10% level

Table 6 Lag order selection criterion of model

Lag	AIC	SC	HQ
0	59.80928	60.08952	59.89894
1	49.78042	51.74209	50.40797
2	49.16603[a]	52.80914[a]	50.33149[a]

[a] Lag order selected by the criterion

Table 7 ARDL short-run estimates

Variable	Coefficient	*t* Statistics	Prob.
FDI	0.001	0.91263	0.1685
REC	0.003	4.116109	0.0406**
Fossil	−0.011	−5.13398	0.0708*
TGHG	−0.031	−0.706063	0.1498
GDP	0.003	5.079495	0.1754
CointEq(−1)	−0.436479	−4.439209	0.0016

Dependent variable is GLP; adjusted *R* square is 0.63

***Significant at 1%, **significant at 5%, *significant at 10%

the Ramsey RESET test *p* value is statistically insignificant. Furthermore, heteroskedasticity has been checked by heteroskedasticity Breusch-Pagan-Godfery test. The *p* value is insignificant, which means that there is no heteroskedasticity problem. Fulfilling the assumption of regression model is that the residuals are normally (Attari et al. 2016) distributed with zero mean, a constant variance. The test of Jarque-Bera normality test has been performed, and the results show that the residuals terms are normally distributed.

To check the model stability, we have performed cumulative sum of recursive residuals and cumulative sum of squares of recursive residual stability test. Figures 3 and 4 show that the models are stable at the 5% level of significance.

The results revealed that renewable energy sources are the most important factor in the long run and short run to encourage sustainable green logistics operations around the country and renewable energy is positively and significantly correlated with green logistics operations. Anable et al. (2012) confirmed that renewable energy is the backbone of green economic growth and sustainable environmental development in the region, while renewable energy sources in logistics activities also attract foreign investment and represent a positive image of country in the international arena (Shahbaz et al. 2015); green logistics operation play significant deal with global warming and climate change issues. Qureshi (2016) shows that renewable energy sources have positive and significant relationship with green logistics performance and

Table 8 ARDL long-run estimates

Variable	Coefficient	*t* Statistics	Prob.
FDI	0.012	0.91263	0.0685*
REC	0.009	4.116109	0.0026***
Fossil	−0.011	−5.13398	0.0006***
TGHG	−0.031	−0.706063	0.0498**
GDP	0.003	5.079495	0.0007***

Dependent variable is GLP; adjusted *R* square is 0.63

***Significant at 1%, **significant at 5%, *significant at 10%

Table 9 Diagnostics tests

Heteroskedasticity Breusch-Pagan-Godfery test			
Obs**R*-squared	20.2106	Prob.	0.382
Breusch-Godfery serial correlation LM test			
Obs**R*-squared	3.1184	Prob.	0.774
Ramsey RESET test			
Log likelihood ratio	0.7402	Prob.	0.4594
Jarque-Bera normality test			
JB Stat	0.9130	Prob.	0.6335

*Rejection of hypothesis at the 10% significance level

foreign direct investment inflows attracted by government sustainable policies and green practices around the Europe. Parajuli et al. (2015) explain that biofuel could be important player for cleaner energy, while a number of countries working on renewable green energy sources found it healthier for country economic growth and also enhance green logistics operations and environmental sustainability (Bhattacharya et al. 2016). The findings suggest that governments should encourage renewable sources in logistics and production activities by tax exemptions and low import duties on green materials and also enforce heavy penalty on polluted materials and fossil fuel consumptions. The use of Jatropha oil and biofuels is promoting green alternative to fossil fuels (Jingura 2011) both in energy context and also as technical reason to deal with global warming and carbon emissions.

