Print ISSN: 1738-3110 / Online ISSN 2093-7717
http://dx.doi.org/10.15722/jds.18.1.202001.71

How do Energy Consumption, Economic Growth and Logistics Development Interrelate?*

Yugang HE**

Received: November 06, 2019 Revised: November 30, 2019 Accepted: January 05, 2020

Abstract

Purpose: Because the energy consumption, economic growth and logistics development are still the heated topics which have attracted many scholars' interests. Therefore, this paper attempts to analyze the effect of logistics development on the economic growth, explore the effect of the economic growth on energy consumption and to discuss the effect of the logistics development on energy intensity. **Research design, data and methodology:** Using the panel data over the period 2000-2017 of 156 countries and employing the country & year fixed effect model, system generalized method moments and random effect model, the empirical analyses of this propositions are performed. **Results:** The empirical findings present that the logistics development is positively related to the economic growth. The energy consumption in the t-1 period and economic growth are positively related to the current energy consumption. The logistics development is negatively related to the energy intensity. Meanwhile, the empirical findings also indicate that there is a great difference about these effects among the four sub-samples (low income 18 countries, low middle income 49 countries, upper middle income 44 countries, high income 49 countries). **Conclusions:** Based on the evidences in this paper provided, we can find that these variables can affect each other.

Keywords: Energy Consumption, Economic Growth, Logistics Development, Country & Year Fixed Effect Model, System Generalized Method Moments

JEL Classification Code: C33, F40, L19, O13

1. Introduction

It is reported that the logistics industry and the energy industry have become a foundation of the national economic development. Meanwhile, the degree of their development also has become one of the most important symbols to measure a country's modernization and comprehensive national strength. At present, the contradiction between the demand and supply of energy resources is increasingly prominent due to the rapid economic development. Moreover, the gap between energy consumption and economic growth is also increasing. Therefore, how to balance the relationship between energy consumption and economic growth is quite meaningful for the operation of the whole society. As for the logistics development, it requires a lot of energy consumption. But the development of logistics industry can deepen and refine the division of labor, and completely transform the production process, which can reduce the production & circulation costs and save energy consumption. More importantly, the logistics development can bring about the knowledge transfer and technological progress, which can accelerate the technological innovation and industrial upgrading, so as to improve energy efficiency.

In fact, the energy consumption, economic growth and logistics development interact and influence each other. The intrinsic influence mechanism among three of them still needs to be investigated. For example, Yang, Zhang and Chen (2009) apply the cointegration technique to discuss the relationship among the regional logistics, energy consumption and economic growth. Using China's 30 provinces' data over the period 1991-2007 to perform the empirical analyses, they find that there is a long-term relationship among three of them. Cao and Zhao (2015) study the same proposition. Using the panel data over the period 1999-2013 and employing econometric approaches

*This work was supported by the research grant of the KODISA Scholarship Foundation in 2020
**First Author, Doctoral Student, Department of International Trade, Jeonbuk National University, South Korea,
Email: 1293647581@jbnu.ac.kr

to conduct the empirical analyses, they find that the regional logistics development, economic growth and energy consumption can affect each other.

The purpose of this paper reflects in four aspects. The first is that we try to explore the impact of the economic growth on logistics development. The second is that we attempt to unearth the impact of the economic growth on energy consumption. The third is that we are going to exploit the impact of the logistics development on energy intensity. The fourth is that we will excavate the differences among these four sub-samples. Employing the country & year fixed effect model, system generalized method moments and random effect model to perform the empirical analyses, we find that the logistics development is positively related to the economic growth; the energy consumption in the t-1 period and GDP per capita are positively related to the energy consumption in the current period; the logistics development is negatively related to the energy intensity. Meanwhile, we also find that there is a significant difference among these four sub-samples (low income 18 countries, low middle income 49 countries, upper middle income 44 countries, high income 49 countries).

The contribution of this paper embodies into two ways. Firstly, we adopt three baseline models to explore the relationship among economic growth, energy consumption and logistics development. Meanwhile, we also enlarge the number of countries which are up to 156 countries. Secondly, due to the unbalanced economic development around the world, according to the income standard of the world bank, we split the world into four sub-samples. This behavior can explore the regional differences among these four sub-samples. At the same time, this process also can be regarded as a robustness test to reconfirm the relationship among these variables.

The rest structure of this paper will be shown as follows: Chapter two analyzes the previous researches about this proposition. Chapter three presents the variables and model specification. Chapter four exhibits the discussions and findings. Chapter five draws the conclusion and provides the corresponding suggestions.

2. Literature Review

A great quantity of attention has been paid to the issue about the relationship among energy consumption, economic growth and logistics development. Due to some limitations such as the differences in samples, methodologies and time spans, those conclusions they drew are quite different.

Taking the relationship between logistics development and economic growth into consideration, Wenjie (2002) attempts to explore the relationship between regional economic development and modern logistics with sample of China. He finds that there is a long-run relationship between regional economic development and modern logistics. Said differently, the national economic growth can promote the development of modern logistics. Meanwhile, the development of modern logistics can also change the regional economic growth patterns. Ying and Lunning (2008) employ the panel unit test and panel cointegration analyses to search for the relationship between regional logistics and regional economic growth. Setting China's 30 provinces' data over the period 1978-2006 as sample, they find that the regional logistics and regional economic growth are cointegrated in the long run. And the regional logistics promote the economic growth. Liu (2009) uses the Grey related analysis method to examine the relationship between logistics industry development and economic growth with a sample of China.

He finds that the total employment of logistics industry, logistics industry value added, freight volume, new fixed assets investment and eight turnover are positively related to the economic growth. Wang (2010) tries to investigate the impact of the logistics on regional economic growth. Using the Granger causality test and logistics model to conduct the empirical analyses, he finds that regional logistics has a positive effect on economic growth. Chu (2012) uses a panel data approach to exploit the relationship between logistics and economic growth. Employing the data from China's 30 provinces over the period 1998-2007 to fulfil the empirical analyses under the conditional convergence model and system generalized method moments. He finds that the logistics development has a greater contribution to the undeveloped interior provinces when comparing with that of coastal provinces. Kuzu and Önder (2014) treat Turkey as an example to search for the long-run relationship between economic growth and logistics development. Using a lot of econometric methods such the unit root tests and Granger causality test to perform the empirical analyses, they find that the logistics development and economic growth are cointegrated.

