



GREEN SUPPLY CHAIN PERFORMANCE AND ENVIRONMENTAL SUSTAINABILITY: A PANEL STUDY

Syed Abdul Rehman Khan¹, Yu Zhang², Solomon Nathaniel³

1) Singhua University, Beijing, **China**, 2) Chang'an University, Xi'an, **China**, 3) University of Lagos, Akoka, **Nigeria**

ABSTRACT. Background: The objective of this research is to identify the relationship between green logistics operations, national economic and environmental indicators in a panel of 42 selected global ranked logistics countries over the period from 2007 to 2018. The study aims to expand the domain of green logistics from the micro/firm level to the macro level.

Methods: This research paper has used a summary OLS (Ordinary Least Squares) method to test hypotheses. From 2007 to 2018, data panels for 42 countries were downloaded from the World Bank website.

Results: The findings of this study indicate that in selected panel countries, the green logistics business has a positive and statistically significant relationship with foreign direct investment inflows, renewable energy consumption, and energy demand. On the other hand, there is a significant negative correlation between CO₂ emissions and green logistics. In addition, foreign direct investment and renewable energy are the driving factors of the green logistics business and also promote environmental sustainability.

Conclusions: This research paper provides insights into the relationship between green logistics operations and economic and environmental sustainability. In addition, the scope of this research paper is much broader than previously published research papers, in which researchers discovered the relationship between green logistics and corporate performance. However, this research paper focuses on the macro level to understand the link between green logistics and national size indicators.

Key words: Green Supply chain management; Environmental sustainability; CO₂ emissions; Green logistics operations; Renewable energy sources

INTRODUCTION

Logistics management is an integrated part of supply chain management. Global logistics activities can pose a significant threat to the environment in terms of GHG (greenhouse gases), CO₂ emissions, hazardous and toxic chemicals [Ai et al. 2015, Gruner, Power 2017]. The concept of green logistics management (GLM) is considered as an environmental innovation [Qureshi et al. 2016]. The primary objective of green logistics is to minimize the harmful effect of logistics and supply chain activities on the environment, mainly related to CO₂ emissions and

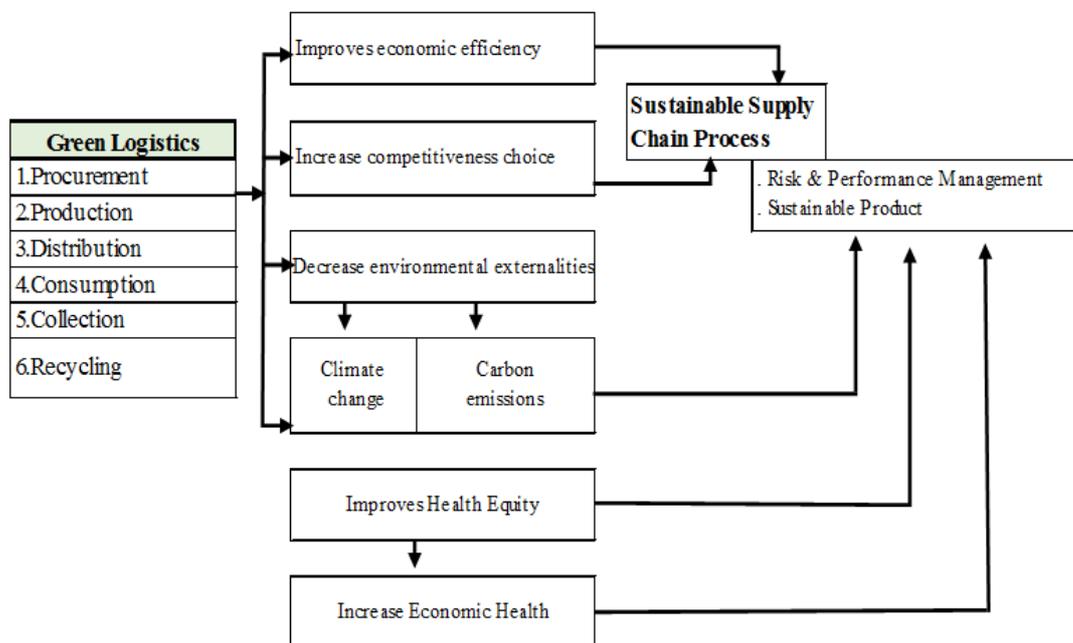
greenhouse gas emissions and therefore build a sustainable balance between environmental, social and economic objectives [Dekker et al. 2012, Ceranic et al. 2017]. In the mid-1990s, the concept of green logistics management broadly realized by practitioners and industry experts. Undeniably, logistics activities are a significant contributor to environmental pollution, including greenhouse gas emissions, global warming, climate change, and CO₂ emissions. Khan et al. [2017] Conducted empirical work to analyze the relationship between green logistics and national economic indicators. The results revealed that manufacturing value-added and per capita income are affected by GHG and CO₂

emissions. Today's customers are more aware as compared to before regarding green products, and governmental authorities are more aggressive to implement green policies.

The European Commission EUROPA [2011 and 2017] report confirms that transport is the main cause of air pollution in terms of burning fossil fuels and energy. It is undeniable that nearly 10 million people are related to transportation-related industries, accounting for about 5% of total employment and contributing 4.6% of GDP. The main goal of the transport master plan adopted in 2016 and the subsequent railway reform is to provide a sustainable and stable roadmap for future investments. In European countries, the energy consumption of the transportation industry is decreasing, and the transportation energy intensity in 2014 and 2015 was 0.94 and 0.83, respectively. In the European country's 2020 strategy, Romania has performed well in renewable energy, national greenhouse gas emissions, and energy efficiency, while the renewable energy share was 24.7% in 2015. Romania has achieved the

2020 renewable energy target. On the other hand, Europe is firmly committed to economic decarbonization and the reduction of harmful emissions. European companies hold about 40% of global renewable energy technology patents [EUROPA 2017].