Transport sector is continuously growing all around the world, and transport sector is a significant contributor of carbon emissions and climate change. Due to ineffective transport policies, carbon emissions are becoming a big challenge for the global ranked logistics countries (Liimatainen et al. 2014). The Transport White Paper of EU (European Union 2011) has set a target to mitigate CO_2 emissions of global logistics and transport shipment by 60% till the end of 2050, while EU white paper also highlighted the logistics sector as main contributor of carbon dioxide. On the other hand, EU has set a target to mitigate CO_2 emissions by 20% in the end of 2020 and also increase the share of green energy sources by 20% European Union's total energy consumption (European Union 2008). A number of countries shift from fossil fuel towards renewable energy sources, including UK, USA, France, Belgium, and Netherlands. In Sweden, 35.50% electricity produced by renewable energy sources and government encourage green logistics operations and implement environmental friendly policies to promote renewable energy and green practices in logistics operations (Nasir et al. 2016). The UK Renewable Energy Strategy and latest energy acts identify bioenergy as a critical means of fulfilling the environmental objectives, including reduction of CO_2 and greenhouse gas emissions. The strategy shows that bioenergy will need to

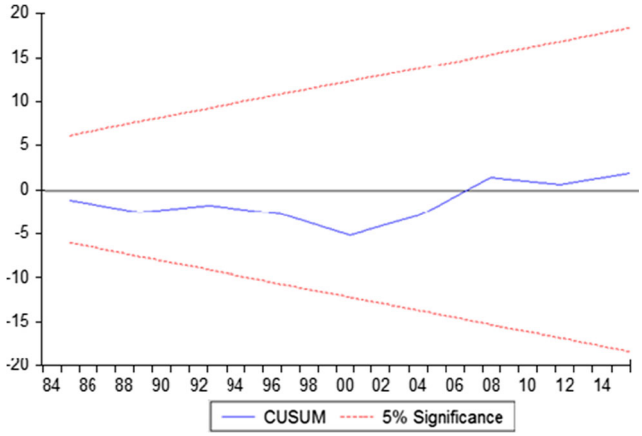

Fig. 3 Cumulative sum of recursive residuals

be a significant promoter of renewable energy mix till the end of 2020. Iakovou et al. (2010a, b) conclude that green energy sources are undeniably helpful to reduce environmental pollution including, CO_2, greenhouse gases, and climate change. On the other hand, renewable energy also plays a vital role to promote green logistics activities and long-term environmental sustainability (Stanek et al. 2015). Hamelinck et al. (2005) suggest that government should implement strict environmental policies and encourage green practices in logistics and transportation sector to mitigate the problem of carbon emission and global warming. On the other hand, regulatory authorities need to impose (Stanek et al. 2015; Zaman and Shamsuddin 2017) heavy penalty on polluted logistics systems to protect sustainable environment.

The results indicate that fossil fuel consumption is negatively correlated with green logistics performance in the short run and long run. In simple words, due to increasing in fossil fuel consumption, green logistics operation performance is decreasing, while fossil fuel consumption is a significant contributor of carbon emissions and greenhouse gases, which create negative effect on environmental sustainability (Mafakheri and Nasiri 2014). Renewable energy sources play a critical role in global strategies to mitigate problems of carbon emissions and climate change, while renewable sources are replacing fossil fuels and encouraging green logistics operations. In similar way (Iakovou et al. 2010a, b; Cucchiella et al. 2015; Nakamichi et al. 2016; Zaman and Shamsuddin 2017), fossil fuel is discouraging green practices in supply chain and logistics management, while the results show that fossil fuel consumptions are positively correlated with poor environmental performance. Negal (2000) highlighted that firms are not adopting renewable energy sources due to heavy investment required in biomass-fired plants, as in a number of countries, government do not provide financial support in term of tax exemption or subsidies. Logistics activities are heavily dependent on fossil fuel burning and emit greater carbon dioxide, which can pollute the living environment such as water, air, and ground (Min and Kim 2012). The best option to protect environmental sustainability is to adopt green practices and renewable energy sources in global logistics and supply chain operations. In similar track (Mafakheri and Nasiri 2014), results conclude that fossil fuel sources are more expensive than renewable energy, while fossil fuel have significant and negative effect on country green economy and sustainable development. On the other hand, the availability of many biomass resources has made it an (Mafakheri and Nasiri 2014) appealing source of green energy.

