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The Impact of Globalization on Renewable Energy Development in the Countries along the Belt and Road Based on the Moderating Effect of the Digital Economy

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Abstract: Within the context of globalization, the development of renewable energy is critical for attaining sustainable development, and the digital economy is also a critical driver for achieving it. This article incorporates globalization, renewable energy development, and the digital economy into its research framework, investigates the relationship between globalization and renewable energy development, and explores the moderating effect of the digital economy, using panel data from countries along the Belt and Road (B&R) from 2001 to 2018. It is found that globalization facilitates the development of renewable energy. The 1% increase in globalization results in a 1.06% increase in renewable energy development; the level of globalization has a significant effect on renewable energy development in high-income countries, upper-middle-income countries, and low-income countries, but not in lower-middle-income countries; the digital economy has a moderating effect on the impact of globalization on renewable energy development in countries along the B&R. Simultaneously, the effect of globalization on renewable energy development in B&R countries is influenced by the digital economy's single threshold effect, and the effect of globalization on renewable energy development is more pronounced when the level of digital economy development is less than the threshold of 0.061. The conclusions of this article have significant implications for the B&R countries' sustainable development in the contexts of globalization and the digital economy.

Keywords: globalization; digital economy; renewable energy development; the 'Belt and Road Initiative' countries

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1. Introduction

Improving the energy structure and promoting a clean energy transition have become the global consensus. In the past decade, global renewable energy consumption has maintained an average annual growth rate of 13.4% [1]. Renewable energy is being developed and used at an accelerated rate in developed countries in Europe and North America [2,3]. In 2019, the renewable energy consumption of developed countries in Europe accounted for 28.2% of that in the global world [4]. The exploitation of renewable energy in developing countries is more urgent than that in developed ones because of their rapid industrialization and urbanization, that there is a great demand and consumption of energy, and that these countries are at the end of the product supply chain and have had to accept industries transferring from developed countries with high CO_2 emissions as part of their globalization [5]. Faced with the contradiction between economic development and environmental protection, sustainable development has attracted global attention [6]. This so-called sustainable development can be articulated as the desire to meet the needs of the present without compromising the needs of future generations [7], and it is gradually becoming an emerging paradigm for economic development in both developed and developing countries [8].

China launched the 'Belt and Road Initiative' (BRI) in 2013, which covers Asia, Africa, and Europe. The BRI reaches 62% of the world's population, 30% of the GDP, and 50% of fossil fuel consumption [9]. Countries along the route are not only rich in fossil energy, but also more than half of the global energy is stored in renewable energies such as natural gas and wind [10]. In 2019, the growth rate of energy consumption in the B&R countries reached 3.57%, far higher than the global average growth rate of 1.76%. The economic growth model with a high energy consumption led to a surge in local emissions of greenhouse gases such as CO_2. Over the past 15 years, energy consumption in the B&R countries has grown by an average of 3%, which was higher than 1.38% for the world as a whole [4]. In this circumstance, the B&R countries should promote the renewable energy industry and reduce their dependence on the fossil energy [10]. However, most of the B&R countries are in the development phase and face issues such as outdated technologies and a lack of funds for renewable energy development [11]. The BRI conforms to the trend of globalization, enhances international exchanges and cooperation, and provides financial and technical support for utilizing local renewable energy [12]. As globalization continues to develop, investment in renewable energy has increased. The overall investment in renewable energy by B&R countries climbed from US $1.72 billion in 2004 to US $7.88 billion in 2017 and US $9.13 billion in 2016. Between 2004 and 2016, it invested 3% of the worldwide renewable energy investment [13]. Following the establishment of the BRI, countries along the route saw an increase in investment in renewable energy, such as in 2015 when the Industrial and Commercial Bank of China (ICBC) and China Export-Import (CEXIM) Bank contributed US $1.227968 billion to Pakistan's Suki Kinari hydropower project, accounting for the largest portion of BRI funds [13].

With the wave of globalization, the digital economy emerges and thrives, accounting for 4.5–15.5% of the global GDP, which can drive economic and social development sustainably [14]. There is some evidence that the digital economy can increase energy efficiency, reduce CO_2 emissions, and change the structure of energy consumption [15,16], but little research has been conducted on the impact of the digital economy on renewable energy development. At present, the internet-based 'Digital Silk Road' (DSR) is a critical component of the BRI, and the digital economy has been prioritized in countries along the route. These countries have enhanced digital communication infrastructure, integrated digitalization, and economic development, and have explored the application of digitalization in natural resources, such as renewable energy, to achieve low-carbon sustainable development [17].