The concept of green logistics and transportation offers European countries the potential to gain a competitive advantage from competitors. Simão et al. [2016] confirmed that green logistics strategies can improve logistics performance while playing an important role in reducing carbon dioxide emissions from transportation activities. Vachon and Mao [2008] studied the green supply chain, and the results showed that the practice of green supply chain can not only improve the environmental performance but also improve the economic performance of enterprises. Zaman and Shamsuddin [2017] conducted a study on green logistics, and the results showed that logistics indicators are closely related to industry added value, energy prices and trade openness, which has inspired green supply chain management in the region.



Source: Zaman and Shamsuddin, 2017

Fig. 1. Relationship between green logistics, environmental and economic factors

Green logistics is an environmentally responsible concept that involves not only freight logistics [Abrams et al. In 2017,

Chunguang et al. [2008], but also covers reverse logistics, including waste recycling, energy recycling, remanufacturing and

landfills. Maritime [2016] investigated the impact of green management activities on customer satisfaction and long-term positioning. Researchers collected data from 214 companies and used structural equation modeling techniques to test the hypothesis. The results show that effective green practices can significantly increase customer satisfaction and promote repeat purchases. Zhu et al. [2008] The relationship between the adoption of GSCM (Green Supply Chain Management) practice and management support by Chinese enterprises was studied. They found that there was a significant positive correlation between management support and the approval of green practices after controlling for the effects of marketing, cost pressures, supplier and business size. The importance of green logistics across European countries is desirable for competing their goods in international markets and provides opportunities for green strategies that encourage improved economic and environmental performance in the region [Colicchia et al. 2017]. The relationship between green logistics and environmental, economic, and social factors can be explained using Figure 1.

In previous research, green logistics practices have been widely discussed at the company level. However, this research will provide a clear picture of green logistics at a macro level. In addition, this study will help discover the relationship between national economic indicators, including foreign direct investment (FDI), energy consumption, CO₂ emissions, greenhouse gas and renewable energy consumption, and green logistics performance. The rest of the research paper is structured as follows. Section 2 provides a literature review and assumptions. The third part discusses research methods. The fourth part discusses the analysis and results. The study concludes with a discussion of the results, policy analysis and conclusions.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

It is undeniable that green logistics is one of the key sub-components of green supply chain management because green supply chain management is the result of adopting different

green practices, including green logistics, green manufacturing and green procurement [Zailani et al. 2012]. In the past few decades, green logistics has been affected by market competition, globalization and meeting customer needs [Isaksson et al. 2011]. The following sections provide detailed literature reviews.

The relationship between energy demand and green logistics

The relationship between energy demand and green logistics has been widely discussed in the supply chain and logistics management processes [Zhu et al. 2008, Zaman et al. In 2017, Khan, Dong 2017, Zaman et al. 2016], and green practices in logistics activities require renewable energy to reduce carbon emissions, the negative impact of greenhouse gases and climate change on the environment, and promote the development of green products [Zaman et al. In 2016, Khan et al. 2018]. Anable et al [2012] argued that transport activities include longer Congestion during delivery consumes more energy for logistics activities. Iakovou et al. [2010] concluded that waste biomass is an appropriate solution to minimize dependence on fossil fuel energy. However, the cost of waste biomass utilization is a major burden on the company's financial statements for logistics activities. Mraïhi and Abid [2013] believe that the relationship between economic activities and the energy used in transportation is one of the important relationships, and the energy use in the transportation sector should be fully studied.

The close connection between the logistics business and economic growth shows that the logistics and transportation sectors play a vital role in economic growth and transportation activities that are heavily dependent on fossil fuels and energy consumption [Khan et al. 2019]. In many European countries, including Germany, France, and the Netherlands, regulators have adopted strict environmental policies to stop pollution activities and encourage renewable energy and green logistics practices. Bhattacharya and others. [2016] The study found the impact of renewable energy consumption on economic growth. The results show that renewable

energy consumption has a positive impact on economic and environmental performance. In addition, Bhattacharya et al. [2016] suggest that governments and international cooperation agencies must work together to promote the use of renewable energy and green logistics investment to achieve better environmental sustainability.

Limanond et al. [2011] studied the situation in Thailand. The research results show that the higher demand for energy in the transportation industry has a positive correlation with economic growth. Khan et al. [2016] emphasized that renewable energy and green practices can improve the financial performance of businesses. In addition, the use of renewable energy has not only improved the company's performance but also established a good market image and reputation. Li and Zhang [2016] believe that energy demand is an important contributor to the logistics industry, helping to save energy and ease energy pressure. Khan et al. [2017] conducted an empirical study, and the results confirmed that the logistics business consumes more electricity and more energy demand has led to increased value-added activities in the industry and increased economic performance of the country. Based on the above research, we propose the following hypotheses:

H1: The energy demand is positively associated with logistics performance

H2: Renewable energy consumption is positively correlated with green logistics performance

The relationship between economic growth and green logistics

Green logistics is closely related to economic growth because green logistics improve financial performance and eliminates waste by reducing costs. In addition, green processes, green product design, and green procurement management under supply chain and logistics management processes help companies adjust their economic performance [Min, Galle 1997, Zhang, Zhao 2012]. Zaman and Shamsuddin, [2017] conducted a study of 15 selected panel countries, and the results showed that green supply chain management

can improve FDI inflows and reduce harmful effects on environmental sustainability. Hansen and Rand [2006] Foreign direct investment plays a vital role in healthier economic performance. The results confirm that foreign direct investment inflows have a positive and significant relationship with the country's economic growth. Bengoa and Sanchez-Robles [2003] studied 18 Latin American countries. They used panel data from 1970 to 1999, and the results showed that green supply chain operations have established a positive image for the country and attracted foreign investors. Khan et al. [2017] argued that the industry's manufacturing share of GDP was affected by CO₂ emissions and greenhouse gas emissions. Logistics performance encourages sector value-added and national economic growth.