Meanwhile, they also find that the Granger causality runs from logistics development to economic growth. Zaman and Shamsuddin (2017) select the 27 European countries as a sample to discuss the relationship between green logistics and national scale economic indicators. Using the time period over 2007-2014 to perform the empirical analyses, their results identify that the logistics performance can significantly increase the per capita income. Munim and Schramm (2018) take 91 countries as a research object to explore the impact of the logistics performance on economic growth. Via the empirical analyses based on a structural equation model, they find that a better logistics performance can lead to a higher economic growth.

In view of the relationship between economic growth and energy consumption, Aqeel and Butt (2001) apply the Granger causality to investigate the causal relationship between economic growth and energy consumption. They find that the economic growth can lead to the energy consumption. Lee and Chang (2007) examine the relationship between economic growth and energy consumption based on a linear and nonlinear effect with a sample of Taiwan province of China over the period 1995-2003. Their findings indicate that there is an inverse U-shape between energy consumption and economic growth. Akinlo (2008) uses the Granger causality test to test the causal relationship between economic growth and energy consumption with a sample of eleven countries in sub-Saharan Africa. He finds that the economic growth Granger is a factor to affect the energy consumption in Sudan and Zimbabwe. Zeng (2011) uses the Cobb-Douglas production function to explain the inner relationship between energy consumption and economic growth with a sample of China. He finds that both of them moves in the same direction.

Ocal and Aslan (2013) treat Turkey as an example to discuss the nexus between renewable energy consumption and economic growth. They also find that a unidirectional causality runs from the economic growth to the renewable energy consumption. Li (2013) uses the revised Diamond model to verify the impact of the economic growth on energy consumption. Employing the panel data over the period 1995-2008 to perform empirical analyses, he finds that 1% increase in the GDP per capita will lead to 0.372% increase in the energy consumption. Bhattacharya, Paramati, Ozturk and Bhattacharya (2016) investigate the relationship between economic growth and renewable energy consumption with top 38 countries. With the panel empirical analyses over the period 1991-2012, they find that there is a long-run dynamics between both of them.

To sum up, the existing researches on the relationship among energy consumption, economic growth and logistics development have attracted considerable attention in the academic and theoretical circles. Because the logistics industry as a large system integration only occurs in the past decade, which is restricted by the availability and reliability of data, some empirical studies still have obvious defects. Therefore, in this paper, the panel data with 156 countries over the period 2000-2017 is employed to explore the relationship among these variables. Due to the unbalanced development of regional economy, we divide the full sample into four sub-samples (low income 18 countries, low middle income 49 countries, upper middle income 44 countries, high income 49 countries) to re-estimate the relationship among these variables. This performance can not only explore the regional differences among these four sub-samples, but also can be regarded as a robustness test to reconfirm the relationship among these variables.

3. Variables and Model Specification

3.1. Variables

To explore how the energy consumption, economic growth and logistics development interrelate, five variables (energy consumption, economic growth, logistics development, GDP per capita and energy intensity) are adopted in this paper. The description of these variables is shown as follows.

Energy Consumption: It refers to the energy consumed in production and everyday life. Energy consumption is a significant indicator of a country's economic development and people's living standards. The more energy consumption is, the greater the GDP and the richer the society will be. In this paper, the energy consumption will be measured by the total energy consumption.

Economic Growth: It usually refers to the continuous increase of a country's output or income level over a long time span. The level of economic growth rate reflects the growth rate of a country or region's economic aggregate in a certain period of time, and it is also a sign to measure the growth rate of a country or region's overall economic strength. In this paper, the economic growth will be measured by the GDP.

Logistics Development: It refers to the whole process of planning, implementation and management of semi-finished products, raw materials, finished products and related information from the origin of goods to the consumption place of goods so as to meet the needs of customers at the lowest cost, via the transportation, storage, distribution and other means. It is also a system to control the raw materials, manufactured goods, finished products and information. Meanwhile, it is a physical movement from the beginning of supply to the end consumers through the transfer and ownership of various intermediate links so as to achieve the clear objectives of the organization. Modern logistics is the product of economic globalization and an important service industry to promote the economic globalization. In this paper, the logistics development will be measured by the freight turnover.

Energy Intensity: It refers to measuring the energy comprehensive utilization efficiency of different economies, and also to comparing the dependence of economic development of different economies on energy. In this paper, the energy intensity will be measured by the ratio of energy consumption to output.

GDP Per Capita: It is a useful tool for people to understand and grasp the macroeconomic operation of a country or region. As an indicator in development economics, it is one of the most important macroeconomic indicators. In this paper, the GDP per capita will be measured by the growth rate of ratio of the GDP to population.

Moreover, all these data over the period 2000-2017 are collected from the World Bank Open Data. Our sample includes one full sample (156 countries) and four sub-samples [(low income 18 countries), (low middle income 49 countries), (upper middle income 44 countries) and (high income 47 countries)].

3.2. Model Specification

The 21st century is an era of logistics and energy globalization. Their roles in the whole society have become more and more significant. It is this point that has stimulated many experts in related fields to study the relationship among energy consumption, economic growth and logistics development using different models. In this paper, we build up three baseline models to explore the relationship among economic growth, energy consumption and logistics development. The first baseline model will be used to exploit the effect of the logistics development on economic growth. The second baseline model will be employed to analyze the effect of the energy consumption on economic growth. The third baseline model will be utilized to discuss the effect of energy intensity on logistics development.