Therefore, under such complex circumstances of increasing CO_2 emissions, globalization, and the digital economy as the new economic engine, the study of the impact of globalization and the digital economy on renewable energy development is of enormous academic and practical importance. However, we find that most of the existing studies mainly analyze the impact of globalization on the development of renewable energy, and few studies focus on whether the prosperous digital economy will affect the use of renewable energy; in addition, corresponding mechanisms and empirical analyses are also scarce. Furthermore, the research objects, such as the G7 group and OECD countries, are mainly discussed [18–20], but the developing countries in most of the world are ignored; or, in other words, their study samples and conclusions are not representative.

This research examines the impact of globalization and the digital economy on renewable energy development using data from the B&D countries. Compared to other studies, the contributions of this paper are as follows. Firstly, we combine the mechanism of globalization and the digital economy on renewable energy development, providing a regional development of renewable energy with a new perspective. Secondly, according to the status quo of these three trends and their internal logical connection, we conduct empirical research on the effect of globalization and the digital economy on the development of renewable energy. Thirdly, considering the differences in the economic development levels in the countries along the Belt and Road, the heterogeneity analysis of the impact of globalization and the digital economy on the development of renewable energy is di-

vided into four categories—low-income, lower-middle-income, upper-middle-income, and high-income countries—and further points out what causes these differences.

2. Literature Review and Research Hypothesis

2.1. Globalization and Renewable Energy

Globalization has improved the technologies in various countries [21], and more advanced technologies can be applied to energy production and consumption [22], to improve energy efficiency, reduce energy demand and exploitation costs, and achieve the targets of energy conservation and emissions reduction [23]. Omri and Nguyen [24], with Zeren and Akkuş [25], analyzed the influence of globalization on renewable energy development from the perspective of trade opening. It was discovered that increased trade opening could improve the use of renewable energy and encourage the worldwide flow of renewable energy development technologies, which is advantageous for developing countries' usage of renewable energy [26]. Meanwhile, Doytch and Narayan [27], Ji and Zhang [28], and Anton and Nucu [29], along with Caglar and Emre [30], explored the effect of globalization on renewable energy utilization based on foreign investment inflow. The increase in foreign investment inflow has improved green technology efficiency and the awareness of low-carbon promotion in developing countries [26] to enhance the use of renewable energy. However, it is not enough to quantify the impact of globalization on renewable energy from the dimensions of foreign trade openings and foreign investment, since its connotation has been broadened due to the pace of globalization. This can be testified by some studies. For instance, the impact of globalization on renewable energy was studied by Subramaniam and Masron [26], and Gozgor et al. [18], using the economic globalization index of Gygli et al. [31]. According to their findings, there is a link between globalization and renewable energy use, economic transformation, and low-carbon development. In spite of this, most previous studies have been conducted on a national scale, with just a few studies being conducted on a regional scale. That is why this present study focuses on the B&R countries as a case study in order to analyze the geographical impact of globalization on renewable energy development.

The initial hypothesis of this paper is as follows, based on the foregoing analysis:

Hypothesis 1 (H1): *The B&R countries can promote their renewable energy development in the globalization process.*

2.2. Globalization, Digital Economy, and Renewable Energy Development

The digital economy, a new economic form, has permeated every corner of economic life, provided information technology services for energy, construction, transportation, agriculture, and other industries, reduced CO_2 emissions, and has exerted the most significant impact on the energy industry [32]. The digital economy development can improve energy efficiency, promote sector reforms, and reduce the demand for energy. Yet, economic growth and its associated activities, such as the emergence of new industries, have increased energy consumption, making it impossible to decouple economic growth from energy demand [33]. The digital economy has moved its attention from fossil fuels to renewable energy in the energy sector as the concept of green and sustainable development has gained traction [34]. The digital economy mainly affects renewable energy through digital technology. In their research on Green Information Technologies, Zacharoula [35] found that the progress of digital technology can provide technical support for renewable energy development, improve energy utilization efficiency, reduce energy exploitation costs, and promote energy transition. In the analysis of telecom base station construction, Ahmed, Naeem, and Iqbal [34] concluded that digitalization can provide information monitoring and early warning technology for renewable energy development with uncertainty, such as in solar energy and wind energy, and ensure the maximum output of these energy sources within the production cycle. Renewable energy is employed through electricity

in its production, consumption, and transportation, quickly confronted with problems such as power grid inefficiencies and failures. Meanwhile, in the analysis of smart grid systems, He et al. [36] found that the digital economy can promote the popularization of mini smart grid services, solve various problems in power conversion of renewable energy, and thus realize efficient use of renewable energy. With the accelerated globalization, more excellent opening to the outside world of various countries, and increased commodity trade, the trade share of digital economy products has been on the rise, stimulated technology spillovers, and penetrated countries with outdated technology, thus enhancing the utilization rate of renewable energy locally [37]. In consideration of Metcalfe's Law of the digital economy, digital technology creates non-line technology spillover effects on renewable energy development [38]. Technology spillovers can make those countries less dependent on other countries and weaken the influence of globalization on renewable energy development regionally.