On the other hand, the green logistics business has increased the inflow of foreign direct investment and the consumption of renewable energy [Khan et al. 2019]. Shahbaz et al. [2014] discovered a long-term relationship between air pollution, energy intensity and national economic growth in African countries. The research results show that energy has a positive correlation with carbon dioxide emissions, and the use of biofuels and renewable energy can improve environmental sustainability. In addition, biofuels and renewable energy are cheap compared to fossil fuels.

The increase in foreign direct investment has contributed significantly to China's economic growth [Wei et al., 2015]. The country is the world's second-largest recipient of foreign direct investment, which brings knowledge, capital and new management skills. Lu et al. [2010] conducted an empirical study to discover the relationship between green logistics performance and foreign direct investment (FDI) inflows. The results confirm that there is a positive correlation between sustainable logistics operations and increased foreign direct investment (FDI) inflows.

In addition, green logistics not only enhances and encourages renewable energy but also improves the economic performance of countries by increasing foreign direct investment and GDP per capita. Wanzala and

Zhihong [2016] inefficient and polluted logistics systems discourage investment and generate significant costs in end-to-end supply chain systems, such as higher import duties, expensive storage, and delays in customs clearance due to contaminated materials, Reduce exports and foreign direct investment inflows.

On the other hand, green logistics not only attracted foreign investors and more foreign direct investment inflows but also increased export opportunities and occupied new markets on the international stage. The literature cited above highlights the need for countries to establish sustainable green logistics systems to encourage green economies and transport policies to promote healthier foreign direct investment inflows. The study assumes:

H3: The green logistics performance is positively correlated with foreign direct investment

The relationship between environment and green logistics performance

Without proper policies for logistics operations, logistics and transportation activities will primarily impair environmental sustainability [Zaman, Shamsuddin 2017]. The flow of reverse logistics to environmentally friendly logistics will be minimized by reducing carbon emissions by implementing green supply chain processes and proposing measures, and by taking environmentally friendly steps in business and transportation activities to achieve "environmental sustainability". Implementation [Van-Hoek 1999]. Several studies were conducted to discover the correlation between environmental performance and logistics performance. Hayami and so on. [2015] believes that due to the dramatic increase in carbon dioxide emissions due to logistics and production activities, the government has failed to implement environmental protection policies to limit or reduce carbon emissions. Similarly, Boin, Kelle, and Whybark [2010] warn that we need to be prepared for ecological disasters due to the ever-increasing emissions of carbon dioxide and greenhouse gases. Wiebe, J. [2014] highlighted sustainability issues and explained that the

main issue is not what people are doing. However, how they work, for example, if companies use renewable energy to produce products, they can not only save the environment but also reduce costs and improve logistics performance.

Nakamichi et al. [2016] estimate the total carbon emissions of each shipment, including transportation and production processes in Thailand. The findings show that placing manufacturing plants close to consumers can significantly reduce carbon dioxide emissions. The company uses global procurement as a competitive advantage, and because of the long delivery time and the long distance between customers/importers and suppliers, vehicles emit more carbon dioxide, which not only increases the considerable cost of the logistics system but also adversely affects the effect on the environment. In short, carbon emissions are negatively related to logistics performance. Dangelico and Pontrandolfo [2013] confirmed that the company's financial performance is positively related to green practices and that CO₂ emissions are not only negatively related to environmental performance but also negatively related to the company's financial performance. In addition, researchers believe that the use of renewable energy and better utilization of by-products may be the most appropriate options for reducing the cost of logistics systems and improving financial performance. Fang Yang [2016] emphasized that green practices in logistics and supply chain operations are positively related to business performance.

The main goal of adopting green practices in logistics operations is to reduce "footprint and CO₂ emissions", but due to the implementation of environmental practices, companies may achieve higher financial performance [Esenduran et al. 2019, Aldakhil and others. 2018, Khan, Dong 2017, Khan et al. 2016]. Colicchia et al. [2016], the two companies have a better reputation, have established a good image with green practices, and have established environmental cooperation relationships with their supply chain partners. [Simão et al. [2016] Delay strategies can improve logistics performance and minimize carbon emissions from transportation activities by reducing total order

delivery time. The findings of Hahn et al. [2010] show that many times, companies are under pressure from regulators and customers to adopt green practices or implement reverse logistics in their logistics systems, even if such green practices may have an impact on their financial goals. It has a negative impact and is huge. Investment in green logistics systems and the cost of staff training may shrink the company's financial performance [Walley, Whitehead 1994]. However, in the long run, green investment is positively related to the environmental and financial performance of companies [Zhu et al. In 2008, Kenneth and others. 2012]. Zailani et al. [2012] claim that adopting environmentally friendly practices in logistics systems can improve company performance, while eco-designed products and practices can significantly reduce carbon dioxide and greenhouse gas emissions through the use of renewable energy.

The above-cited studies show that the need for green and environmentally friendly practices in logistics activities; therefore, it is desirable to reduce environmental concerns in logistics operations for healthier green logistics performance. The study hypothesizes that

H4: The environmental concerns in logistics operations are positively correlated with green logistics performance.

METHODOLOGY

The study found the relationship between green logistics operations, energy demand, environmental and economic factors in a group of 42 globally ranked logistics countries. There is no doubt that energy is a key factor for supporters of logistics operations and economic activities. On the other hand, in the absence of environmentally friendly practices, environmental and economic factors are negatively related to global logistics operations. The main purpose of this research is to link logistics operations with energy needs, environmental and economic factors. Table 1 shows the definition of the structure.