3.2.1. First Baseline Model

Using a panel data approach, Chu (2012) employs China's 30 provincial data over the period 1998-2007 to investigate the effect of logistics on the economic growth. He finds that the logistics development is positively related to the economic growth. Lean, Huang and Hong (2014) use the joint short and long-term causality test to explore the relationship between logistics and economic growth with a sample of China. They find that the logistics is a factor to affect the economic growth. Based on these previous foundations, the baseline model is built up as follows:

$$gdp_{i,t} = a_0 + a_1 \log istics_{i,t} + \eta_t^f + v_i^f + \mu_{i,t}^f \tag{1}$$

Where i stands for the country; t stands for the year; gdp stands for the growth rate of the GDP; $\log istics$ stands for the growth rate of the freight turnover; a_0 stands for the constant; a_1 stands for the coefficient of the growth rate of the freight turnover and it is greater than zero; Superscript f stands for the first baseline model; η stands for the year effect; v stands for the country effect; μ stands for the white noise.

3.2.2. Second Baseline Model

Employing the time series, Asafu-Adjaye (2000) regards the Asian developing countries as a sample to discuss the relationship between energy consumption and economic growth (GDP per capita). He finds that the economic growth is a factor to affect the energy consumption. Mehrara (2007) use 11 countries as an example to explore the relationship between energy consumption and economic growth. He finds the same conclusion.Using China's provincial data over the period 1999-2013, Cao and Zhao (2015) analyze the effect of the economic growth (GDP per capita) on the energy consumption. Surprisingly, they find that the energy consumption in t-1 period is positively related to the energy consumption in t period. Furthermore, they also find the economic growth is also positively related to the energy consumption. Based on these previous foundations, the baseline model is built up as follows:

$$energy_{i,t} = \beta_0 + \beta_1 energy_{i,t-1} + \beta_2 gdpper_{i,t} + \mu_{i,t}^s \tag{2}$$

Where $energy$ stands for the growth rate of total energy consumption. $gdpper$ stands for the growth rate of GDP per capita; β_0 stands for the constant; β_1 and β_2 are the coefficients of the growth rate of total energy consumption in t-1 period and the growth rate of GDP and they are greater than zero; Superscript s stands for the second baseline model.

3.2.3. Third Baseline Model

Utilizing the data over the period 1980-2010, Dai and Gao (2016) employ the LMDI approach to explore the effect of logistics development on energy intensity. They find that the logistics development is negatively related to the energy intensity. Even though with different samples, Cholette and Venkat (2009), Cao and Zhao (2015) also draw the same conclusions. Based on these previous foundations, the baseline model is built up as follows:

$$\text{int}\, ensity_{i,t} = \gamma_0 + \gamma_1 \log istics_{i,t} + \eta_t^t + v_i^t + \mu_{i,t}^t \tag{3}$$

Where $\text{int}\, ensity$ stands for the energy intensity; γ_0 stands for the constant; γ_1 stands for the coefficient of the logistics development and it is less than zero; Superscript t stands for the third baseline model.

4. Empirical Analyses

4.1. Basic Description

Having a preliminary understanding of the data used in this paper, the variable description is used to conduct a basic statistic. The results of variable description is shown up in <Table 1>.

<Table 1> concentrates on mean. median, minimum, maximum and standard error of these variables used in this paper. For the full sample (156 countries), the mean of the growth rate of GDP is 0.084 with a standard deviation of 0.138. The mean of the growth rate of GDP per capita is 0.069 with a standard deviation of 0.135. The mean of the growth rate of logistics is 0.002 with a standard deviation of 0.272. The mean of the growth rate of energy consumption is 0.168 with a standard deviation of 0.0.201. The mean of the energy intensity is 0.085 with a standard deviation of 0.123.

Table 1: Basic Description

Full Sample (World 156 Countries)					
Variable / Statistic	gdp	$gdpper$	$logistics$	$energy$	$intensity$
Mean	0.084	0.069	0.002	0.168	0.085
Median	0.078	0.063	0.010	0.125	0.028
Maximum	1.189	1.163	1.169	1.263	0.865
Minimum	-0.636	-0.640	-1.000	-0.579	0.000
Std. Dev.	0.138	0.135	0.272	0.201	0.123
Sub-sample One (Low Income 18 Countries)					
Variable / Statistic	gdp	$gdpper$	$logistics$	$energy$	$intensity$
Mean	0.091	0.062	-0.032	0.195	0.104
Median	0.092	0.062	-0.000	0.189	0.091
Maximum	1.037	0.988	0.969	1.094	0.374
Minimum	-0.264	-0.284	-0.998	-0.204	0.004
Std. Dev.	0.144	0.141	0.328	0.158	0.076
Sub-sample Two (Low Middle Income 49 Countries)					
Variable / Statistic	gdp	$gdpper$	$logistics$	$energy$	$intensity$
Mean	0.097	0.079	0.001	0.195	0.098
Median	0.088	0.073	0.013	0.150	0.059
Maximum	1.189	1.163	1.312	1.263	0.593
Minimum	-0.397	-0.412	-1.000	-0.278	0.002
Std. Dev.	0.143	0.141	0.313	0.201	0.113
Sub-sample Three (Upper Middle Income 44 Countries)					
Variable / Statistic	gdp	$gdpper$	$logistics$	$energy$	$intensity$
Mean	0.096	0.086	0.009	0.195	0.100
Median	0.091	0.083	0.010	0.146	0.034
Maximum	1.360	1.345	1.183	1.982	0.865
Minimum	-0.636	-0.640	-0.997	-0.579	0.001
Std. Dev.	0.159	0.159	0.284	0.229	0.138
Sub-sample Four (High Income 47 Countries)					
Variable / Statistic	gdp	$gdpper$	$logistics$	$energy$	$intensity$
Mean	0.064	0.052	0.014	0.123	0.058
Median	0.059	0.049	0.011	0.083	0.004
Maximum	0.446	0.453	1.12	0.955	0.620

For the sub-sample one (low income 18 countries), the average value of the growth rate of GDP is 0.091 with a standard deviation of 0.144. The average value of the growth rate of GDP per capita is 0.062 with a standard deviation of 0.141. The average value of the growth rate of logistics -0.032 with a standard deviation of 0.272. The average value of the growth rate of energy consumption is 0.195 with a standard deviation of 0.158. The average value of the energy intensity is 0.104 with a standard deviation of 0.076.