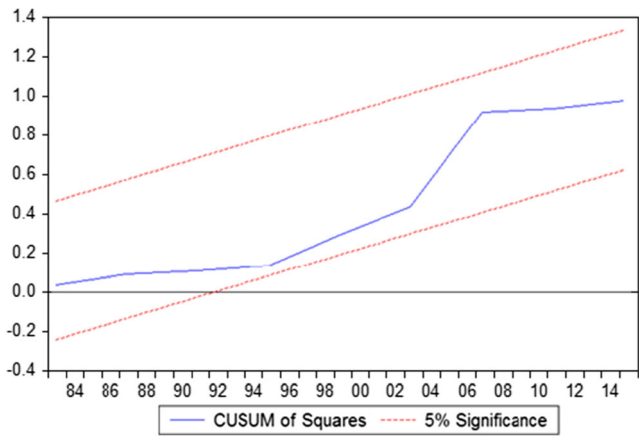

Fig. 4 Cumulative sum of squares of recursive residuals

The greater TGHG emissions are the evidence of poor environmental performance in the country, while TGHG missions cannot be reduced without the help of environmental friendly policies implemented by sitting government and regulatory authorities. This research conclude that greater TGHG have negatively effect on the GLP, while green logistics are heavily dependent on energy demand and fossil fuel consumption; the best options to maintain environmental sustainability without slowing down economic growth are adoption of green practices and renewable energy sources in logistics operations. In the similar way (Ala-harja and Helo 2014; Hayami et al. 2015), greenhouse gases and climate change are the cause of polluted logistics activities around the globe, while greenhouse gases are negatively correlated with environmental friendly logistics operations. WRI (2011) highlighted that 13.5% of global greenhouse gases are produced by global logistics activities, which can be reduced significantly by implementation of green operations and replacing fossil fuel with renewable energy sources (Mitra and Datta 2014). Economic viability is basic reason for a firm to survive, but it is not possible to sustain the firm in the long run if it causes irreversible damages to the environmental sustainability by producing GHG and CO_2 emissions. Therefore, it is very important for firms to protect environmental sustainability while achieving its financial objectives (Mitra and Datta 2014).

WDI report shows that UK produced 5.85 billion tonnes total GHG emission in 2012 (source: http://wdi.worldbank.

org/table/3.9), while this figure is continuously decreasing due to heavy adoption of green logistics and replacing fossil fuel with renewable energy sources; on the other hand, strict environmental policies are also encouraging firms to greening their business operations (Zaman and Shamsuddin 2017). Global energy and fossil fuel are closely associated with polluted logistics systems, which create a number of environmental and social issues (Styles and Schoenberger 2012) including smog-forming gases and acidifying gases that damage human health and ecosystem. Simão et al. (2016) confirmed that logistics and transportation activities not only emit heavy GHG and CO_2 emissions but also have negative effects on biodiversity due to habitat fragmentation (European Commission 2011) caused by transport infrastructure. Lee and Wu (2014) confirmed that only a very small number of firms can also significantly reduce GHG emissions by adopting green practices in their logistics operations.

The ARDL long-run results show that economy is significantly and positively correlated with green logistics operations, while economy activities can be measured by GDP per capita income and/or foreign direct investment inflows. In our results, FDI inflows are attracted by green logistics operations and environmental friendly policies implemented by regulatory authorities. In similar track, Ga et al. (2011) confirmed that green manufacturing and green logistics activities are significant contributors in healthier economic growth in European Union countries (Giovanni and Esposito 2012) as FDI inflows attracted by environmental friendly policies implemented by government (Zhu et al. 2007). The Chinese automobile market is contributing 20% in total GDP growth, while since the last couple of decades, Chinese governments have very strict policies to mitigate carbon emissions and encourage renewable energy sources and green practices in transportation industry. Europa (2011) highlighted that more than 10 million people are working in transport sector, which is almost 4.5% of total employment and contributed around 4.6% in gross domestic product. Zaman and Shamsuddin (2017) argue that European countries have healthier economy and strict environmental policies to enforce green logistics operations and renewable energy projects in their countries; on the other hand, green logistics also play a significant contribution in European economy development and greater foreign investment inflow. The costs of logistics in the American economy went from about 16% of the GDP (Hesse 2004) in 1980 to 10% in 2000; in USA, government have very strict environmental policies and heavy financial penalty on polluted logistics systems to encourage green energy sources and environmental friendly logistics operations.