Table 1. Definition of Constructs

Constructs	Definitions
GLP (green logistics performance)	The logistics green practices have been adopted by the regulatory authority to reduce emissions, while GLP has been calculated by efficiency of customs clearance process to reduce carbon emissions, Quality of trade and transport-related infrastructure, and competence and quality of logistics services with minimum possible emissions.
FDI (foreign direct investment)	Foreign direct investment inflows is a leading indicator of handsome economic activities.
REC	REC is the renewable energy (% of total final energy consumptions) used and prompted by the government for protecting environment.
Energy	Energy is the energy consumption (Kg of oil equivalent per capita) in logistics operations.
CO2	CO2 is the carbon emissions (metric tons per capita) emits through logistics systems, which does harm to environmental sustainability.

The equation given below will be used to estimate the factors green logistics under a panel of 42 selected global ranked logistics countries, i.e.,

$$GLP_{it} = \beta_0 + FDI_{it}\beta_F + CO2_{it}\beta_C + Energy_{it}\beta_E + REC_{it}\beta_R + \varepsilon_{it} \quad (1)$$

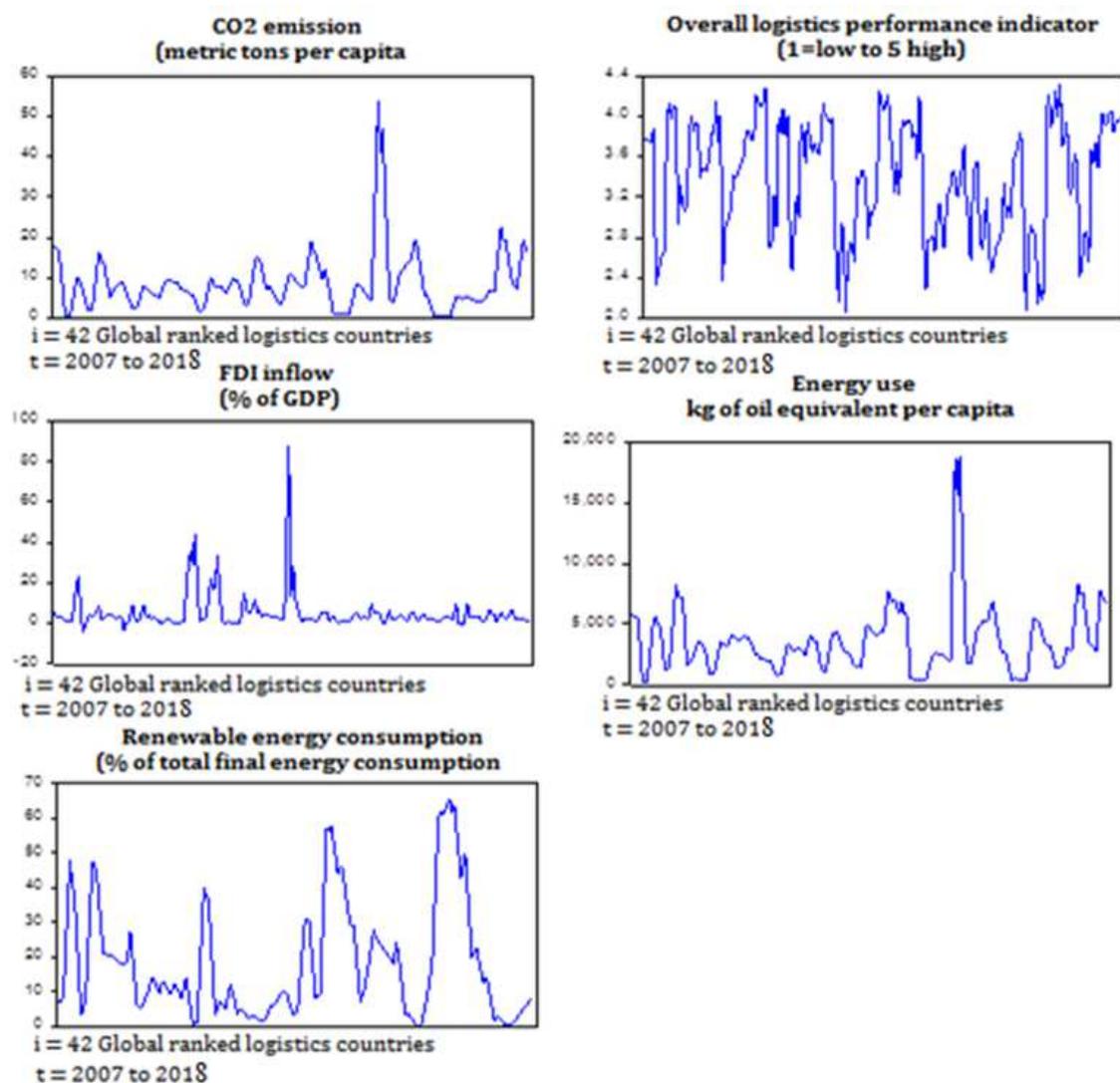
where, GLP indicates overall green logistics performance; FDI indicates foreign direct investment net inflow; CO₂ shows the CO₂ carbon emissions metric tons per capita; Energy indicates GDP per unit of energy use; REC indicates the renewable energy consumption (% of total final energy consumption).