For the sub-sample two (low middle income 49 countries), the average value of the growth rate of GDP is 0.097 with a standard deviation of 0.143. The average value of the growth rate of GDP per capita is 0.079 with a standard deviation of 0.141. The average value of the growth rate of logistics 0.001 with a standard deviation of 0.313. The average value of the growth rate of energy consumption is 0.195 with a standard deviation of 0.201. The average value of the energy intensity is 0.098 with a standard deviation of 0.113. For the sub-sample three (upper middle income 44 countries), the average value of the growth rate of GDP is 0.096 with a standard deviation of 0.159. The average value of the growth rate of GDP per capita is 0.086 with a standard deviation of 0.0.159. The average value of the growth rate of logistics 0.009 with a standard deviation of 0.284. The average value of the growth rate of energy consumption is 0.195 with a standard deviation of 0.229. The average value of the energy intensity is 0.100 with a standard deviation of 0.138.

For the sub-sample four (high income 49 countries), the average value of the growth rate of GDP is 0.064 with a standard deviation of 0.117. The average value of the growth rate of GDP per capita is 0.052 with a standard deviation of 0.113. The average value of the growth rate of logistics 0.014 with a standard deviation of 0.241. The average value of the growth rate of energy consumption is 0.123 with a standard deviation of 0.187. The average value of the energy intensity is 0.058 with a standard deviation of 0.124.

4.2. Correlation Test

Multicollinearity problem is an important factor that seriously affects the inaccuracy of our regression results. Therefore, before our regression, we need to confirm the Multicollinearity problem among those variables used in this paper. The results exhibit in <Table 2>.

<Table 2> depicts the results of correlation test. Regarding the Gujarati as a standard, when the correlation coefficient between two variables is greater than 0.800, the serious multicolinearity problem will be existed.

Table 2: Correlation Matrix

Full Sample (World 156 Countries)					
Variable	*gdp*	*gdpper*	log*istics*	*energy*	int*ensity*
gdp	1.000 ---				
gdpper	0.590 (0.413)	1.000 ---			
log*istics*	0.106*** (0.012)	0.096 (0.065)	1.000 ---		
energy	0.479** (0.224)	0.357*** (0.135)	0.101* (0.063)	1.000 ---	
int*ensity*	0.183* (0.112)	0.129 (0.253)	0.046 (0.124)	0.439*** (0.159)	1.000 ---
Sub-sample One (Low Income 18 Countries)					
Variable	*gdp*	*gdpper*	log*istics*	*energy*	int*ensity*
gdp	1.000 ---				
gdpper	0.583 (0.448)	1.000 ---			
log*istics*	0.194*** (0.059)	0.199* (0.112)	1.000 ---		
energy	0.477 (0.362)	0.461* (0.255)	0.153 (0.136)	1.000 ---	
int*ensity*	-0.067*** (0.015)	-0.096 (0.129)	-0.049* (0.026)	0.421 (0.382)	1.000 ---
Sub-sample Twao (Low Middle Income 49 Countries)					
Variable	*gdp*	*gdpper*	log*istics*	*energy*	int*ensity*
gdp	1.000 ---				
gdpper	0.599 (0.398)	1.000 ---			
log*istics*	0.060* (0.033)	0.068 (0.045)	1.000 ---		
energy	0.436* (0.226)	0.417 (0.311)	0.074 (0.049)	1.000 ---	
int*ensity*	0.220* (0.114)	0.190** (0.092)	0.056** (0.022)	0.418** (0.165)	1.000 ---

Sub-sample Three (Upper Middle Income 44 Countries)					
Variable	*gdp*	*gdpper*	*logistics*	*energy*	*intensity*
gdp	1.000 ---				
gdpper	0.597 (0.392)	1.000 ---			
logistics	0.060*** (0.014)	0.055 (0.036)	1.000 ---		
energy	0.105 (0.117)	0.191* (0.113)	0.035 (0.215)	1.000 ---	
intensity	0.179 (0.118)	0.159** (0.068)	-0.011 (0.031)	0.528 (0.455)	1.000 ---
Sub-sample Four (High Income 47 Countries)					
Variable	*gdp*	*gdpper*	*logistics*	*energy*	*intensity*
gdp	1.000 ---				
gdpper	0.577 (0.421)	1.000 ---			
logistics	0.128** (0.062)	0.082** (0.039)	1.000 ---		
energy	0.161 (0.143)	0.167 (0.112)	0.166** (0.066)	1.000 ---	
intensity	0.205** (0.097)	0.086 (0.106)	0.130* (0.077)	0.479* (0.262)	1.000 ---

Note: * indicates the 10% significant level; ** indicates the 5% significant level; *** indicates the 1% significant level; ( ) indicates the standard error.

For the full sample (156 countries), the correlation coefficients between these variables used in this paper range from 0.046 to 0.590. For the sub-sample one (low income 18 countries), the correlation coefficients between these variables range from -0.067 to 0.583.

For the sub-sample two (low middle income 49 countries), the correlation coefficients between these variables range from 0.056 to 0.599. For the sub-sample three (upper middle income 44 countries), the correlation coefficients between these variables range from 0.035 to 0.597. For the sub-sample four (high income 49 countries), the correlation coefficients between these variables range from 0.082 to 0.577. Based on these results, it can be concluded that there is no serious multicolinearity problem in this paper.

4.3. Unit Root Test

When a series has a unit root, it means that this series is not non-stationary. If it is directly used to embed into a model to conduct the empirical analyses, this process may lead to the spurious regression. To avoid this problem, the ADF test and PP test are used to confirm whether a series is stationary or not. Based on the performance of He and Feng (2019), Yugang and Jingnan (2019), the results of ADF test and PP test are shown in <Table 3>.