During 1960s to 2000s, the Korea's economy has displayed two-digit annual growth by concentrating on electronics and transport sectors (Youn et al. 2013). The GDP per capita of Korea grew from $67 in 1960s to $20,000 in 2008 (Shin and Ciccantell 2009). The polluted logistics system discourages foreign investments and lower FDI inflow is the significant contributor in greater unemployment rate (Wanzala and Zhihong 2016), and due to polluted logistics activities, firm logistics operation costs are increasing in terms of heavy government taxes, import duties, and delay in custom clearance. On the other hand, government imposes heavy financial penalties to enforce environmental policies in country to protect long-term environmental sustainability (Vachon and Mao 2008). The results show that firms' poor environmental performance are closely correlated with lower FDI inflows, and polluted logistics activities may destroy firm reputation and image (Park et al. 2016; Khasnis and Nettleman 2005), which will direct effect on firm financial objectives (Laosirihongthong et al. 2013).

Conclusion

The importance of global transportation in advancing economic activities is significantly assessed and debatable topic under the logistics management process. This discussion is prolonged with the green logistics operations that are correlated with the renewable energy sources to address environmental issues that also linked with poor economic performance including customers' centric demand and high-tech industry pollution. This research explores the interrelationship between green logistics operations, renewable energy sources, and economic and environmental indicators during the period of 1981 to 2016 in the context of UK.

The study employed ARDL method in order to estimate short-run and long-run association between endogenous and exogenous variables. In the short run, the results show that the green logistics operations have statistically significant and positive association with renewable energy, while fossil fuel consumption is significantly and negatively correlated with green logistics operations. In the long run, results of ARDL show that renewable energy and economic activities including FDI inflows have statistically significant and positive impact on green logistics performance, while total greenhouse gas and fossil fuel are negatively correlated with green logistics performance. Therefore, in long-run ARDL results, our hypotheses (H1, H2, and H3) were accepted at the different level of confidence.

The results indicate that renewable energy sources are positively correlated with green logistics performance, while renewable energy also plays significant role to mitigate harmful effect on the environment, while foreign investments are attracted by government commitments towards implementation of environmental friendly policies in logistics and business activities. On the other hand, the results show that fossil fuel consumption and total greenhouse gases are statistically and negatively correlated with green logistics performance, while fossil fuel and TGHG are not only reason of

environmental degradation but also incur huge costs in the logistics systems in terms of heavy taxes and import duties, limited opportunities to export in European market due to polluted goods, heavy financial penalties imposed by regulatory authorities, and polluted logistics systems that also build negative image of the firms.

The green logistics policies are required to promote renewable energy sources and green practices in logistics operations to mitigate problems of environmental sustainability. The main contribution of this study is to build an eco-friendly mode, which is well aligned with logistics performance in the context of UK. The study used TGHGs, FDI inflows, RECs, and per capita income with the global logistics performance. The research findings are helpful in building green logistics policies which are helpful to protect environmental sustainability in order to reduce CO_2, GHG emissions, and global warming issues for pollution-free environment. The green logistics is representing global competitive war of healthier economy with less pollution. The regulatory authorities have significant power to enforce environmental friendly policies in order to reduce emissions and global warming which seriously damaged to the global natural flora and fauna, while eco-friendly policies are prerequisite to promote green practices in logistics and business operations. This significant discussion has drawn short-term and long-term policy implications.

Policy implications

The "green logistics operations" is correlated with business and supply chain processes, which cover product planning to product execution. The logistics activities are heavily dependent on energy demand to complete their task efficiently; therefore, the logisticians and policy makers required comprehensive knowledge of biofuel, cleaner and greener energy sources which are significantly reducing harmful effect of logistics activities on the environment. On the other hand, governments need to play aggressive role to impose environmental friendly laws; the policies should be made to reduce environmental degradation by the adoption of renewable energy sources, reduction in the freight transport charges, sustainable product life cycle, and tax impositions and also provide healthy subsides to encourage renewable energy and green practices.

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