The primary objective of this research is to find the effect of explanatory variables (energy demand, foreign direct investment, renewable energy consumption, and CO₂ emissions) on logistics performance, so Pooled OLS (ordinary least square) estimator is used to test the research hypothesis. Pooled OLS is the most effective and suitable statistical method when data is stationary on level [Vachon, Mao 2008]. The research selected a panel of 42 countries namely, Australia (AUS), Belgium (BEL), Bangladesh (BGD), Brazil (BRA), China (CHN), Canada (CAN), Denmark (DNK), European Union (EUU), Egypt Arab Republic (EGY), France (FRA), Germany (DEU), Greece (GRC), Hong Kong (HKG),

Ireland (IRL), Indonesia (IDN), Italy (ITA), Jordan (JOR), Japan (JPN), Kazakhstan (KAZ), Malaysia (MYS), Mexico (MEX), New Zealand (NZL), Netherlands (NLD), Norway (NOR), North America (NAC), Philippines (PHL), Portugal (PRT), Poland (POL), Pakistan (PAK), Qatar (QAT), Russian Federation (RUS), Sri Lanka (LKA), Saudi Arabia (SAU), Spain (ESP), Switzerland (CHE), Sweden (SWE), Sudan (SDN), Turkey (TUR), United Arab Emirates (ARE), Ukraine (UKR), United Kingdom (GBR), United States (USA) for the period of 2007 to 2016 for

robust inferences. Figure 2 shows the plots of level data for ready reference.

The study used CO₂ emissions in metric tons per capita as an environmental factor; Energy demand variables include renewable energy use (REC) in the percentage of total energy consumption and GDP per unit of energy use (Energy), while foreign direct investment net inflow % of GDP use as an economic health indicator. The data has been downloaded directly from World Development Indicators, which is officially published by World Bank [2016].



Source: World Bank, 2016

Fig. 2. Graph of level data

ANALYSIS AND RESULTS

Table 2 lists descriptive statistics for endogenous and exogenous variables. The table shows that all selected variables have positive averages and have significant distribution peaks, indicating strong logistical support for 42 selected globally ranked logistics countries with healthier economic policies.

It is undeniable that higher positive averages of energy demand and CO₂ will harm environmental sustainability, and REC (Renewable Energy Consumption) can reduce the harmful effects of logistics operations. In addition, foreign direct investment inflows are attracted by green logistics operations and environmental protection policies implemented by regulators in various countries.

Table 2. Descriptive Statistics

	GLP	FDI inflow	Energy	CO2	REC
Mean	3.363691	5.562496	3330.214	7.753668	17.89986
Median	3.470000	3.040327	3062.361	7.240367	10.09366
Maximum	4.320000	87.44259	8343.109	22.56662	65.72482
Minimum	2.050000	-3.679174	173.5810	0.301083	0.008264
Std. Dev.	0.590638	9.789309	2121.857	5.202639	17.76116
Skewness	-0.418048	5.432041	0.509697	0.742526	1.196345
Kurtosis	2.028300	41.63141	2.422557	2.952168	3.325628

Table 3. Correlation Matrix

	GLP	FDI inflow	Energy	CO2	REC
GLP	1.000000				
FDI inflow	0.239731	1.000000			
Energy	0.571393	0.077207	1.000000		
CO2	0.420421	0.078731	0.811122	1.000000	
REC	0.276257	0.236142	-0.349946	-0.536392	1.000000

Table 3 gives the correlation matrix. It is found that environmental factors such as CO₂ emissions, energy demand, and renewable energy consumption are positively correlated with logistics performance indicators. The logistics business is an important factor in emissions and energy consumption, but the consumption of renewable energy is on the rise, and many developed and developing countries are transitioning to renewable energy.

inflows are directly proportional to renewable energy, as REC (Renewable Energy Consumption) is the first step towards green production and logistics operations, and REC attracts foreign investors. It provides the opportunity to invest in a country, which is a positive signal for green logistics performance and economic health.

Foreign direct investment (FDI) inflows are positively correlated with the logistics performance index. This means that inflows of foreign direct investment are attracted by environmental protection policies in business and logistics activities. Energy efficiency is positively related to FDI inflows and logistics performance. With the increase of renewable energy consumption and the reduction of carbon dioxide emissions, CO₂ emissions are negatively related to renewable energy consumption, which is a positive signal for a healthy and environmentally friendly logistics operation. Finally, foreign direct investment

Before applying the combined OLS statistical method, we need to confirm that all endogenous and exogenous variables are stable at a level that meets the prerequisites of the combined OLS method. Table 4 shows the unit root test by considering three different standards, including the Levin, Lin & Chu test, ADF-Fisher test, and PP-Fisher test. The results of the unit root test confirm that all variables are stable at the level.

After fulfilling the essential parametric assumptions, OLS statistical method was used to determine: what is the magnitude of the relationship between endogenous (green logistics performance) and exogenous variables (FDI inflow, Energy, CO₂ emissions,

and REC); and how much exogenous variables individually contribute to estimating green logistics performance. Table 5 shows

hypothesis testing through the pooled OLS method.

Table 4. Unit root tests

Variables	Levin, Lin & Chu Test		ADF- Fisher Test		PP- Fisher Test	
	At level		At level		At level	
	T-statistics	Prob.	T-statistics	Prob.	T-statistics	Prob.
GLP	-19.4131	0.0000	137.015	0.0001	215.51	0.0000
FDI inflow	-4.18247	0.0000	246.761	0.0000	285.08	0.0000
Energy	-6.09683	0.0000	181.213	0.0000	214.176	0.0000
CO2	-7.8911	0.0000	185.775	0.0000	216.141	0.0000
REC	3.45838	0.0315	71.7959	0.0431	84.0082	0.0324

Table 5. Hypotheses Testing for Green Logistics Performance

Hypothesis	Variable	Coefficient	Std. Error	t-Statistic	Prob.	Remarks
	(Constant)	3.101546	0.117147	26.47564	0.000	
H1	Energy	0.000374	0.000491	7.625093	0.000	Supported
H2	REC	0.009785	0.002943	3.325409	0.001	Supported
H3	FDI inflow	0.008634	0.004145	2.083032	0.039	Supported
H4	CO2 emissions	-0.110549	0.022258	-4.966705	0.000	Supported

a. Dependent variable: Green logistics performance (F = 44.087, <0.001; Adjusted R = 59.6%)