<Table 3> shows the results of ADF test and PP test. It can be found that both the null hypotheses (a series has a unit root) of ADF test and PP test are rejected at 5% significant level. In other word, all variables in the full sample and four sub-samples are stationary. Then, all these variables will be used to conduct empirical estimations in the following sub-chapters.

Table 3: Results of Unit Root Test

Full Sample (World 156 countries)						
Approach	Statistics	Variable				
		gdp	*gdpper*	*logistics*	*energy*	*intensity*
ADF	t-Statistic	-9.867	-10.125	-46.742	-10.119	-9.005
	P-value	0.000	0.000	0.000	0.000	0.000
PP	Adj.t-Statistic	-43.298	-43.513	-46.742	-36.251	-11.625
	P-value	0.000	0.000	0.000	0.000	0.000
Sub-sample (Low Income 18 Countries)						
Approach	Statistics	Variable				
		gdp	*gdpper*	*logistics*	*energy*	*intensity*
ADF	t-Statistic	101.429	92.888	38.076	83.296	73.799
	P-value	0.000	0.000	0.009	0.000	0.001
PP	Adj.t-Statistic	410.736	219.677	95.832	198.855	69.497
	P-value	0.000	0.000	0.000	0.000	0.003

Sub-sample (Low Middle Income 49 Countries)						
Approach	Statistics	Variable				
		gdp	*gdpper*	log*istics*	*energy*	int*ensity*
ADF	t-Statistic	149.951	149.429	139.855	131.627	156.516
	P-value	0.000	0.000	0.000	0.000	0.000
PP	Adj.t-Statistic	262.874	262.399	287.196	228.834	165.084
	P-value	0.000	0.000	0.000	0.000	0.000
Sub-sample (Upper Middle Income 44 Countries)						
Approach	Statistics	Variable				
		gdp	*gdpper*	log*istics*	*energy*	int*ensity*
ADF	t-Statistic	199.333	199.370	164.447	176.524	188.836
	P-value	0.000	0.000	0.000	0.000	0.000
PP	Adj.t-Statistic	297.512	297.575	420.420	253.911	168.626
	P-value	0.000	0.000	0.000	0.000	0.000
Sub-sample (High Income 47 Countries)						
Approach	Statistics	Variable				
		gdp	*gdpper*	log*istics*	*energy*	int*ensity*
ADF	t-Statistic	273.269	278.873	220.443	261.364	178.227
	P-value	0.000	0.000	0.000	0.000	0.000
PP	Adj.t-Statistic	403.906	413.186	557.438	380.282	196.260
	P-value	0.000	0.000	0.000	0.000	0.000

4.4. Effect of Logistics Development on Economic Growth

Based on equation (1), we will analyze the effect of the logistics development on economic growth. Following the behaviors of Yugang and Beak-Ryul (2019), this paper use the LR test to conduct empirical analysis. It can be found that the null hypothesis (H_0: Pooled OLS) is rejected at 5% significant level. Then, we will perform the Hausman test to distinguish the random effect model and country & year fixed effect model. It can be found that the null hypothesis (H_0: random effect) is rejected at 5% significant level. Consequently, the country and year fixed effect model will be employed to explore the effect of the logistics development on economic growth. The estimated results are shown in <Table 4>.

Table 4: Results of Effect of Logistics development on Economic Growth

World (156) Countries			
Model	Model (1)	Model (2)	Model (3)
Method / Variable	Pooled OLS	Random Effect	Country and Year Fixed Effect
log*istics*	0.048*** (0.013)	0.048*** (0.013)	0.024** (0.011)
Cons	0.084*** (0.003)	0.084*** (0.003)	0.038*** (0.001)
R^2	0.289	0.288	0.333
LR Test	1074.093> 198.944		
Hausman Test		9.381	
P-Value		0.037	
Country Fixed Effect		YES	YES
Year Fixed Effect		YES	YES
Observation	2,141	2,141	2,141

Note: * indicates the 10% significant level; ** indicates the 5% significant level; *** indicates the 1% significant level; ( ) indicates the standard error.

In view of results of country & year fixed model, it can be found that the logistics development is positively related to the economic growth. Stated differently, a 1% increase in logistics development will lead to a 0.024% increase in economic growth. This result also satisfies the reality in world. Nowadays, the economic globalization provides an opportunity for the logistics development. Meanwhile, the rapid logistics development provides a solid foundation for the global economic integration. Furthermore, this result is consistent with that of Li, Jin, Qi, Shi and Ng (2018). Moreover, due to the unbalanced economic development around the world, according to the income standard of the world bank, we divide the world into four groups of countries. There are the low income countries, low middle income countries, upper middle income countries and high income countries. To identify the differences of the effect of the logistics development on economic growth among these four groups, the country and year fixed effect model will be used to re-estimate the effect of the logistics development on economic growth. The estimated results are shown in <Table 5>.

Table 5: Results of Effect of Logistics Development on Economic Growth in Sub-samples

Model	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Group	World (156) Countries	Low Income (16) Countries	Low Middle Income (49) Countries	Upper Middle Income (44) Countries	High Income (47) Countries
Method / Variable	Country and Year Fixed Effect	Country and Year Fixed Effect	Country and Year Fixed Effect	Country and Year Fixed Effect	Country and Year Fixed Effect
$\log istics$	0.024*** (0.002)	0.049*** (0.014)	0.033*** (0.006)	0.021*** (0.002)	0.012*** (0.001)
$Cons$	0.038*** (0.010)	0.029* (0.015)	0.035* (0.017)	0.042*** (0.012)	0.068*** (0.013)
R^2	0.333	0.540	0.249	3.921	0.505
Country Fixed Effect	YES	YES	YES	YES	YES
Year Fixed Effect	YES	YES	YES	YES	YES
Observation	2,141	185	569	628	774

Note: * indicates the 10% significant level; ** indicates the 5% significant level; *** indicates the 1% significant level; ( ) indicates the standard error.