The co-efficient of parameter estimates suggest the 'Energy' (.00037, $p < 0.01$), 'REC' (.00975, $p < 0.01$), 'FDI inflow' (.0086, $p < 0.05$) reflect a statistically significant and positive impact on green logistics performance. On the other hand, 'CO₂ emissions' (-0.1105, $p < 0.01$) has indicated a significantly negative impact on green logistics performance. Therefore, our hypothesis (H1, H2, and H3) was accepted at the 0.01 confidence level, while hypothesis (H4) was accepted at the 0.05 confidence level, respectively. The results of pooled OLS analysis show that exogenous variables, including Energy, REC, and FDI inflow, have a statistically significant and positive relationship with green logistics performance, while CO₂ is negatively correlated with green logistics performance.

DISCUSSION

The research results show that energy is the most important and important factor. At a confidence level of 0.01, the driving force of logistics operation and energy is positively and significantly related to logistics performance. Similarly, Anable et al. [2012] and Shahbaz et al. [2014] also show that energy is the foundation of economic growth, economic activities are heavily dependent on logistics and supply chain operations, and energy has

a significant negative impact on environmental sustainability. It can be minimized by using renewable and green energy. Qureshi et al. [2016] conducted an empirical study, and the results showed that economic growth and energy demand have a strong relationship in developed countries in the world. On the other hand, which countries are suffering from energy shortages, their economic growth has been extended, and because of energy shortages, logistics and manufacturing cannot make a significant contribution to economic growth.

Energy demand shows positive signs of economic growth in developed countries, and reducing the impact of energy on sustainability, renewable energy, and clean energy is an appropriate choice to continue economic growth through logistics and supply chain operations. Bhattacharya and others. [2016] The results show that green energy is the best solution for green development. Without government support to promote clean technologies in logistics operations, green energy cannot be implemented. Zaman et al. [2016] A study of BRICS countries has shown that energy demand in developed countries is increasing. In the Chinese context, governments and regulators are working to improve their sustainable development image through the use of cleaner technologies, green

and renewable energy [Zhu et al., 2008; Abdul et al., 2017]. In developed countries, renewable and green energy consumption is more flammable than in less developed countries, and one reason is that the government encourages governments and regulators in terms of tax exemptions and subsidies [Vance et al., 2015, Khan et al. 2019, Bhattacharya et al. , 2016, Bai, 2019, Abdul, Khan 2017]. Logistics operations and production activities are key factors for economic growth in any country, and countries using green logistics and sustainable logistics operations can reduce general energy consumption and increase operational efficiency by using green practices [Grekova et al. , 2014]. Research by Vance et al. [2015] confirms that the use of natural gas, renewable energy and green energy to generate electricity can significantly reduce costs by about 17%, and also plays an important decisive role in improving environmental sustainability and logistics operations effect.

Renewable energy plays an important role in implementing green practices, and REC (Renewable Energy) is the first step to achieving sustainable or green logistics business in the country. The results show that with a confidence level of 0.01, the performance of renewable energy and green logistics activities is positively correlated and significantly correlated. Parajuli et al. [2015] emphasized that biofuels can be part of green and clean energy, while countries engaged in biofuels and / or renewable green energy have healthier economic growth and improved sustainable logistics performance. Lee et al. [2015] conducted research and confirmed that the Chinese government and enterprises are working to adopt renewable energy to achieve a sustainable environment and healthier economic growth. On a similar track, Bhattacharya et al. [2016] A group study of 38 selected countries has shown that energy planners, governments and regulators should work together to encourage the use of renewable energy in production and logistics operations to achieve sustainable environmental growth.

Some developed countries are using 100% of clean energy procurement, including Denmark and Ireland, and their economic growth is more sustainable due to the higher

performance of green logistics operations. In the energy sector and in the fight against climate change, the use of biofuels and jatropha oil is encouraging a viable alternative to fossil fuels [Jingura 2011]. The key advantage of biofuels is the reduction of greenhouse gas and carbon dioxide emissions. Compared to renewable energy systems, fossil fuels are expensive. Renewable energy provides locally available energy and also reduces the cost of buying fossil fuels. Renewable energy can not only deal with climate change but also improve the performance of green logistics [Zawaydeh 2017]. Abbasi and Nilsson [2016] explained that logistics activities have many negative effects on environmental sustainability. Because many countries still rely on non-renewable energy sources; severe adverse effects on climate change, air pollution, and people's health.

On the other hand, Abbasi and Nilsson [2016] insist that the use of green practices in logistics operations is inconclusive and that renewable energy is not used in production and logistics activities. The green development of logistics requires action to bring the greatest social and economic benefits without neglecting environmental issues. Egilmez and Park [2014] concluded that manufacturing and logistics are the main causes of air pollution, CO₂ emissions, greenhouse gases, and climate change, and these environmental issues can be addressed through green practices, such as the use of renewable energy. Zaman and Shamsuddin, [2017] The sustainable development of logistics business require renewable energy to reduce carbon dioxide emissions and improve PM 2.5 (fine particulate matter) air quality, and the green logistics business has also made a significant positive contribution to the country's economic development. increase.

Foreign direct investment inflows are a measure of healthier economic growth and business-friendly policies, while green practices in logistics and business activities have attracted foreign investors. In developed countries, FDI inflows are high due to environmentally friendly practices and strategies adopted by regulators. Our research shows that the inflow of foreign direct

investment has a statistically positive correlation and significance with green logistics countries (confidence of 0.05). It is undeniable that carbon dioxide emissions, greenhouse gas emissions, and climate change have become global issues, and governments and business sectors are facing pressure from the international community, customers, and the United Nations (United Nations) to adopt green practices to reduce the harmful effects on the environment. Impact in manufacturing and logistics operations. Zaman and Shamsuddin, [2017] studied the performance of green logistics in European countries, and the results confirmed that foreign direct investment (FDI), industrial added value and energy have a positive and strong relationship with the generation of green logistics business. Wanzala and Zhihong [2016], non-green logistics systems have a negative correlation with national economic growth and are not conducive to foreign direct investment. In addition, unsustainable logistics will also incur heavy costs in the end-to-end supply chain, including heavy import duties and delays in customs clearance due to contaminated materials. On the other hand, the contaminated logistics system is also facing huge pressure from the government and customers, including severe punishment, bad reputation, and resistance to products from polluted enterprises [Khan, Qianli 2017].

Governments and regulators have implemented environmentally friendly policies to improve the country's image on the international stage, and in addition to pressure from local communities, they have also become incentives to adopt green practices in logistics systems [Taylor et al. 2014]. Zhao et al. [2008] conducted a study on the relationship between policy and green growth and found that environmental enforcement can be improved through vigorous enforcement by regulators. The main reasons for companies to participate in environmentally friendly policies include government policies, the degradation of the life-threatening global ecosystem, and pressure from customers [Li et al. 2016]. In addition, some monetary benefits also encourage companies to participate in green logistics operations, including improving their image and reputation in the international market, and reducing the cost of recycling,

remufacturing, and reusing technologies [Nurjanni et al., 2016]. HC's Chandan [2015] discusses how to build a company to focus its CS (Corporate Sustainability) work on environmental, social and financial aspects in line with the ten principles of the United Nations Global Compact in four key areas: the environment, Labor standards, anti-corruption, and human rights. The results confirm that green logistics business can reduce costs, increase pricing opportunities, and improve corporate image on the international stage. In addition, the government plays an important role in implementing environmental policies in promoting green practices in logistics and supply chain operations, and the adoption of higher green practices in logistics activities has not only attracted inflows of foreign direct investment [Pearson 2013, Forte Wait. 2017, Schaltegger, Synnestvedt 2002], but also provide more export opportunities for international markets [Abdul, Khan, 2017]. The company's sustainability provides a net present value benefit, but its marginal utility continues to decline until it reaches the optimal level of economic performance [Schaltegger, Wagner 2006, Park et al. 2016].

Higher CO₂ emissions and GHG (greenhouse gas) emissions are factors that represent poor environmental performance. The results show that in selected logistics countries with global confidence of 0.01, CO₂ emissions are significantly negatively correlated with green logistics performance. This result is also supported by other studies, including Dangelico and Pontrandolfo, [2013] confirming that the financial performance of enterprises is negatively correlated with higher CO₂ emissions and that larger amounts of CO₂ emissions not only impede the implementation of green logistics operations but Negative impact on the environment. The impact on the company's image and the considerable cost to the logistics system in terms of large consumption of fossil fuels, delays in customs clearance and heavy import duties due to contaminated materials. K. H. Lee and Wu [2014] Logistics activities are important factors that cause CO₂ emissions and greenhouse gases. In order to reduce the negative impact of logistics activities, companies need to use renewable energy in logistics activities to keep the environment

clean and green. The Intergovernmental Panel on Climate Change (IPCC) confirmed that greenhouse gas emissions from industrial and logistics operations accounted for 21% and 14%, respectively [Wang et al. 2015]. Higher emissions are due to global logistics activities and longer lead times, and the harmful effects of carbon dioxide and greenhouse gases can be reduced by adopting green practices in logistics operations.

Similarly, Nakamichi et al. [2016] Long lead times between shippers and consignees result in higher CO₂ emissions. Further researchers suggest that placing manufacturing plants close to customers can reduce emissions while reducing the overall cost of the system and have a positive impact on environmental sustainability. CO₂ emissions and greenhouse gases are negatively related to ecological sustainability.

It is undeniable that many countries have failed to control pollution problems, undermining the country's environmental sustainability and economic growth [Nakamichi et al. 2016]. On the other hand, commercial activities and logistics activities have a strong positive relationship. If regulators fail to implement green practices in logistics operations, in other words, they will not be able to bring inflows of FDI and economic growth [Hayami et al. 2015]. Manufacturing and logistics activities are burning fossil fuels in large quantities and producing pollution, including nitrogen oxides, sulfur dioxide, volatile organic compounds and particulate matter [Silva, Zhu 2009, 2011]. The pollution spread to residential areas with storms and watercourses. It can cause serious health problems, including asthma attacks, weakened lung function, pneumonia, bronchitis, and various types of cancer. [Kawamoto 2008, Memon 2010]. Climate change is severely affected by global logistics activities and freight, as an increase in the number of vehicles means an increase in global greenhouse gas and carbon dioxide emissions, while the links between foreign direct investment, trade, and sustainable logistics activities have made economic profits and greatly increased Reduced carbon dioxide and greenhouse gas emissions. Adverse effects on the environment [Brooks 2008, Meyer et al.

2007]. Khan et al. [2017] A study of 15 globally ranked logistics countries shows that per capita income, manufacturing, and green logistics activities are severely affected by higher CO₂ and greenhouse gas emissions, while foreign direct investment (FDI) Inflows for regional sustainability [Zaman, Shamsuddin 2017, Khan et al. 2017]. In addition, the Causality Association has confirmed that more renewable energy demand will lead to higher performance of green logistics activities and positive economic growth in various countries. In addition, green logistics and supply chain operations have significantly improved energy efficiency, FDI inflows, sector and economic growth in selected countries [Khan et al. 2017].