<Table 5> shows the re-estimated results. Based on the values of intercept term, we can find that the values of intercept term in the high income countries and upper middle income countries are greater than that of world level. But the values of intercept term in the low income countries and low middle income countries are less that of world level. In other word, the regional differences in the role of logistics development in promoting the economic development. Because the overall development speed of the high income countries and upper middle income countries is faster than that of the low income countries and low middle income countries, it has made the economic growth rate of the high income countries and upper middle income countries higher than that of the low income countries and low middle income countries in the horizontal effect.

Referring to values of elasticity of logistics development to the economic growth, the elasticity of logistics development to the economic growth is different. Specifically speaking, a 1% increase in the logistics development will result in a 0.049 % increase in the economic growth in low income countries, a 0.33% increase in the economic growth in low income middle countries, a 0.033% increase in the economic growth in upper middle income countries, a 0.068% increase in the economic growth in high income countries. The large elasticity value in the low income countries and low middle income countries indicates that the logistics development in the low income countries and low middle income countries has a great elasticity to the economic growth. Moreover, this also means that the future logistics development has a great potential to promote the economic growth in the low income countries and low middle income countries.

4.5. Effect of the Economic Growth on Energy Consumption

Based on the equation (2), we will analyze the effect of the energy consumption in t-1 period and economic growth on energy consumption. Because of exploring the effect of the energy consumption in t-1 period on the energy consumption. The system generalized method moments will be employed to exploit the relationship between both of them. The estimated results show in <Table 6>.

<Table 6> shows the results of the effect of energy consumption on economic growth. It can be found that the energy consumption in t-1 period and economic growth is positively related to the current energy consumption. More concretely, a 1% increase in the energy consumption in t-1 period will lead to a 0.644% increase in the current energy consumption in the world level, a 0.221% increase in the current energy consumption in the low income countries, a 0.264% increase in the current energy consumption in the low middle income countries, a 0.325% increase in the current energy consumption in the upper middle income countries, a 0.465% increase in the current energy consumption in the high income countries. Meanwhile, a

1% increase in the economic growth will result in a 0.253% increase in the current energy consumption in the world level, a 0.451% increase in the current energy consumption in the low income countries, a 0.249% increase in the current energy consumption in the low middle income countries, a 0.128% increase in the current energy consumption in the upper middle income countries, a 0.119% increase in the current energy consumption in the high income countries.

As far as the comparison of the four economic groups is concerned, the effect of energy consumption in t-1 period on current energy consumption in the upper middle income countries and high income countries is greater than that of in the low middle income countries and low income countries. This indicates that the energy consumption in t-1 period of the upper middle income countries and high income countries is more flexible to the current energy consumption when compared with that of the low middle income countries and low income countries. that is, the inertia of energy consumption in the upper middle income countries and high income countries is relatively larger. In fact, this is determined by the industrial structure and resource conditions of the upper middle income countries and high income countries. The upper middle income countries and high income countries have developed industries, while the energy mainly comes from the outside of the upper middle income countries and high income countries. Therefore, it can be understood that the dependency of energy consumption is relatively greater. To sum up, the sustainable development of the upper middle income countries and high income countries needs to vigorously develop the new energy technology, to get rid of the dependency of energy consumption and to reduce the inertia of energy consumption.

Table 6: Results of Effect of the Economic Growth (GDP Per Capita) on Energy Consumption

Model	Model (8)	Model (9)	Model (10)	Model (11)	Model (12)
Group	World (156) Countries	Low Income (16) Countries	Low Middle Income (49) Countries	Upper Middle Income (44) Countries	High Income (47) Countries
Method / Variable	Country and Year Fixed Effect	Country and Year Fixed Effect	Country and Year Fixed Effect	Country and Year Fixed Effect	Country and Year Fixed Effect
$energy_{-1}$	0.644*** (0.036)	0.221*** (0.032)	0.264*** (0.036)	0.325*** (0.033)	0.465*** (0.032)
$gdpper$	0.253*** (0.046)	0.451*** (0.043)	0.249*** (0.056)	0.128*** (0.034)	0.119*** (0.038)
$Cons$	0.165*** (0.021)	0.163*** (0.061)	0.049** (0.023)	0.085*** (0.023)	0.056*** (0.011)
Sargan Test	133.597	28.921	7.045	36.876	45.832
P-Value	0.395	1.000	1.000	1.000	1.000
Hansen Test	1.448	0.180	0.439	0.967	0.974
P-Value	0.229	0.671	0.508	0.464	0.845
Observation	1,707	141	444	496	654

Note: * indicates the 10% significant level; ** indicates the 5% significant level; *** indicates the 1% significant level; Instrumental variables include constant, $gdpper_{i,t-j}$ ($j=1,2,3$). ( ) indicates the standard error.

Considering the effect of the economic growth on current energy consumption, the elasticity of the low middle income countries and low income countries is greater than that of the upper middle income countries and high income countries. The reason is that the economic growth is accompanied by a large amount of energy consumption. However, the economic growth of the low middle income countries and low income countries mainly depends on the input and use of a large number of resource-based elements. Therefore, the low middle income countries and low income countries need to optimize the industrial structure, to change the traditional mode of economic development and to achieve the industrial upgrading.

4.6. Effect of the Logistics Development on Energy Intensity

Based on the equation (3), we will exploit the effect of the logistics development on energy intensity. Employing the LR test to conduct the empirical analysis, it can be found that the null hypothesis (H_0: Pooled OLS) is rejected at 5% significant level. Then, we will perform the Hausman test to distinguish the random effect model and country and year fixed effect model. It can be found that the null hypothesis (H_0: random effect) is not rejected at 5% significant level. Therefore, the random fixed effect model will be employed to explore the effect of the logistics development on energy intensity. The estimated results are shown in <Table 7>.

<Table 7> shows the results of the effect of the logistics development on energy intensity. It can be found that the logistics development is negatively related to the energy intensity. Specifically, a 1% increase in the logistics development will lead to a 0.051% decrease in the energy intensity. As a matter of fact, the of logistics development can improve the efficiency of energy consumption so as to effectively reduce the energy intensity. Due to the unbalanced development of logistics and energy intensity in each country, we will analyze the effect of the logistics development on the energy intensity among the four sub-samples, respectively. The estimated results are shown in <Table 8>.

Table 7: Results of Effect of Logistics Development on Energy Intensity

World (156) Countries		
Model	Model (13)	Model (14)
Method / Variable	Pooled OLS	Random Effect
$\log istics$	0.018* (0.096)	-0.051*** (0.014)
Cons	0.085*** (0.003)	0.084*** (0.009)
R^2	0.216	0.288
LR Test	4730.055>198.944	
Hausman Test		0.094
P-Value		0.954
Country Fixed Effect		NO
Year Fixed Effect		NO
Observation	2,141	2,141

Note: * indicates the 10% significant level; ** indicates the 5% significant level; *** indicates the 1% significant level; ( ) indicates the standard error.

Table 8: Results of Effect of Logistics Development on Energy Intensity in Sub-samples

Model	**Model (14)**	**Model (15)**	**Model (16)**	**Model (17)**	**Model (18)**
Group	World(156) Countries	Low Income (16) Countries	Low Middle Income (49) Countries	Upper Middle Income (44) Countries	High Income (47)Countries
Method / Variable	Random Effect	Random Effect	Random Effect	Random Effect	Random Effect
$\log istics$	-0.051*** (0.014)	-0.068*** (0.023)	-0.042*** (0.012)	-0.033** (0.015)	-0.026** (0.011)
Cons	0.084*** (0.009)	0.124*** (0.020)	0.084*** (0.014)	0.098*** (0.019)	0.058*** (0.017)
R^2	0.288	0.224	0.232	0.214	0.258
Country Fixed Effect	NO	NO	NO	NO	NO
Year Fixed Effect	NO	NO	NO	NO	NO
Observation	2,141	185	569	628	774

Note: * indicates the 10% significant level; ** indicates the 5% significant level; *** indicates the 1% significant level; ( ) indicates the standard error.

<Table 8> shows the results of the effect of the logistics development on energy intensity among the four sub-samples, respectively. Based on the empirical analyses under the random effect model, we find that the logistics development is still negatively related with the energy intensity. a 1% increase in the logistics development will lead to a 0.068% decrease in the low income countries, a 1% increase in the logistics development will lead to a 0.042% decrease in the low middle income countries, a 1% increase in the logistics development will lead to a 0.033% decrease in the upper middle income countries, a 1% increase in the logistics development will lead to a 0.026% decrease in the high income countries. We also find that form the low income countries to the high income countries, the absolute elasticity value presents a decreasing trend. Therefore, to vigorously develop the modern logistics industry in the low income countries can effectively improve the energy utilization rate and significantly reduce the energy intensity.

5. Conclusions

The economic growth, energy consumption and logistics development are still the hottest issues that draw much attention from the related scholars. Therefore, this paper aims at exploring the effect of the logistics development on economic growth, to analyze the effect of the economic growth on energy consumption and to discuss the effect of the logistics development on energy intensity, respectively. Then, using the panel data over the period 2000-2017 of 156 countries and employing the country and year fixed effect model, random effect model and system generalized method moments, we perform the empirical analyses. The empirical findings are presented as follow:

Firstly, the findings indicate that the logistics development is positively related to the economic growth. Due to the regional imbalance in the logistics development, the findings also find that the obvious regional differences in the effect of the logistics development on regional economic growth exist. The relatively developed logistics industry in the upper middle income countries and high income countries makes their growth rate of GDP higher than that of the low income countries and low middle income countries in terms of horizontal effect. The economic growth in the low income countries and low middle income countries is more flexible for the logistics development, which means that the future logistics development has a great potential to promote the economic growth. Secondly, the findings present that the economic growth is positively related to the energy consumption. Meanwhile, the energy consumption in the t-1 period is also positively related to the energy consumption in the current energy consumption. For the sub-samples, because of the developed industry in the upper middle income countries and high income countries, the energy mainly comes from the outside of these countries. So, the time path of the dependence of energy consumption is large. The elasticity of energy consumption to GDP per capita in the low income countries and low middle income countries is relatively large. And the economic growth is accompanied by a large amount of energy consumption. The reason is that the low income countries and low middle income countries are still in the extensive development mode of high energy consumption, high pollution and resource dependence. And the economic growth depends on the input and use of a large number of resource-based elements. Thirdly, the findings show that the logistics development is negatively related to the energy intensity. The logistics development reduces the production & circulation costs and saves the energy consumption. Meanwhile, the logistics development is conducive to accelerating the technological innovation and industrial upgrading so as to improve the energy efficiency and effectively reduce the energy intensity. The energy utilization efficiency of the low income countries and low middle income countries is less than that of the world level, upper middle income countries and high income countries. However, the elasticity of energy intensity of the low income countries and low middle income countries to the logistics development level is greater than that of the world and the upper middle income countries and high income countries. In other words, this means that the logistics development can reduce the energy intensity on the whole, and the logistics development in the low income countries and low middle income countries will significantly reduce the energy intensity.

Based on the empirical evidence in this paper provided, we provide some related suggestions. In the upper middle income countries and high income countries, although the development of modern logistics industry is fast, the productivity level is advanced, and the economy is relatively developed, the inertia of energy consumption is relatively large, it is necessary to continuously adopt the lean logistics technology, agile logistics technology, new energy technology and green logistics technology. The elasticity of economic growth to the logistics development in the low income countries and low middle income countries is greater than that of the world, upper middle income countries and high income countries. In the future, the logistics development in the low income countries and low middle income countries will not only promote the economic growth, but also improve the energy efficiency. Therefore, the low income countries and low middle income countries need to vigorously develop the modern logistics industry, optimize the industrial structure, and change the traditional mode of economic development. For example, these countries can gradually adjust the energy structure, improve the energy utilization rate, and then reduce the energy intensity.