CONCLUSIVE REMARKS

Long-term and sustainable logistics policies are needed to encourage green products to reduce the harmful effects of carbon dioxide and greenhouse gas emissions through environmentally friendly logistics practices. The key contribution of this research is to establish an environmentally friendly model that is highly consistent with the logistics operations and performance of 42 globally ranked logistics countries. The study used carbon dioxide emissions, FDI (foreign direct investment) inflows, energy demand, and renewable energy, all of which have logistics operations performance worldwide. In addition, the study found that inflows of foreign direct investment, renewable energy, and lower carbon dioxide emissions have had a positive impact on the green logistics operations of selected country groups. The study uses the collective least squares (OLS) (ordinary least squares) method to discover the impact of economic indicators on green logistics performance, and carbon dioxide emissions are negatively related to sustainable logistics performance. This problem can be solved by using renewable energy. To reduce the negative impact on environmental sustainability, FDI is also encouraged to flow into the country. These findings will help shape long-term green logistics policies to help conserve natural resources and address environmental issues, including higher carbon dioxide, greenhouse gas emissions, climate

change, and global warming for a clean and green environment.

Green logistics operations performance measures the efficiency and commitment of countries to sustainable environmental and healthier economic development policies. In addition, the green logistics business also represents a healthy global financial competition for ecologically sustainable development. Government agencies can protect natural resources, reduce carbon emissions and control global warming and climate change. By adopting green initiatives in logistics and freight, this could severely disrupt natural flora and fauna around the world. A sound sustainable policy is a prerequisite for encouraging development. Green practices in global logistics operations and freight transportation will help achieve each country's sustainable growth agenda.

The study also has some limitations. For example, we only covered 42 globally ranked logistics countries from 2007 to 2016. However, future researchers may also conduct research in the EU, BRICS and SAARC countries to check whether this model has negative or positive effects. In this study, we only include exogenous variables (renewable energy, CO₂ emissions, foreign direct investment inflows, and energy demand) in the four countries' economies and the environment. However, future researchers may include more exogenous variables in the model, including industry value-added, manufacturing value-added, political stability, and research and development expenditure to study the relationship with green logistics performance.

POLICY ANALYSIS

The study confirms that energy demand, economic health, and environmental sustainability are closely related to environmentally friendly logistics operations in selected country groups. Studies show that green logistics performance improves energy efficiency, renewable energy consumption, economic growth, and foreign direct investment inflows while reducing carbon dioxide emissions, greenhouse gas emissions, and mitigating issues related to climate change.

On the same track, renewable energy has an important and positive relationship with the green logistics business, attracting foreign investors and promoting economic growth. In short, the government needs to promote renewable energy in a country to promote environmentally friendly practices in logistics and manufacturing operations to increase economic growth and inflows of foreign direct investment.

Global logistics business consumes a lot of electricity, which is also an important factor causing CO₂ emissions, and a country's polluted environment will discourage foreign investors and create non-tariff barriers for local companies to export to the international market. On the other hand, the polluted logistics system still faces several problems, and it must bear heavy taxes in the entire logistics system. The government has imposed fines on domestic and foreign ports due to polluted logistics operations, a negative image of the company, and the country's Negative Effects. The international community. The relationship between logistics indicators and economic and environmental sustainability clearly demonstrates that eco-friendly logistics operations will greatly improve renewable energy utilization and healthier economic activities, including improving foreign direct investment inflows into the region. Promote environmental sustainability.

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ROZWÓJ ZRÓWNOWAŻONY W ZIELONYM ŁAŃCUCHU DOSTAW: STUDIUM PANELOWE

STRESZCZENIE. Wstęp: Celem pracy jest zidentyfikowanie zależności pomiędzy operacjami zielonej logistyki wskaźnikami ekonomicznymi i ekologicznymi w oparciu o panel 42 wybranych krajów z globalnego rankingu logistycznej w okresie od 2007 do 2018. Badanie to w szczególności rozszerza domenę zielonej logistyki z poziomu mikro czy poszczególnych przedsiębiorstw do skali makro.

Metody: W celu testowania hipotez zastosowano metodę OLS (najmniejszych kwadratów). Dane dotyczące wybranych 42 krajów zostały pobrane ze strony internetowej Banku Światowego dla okresu od 2007 do 2018.

Wyniki: Uzyskane wyniki pokazują statystycznie istotną i pozytywną współzależność z bezpośrednimi zagranicznymi inwestycjami, konsumpcją energii odnawialnej oraz popytem na energię w analizowanych krajach. Z drugiej strony emisja CO₂ oraz zielona logistyka są istotnie negatywnie ze sobą skorelowane. Dodatkowo, FDI oraz źródła energii odnawialnej są kluczowymi czynnikami wspomagającymi operacje zielonej logistyki, która prowadzi do zrównoważonego rozwoju pod względem ekologicznym.

Wnioski: Prezentowana praca daje wgląd w zależności pomiędzy operacjami zielonej logistyki a ekonomicznym i ekologicznym rozwojem zrównoważonym. Dodatkowo, praca ta ma znacznie szerszy zakres niż wcześniejsze prace dotyczące tej tematyki, w których to zostały przedstawione zależności pomiędzy zieloną logistyką a działalnością firmy. Prezentowana praca skupia się na poziomie makro w celu uchwycenia zależności pomiędzy zieloną logistyką a wskaźnikami na poziomie krajowym.

Słowa kluczowe: zarządzanie zielonym łańcuchem dostaw, rozwój zrównoważony, emisja CO₂, operacje zielonej logistyki, źródła energii odnawialnej

Syed Abdul Rehman Khan
School of Economics and Management
Singhua University, Beijing, **China**
e-mail: Khan_syed@sem.tsinghua.edu.cn

Yu Zhang
School of Economics and Management
Chang'an University, Xi'an, **China**
e-mail: Zhangyu19@foxmail.com

Solomon Nathaniel
University of Lagos, Akoka, **Nigeria**
e-mail: nathaniel_solomon21@yahoo.com