Of course, there are certain limitations in this paper. For instance, the data acquisition is difficult; the time span is too short. These limitations also leave a room for the upcoming scholars to re-reanalyze this proposition.

References

Akinlo, A. E. (2008). Energy consumption and economic growth: Evidence from 11 Sub-Sahara African countries. *Energy economics, 30*(5), 2391-2400. https://doi.org/10.1016/j.eneco.2008.01.008

Aqeel, A., & Butt, M. S. (2001). The relationship between energy consumption and economic growth in Pakistan. *Asia-Pacific Development Journal, 8*(2), 101-110.

Asafu-Adjaye, J. (2000). The relationship between energy consumption, energy prices and economic growth: time series evidence from Asian developing countries. *Energy economics, 22*(6), 615-625. https://doi.org/10.1016/S0140-9883(00)00050-5

Bhattacharya, M., Paramati, S. R., Ozturk, I., & Bhattacharya, S. (2016). The effect of renewable energy consumption on economic growth: Evidence from top 38 countries. *Applied Energy, 162*, 733-741. https://doi.org/10.1016/j.apenergy.2015.10.104

Cao, C. Z, & Zhao, G. H. (2015). Regional Logistics Development, Economic Growth and Energy Consumption: Provincial Data Analysis in China. *Finance and Trade Research, 26*(2), 44-52.

Cholette, S., & Venkat, K. (2009). The energy and carbon intensity of wine distribution: A study of logistical options for delivering wine to consumers. *Journal of Cleaner Production, 17*(16), 1401-1413. https://doi.org/10.1016/j.jclepro.2009.05.011

Chu, Z. (2012). Logistics and economic growth: a panel data approach. *The Annals of regional science, 49*(1), 87-102. doi: 10.1007/s00168-010-0434-0

Dai, Y., & Gao, H. O. (2016). Energy consumption in China's logistics industry: A decomposition analysis using the LMDI approach. *Transportation Research Part D: Transport and Environment, 46*, 69-80. https://doi.org/10.1016/j.trd.2016.03.003.

He, Y., & Feng, W. (2019). A Study on the Determinants of Income Distribution: Evidence from Macroeconomics. *Journal of Distribution Science, 17*(1), 21-31. http://dx.doi.org/10.15722/jds.17.01.201901.21

Kuzu, S., & Önder, E. (2014). Research into the long-run relationship between logistics development and economic growth in Turkey. *Journal of Logistics Management, 3*(1), 11-16. doi: 10.5923/j.logistics.20140301.02

Lean, H. H., Huang, W., & Hong, J. (2014). Logistics and economic development: Experience from China. *Transport Policy, 32*, 96-104. https://doi.org/10.1016/j.tranpol.2014.01.003.

Lee, C. C., & Chang, C. P. (2007). The impact of energy consumption on economic growth: Evidence from linear and nonlinear models in Taiwan. *Energy, 32*(12), 2282-2294. https://doi.org/10.1016/j.energy.2006.01.017

Li, K. X., Jin, M., Qi, G., Shi, W., & Ng, A. K. (2018). Logistics as a driving force for development under the belt and road initiative–the Chinese model for developing countries. T*ransport Reviews, 38*(4), 457-478. https://doi.org/10.1080/01441647.2017.1365276

Li, P. (2013). Energy consumption and China economic growth--Empirical analysis based on the dynamic panel data. *Economic Management Journal,12*,(1) 1-10.

Liu, S. (2009). A research on the relationship of logistics industry development and economic growth of China. *International Business Research, 2*(3), 197-200.

Mehrara, M. (2007). Energy consumption and economic growth: the case of oil exporting countries. *Energy policy, 35*(5), 2939-2945. https://doi.org/10.1016/j.enpol.2006.10.018

Munim, Z. H., & Schramm, H. J. (2018). The impacts of port infrastructure and logistics performance on economic growth: the mediating role of seaborne trade. *Journal of Shipping and Trade, 3*(1), 1-19. https://doi.org/10.1186/s41072-018-0027-0

Ocal, O., & Aslan, A. (2013). Renewable energy consumption–economic growth nexus in Turkey. *Renewable and sustainable energy reviews, 28*, 494-499. https://doi.org/10.1016/j.rser.2013.08.036

Wang, A. (2010). Research of logistics and regional economic growth. iBusiness, 2(04), 395-400.

Wenjie, Z. (2002). Regional economic development and modern logistics. *China Business and Market, 12*(1), 12-14.

Yang, Z. L., Zhang, L, & Chen, X. L. (2009). Co-integration test for regional logistics, energy consumption and economic growth. *Logistics Technology, 24*(6), 1-2. doi: 10.1061/41139(387)173

Ying, L., & Lunning, R. (2008). Empirical research on regional logistics and regional economic growth: a panel unit toot & panel cointegration analysis. *Journal of Nanchang University (Humanities and Social Sciences), 6*(3), 64-69.

Yugang, H. E., & Baek-Ryul, C. H. O. I. (2019). What Determines the Foreign Direct Investment in Finances of OECD Countries. *The International Journal of Industrial Distribution & Business, 10*(11), 15-23. doi: http://dx.doi.org/ 10.13106/ ijidb .20 19 .vol 10 .no 1 1 15

Yugang, H. E., & Jingnan, W. A. N. G. (2019). A Panel Analysis on the Cross Border E-commerce Trade: Evidence from ASEAN Countries. *The Journal of Asian Finance, Economics and Business, 6*(2), 95-104. doi:10.13106/jafeb.2019.vol6.no2.95

Zaman, K., & Shamsuddin, S. (2017). Green logistics and national scale economic indicators: Evidence from a panel of selected European countries. *Journal of cleaner production, 143*, 51-63. https://doi.org/10.1016/j.jclepro.2016.12.150

Zeng, S. (2011). Research of energy consumption, economic growth and energy demand forecast on China. *Business Review, 23*(2), 38-44.