The following are the paper's second and third research hypotheses, which are derived from the information presented above:

Hypothesis 2 (H2): *In the B&R countries, the digital economy has a positive effect on the development of renewable energy.*

Hypothesis 3 (H3): *Digital economy is a threshold variable for the globalization of the B&R countries to affect renewable energy development.*

In general, it appears that some studies on globalization and renewable energy have been conducted, but they primarily analyze the impact of trade opening or foreign investment on renewable energy development [24–30], or the relationship between the two at the national level [18,31], with few studies examining the impact of globalization on renewable energy development from a regional perspective in a comprehensive manner. At the same time, few studies have analyzed the impact of renewable energy development in the dual context of the digital economy and globalization, whereas the research presented in this paper combines the three into a unified framework and examines the impact of the digital economy and globalization on renewable energy development. Furthermore, most current research shows that globalization has a linear impact on renewable energy development; however, this paper finds that the impact of globalization on renewable energy development is nonlinear due to the digital economy's level of development. The related impact mechanism is shown in Figure 1.

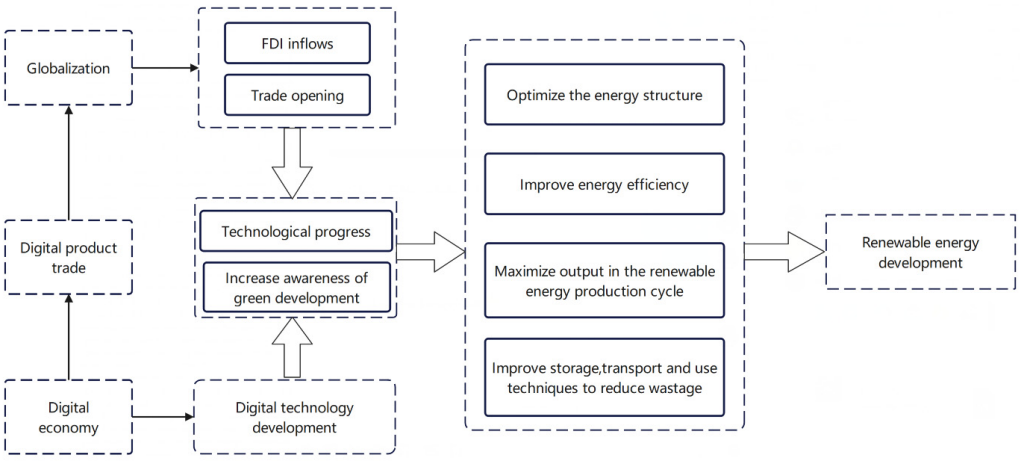

Figure 1. The mechanism of globalization and the digital economy on the development of renewable energy.

3. Model Setting and Variable Selection

We utilized panel data from 36 countries along the B&R from 2001 to 2018 to account for data availability, including Albania, Azerbaijan, Belarus, Bosnia and Herzegovina, Bulgaria, Cambodia, China, Croatia, Czech Republic, Egypt, Estonia, Georgia, Greece, Hungary, India, Indonesia, Israel, Jordan, Kazakhstan, Kyrgyz Republic, Latvia, Lithuania, Malaysia, Moldova, North Macedonia, Pakistan, Philippines, Poland, Romania, Russia, Singapore, Slovakia, Slovenia, Turkey, Ukraine, and Vietnam.

3.1. Model Setting

According to the previous discussion, this part sets the benchmark regression model for this study, and the specific form is as follows:

$$RED_{it} = \alpha_0 + \alpha_1 KOFEGI + \alpha_2 X_{it} + \varepsilon_{it} \quad (1)$$

RED_{it} depicts the renewable energy development of country i in period t, $KOFEGI_{it}$ represents the globalization level of country i in period t, X_{it} are the control variables, including per capita GDP, net inflow of foreign investment (FDI), oil price (OP), and ε_{it} the random disturbance term.

Given the moderating role of the digital economy on renewable energy development in globalization, the following model is constructed to test its regulating effect:

$$RED_{it} = \alpha_0 + \alpha_1 KOFEGI_{it} + \alpha_2 DE_i t + \alpha_3 DE_{it} \times KOFEGI_{it} + \varepsilon_{it} \quad (2)$$

The interaction coefficient's significance can reflect whether the digital economy can moderate renewable energy development in globalization. Meanwhile, due to the interaction of the digital economy and globalization index, there may exist problems such as collinearity, which causes regression mistakes. As a result, the interaction items are thus centralized according to the research conducted by Balli and Srensen [39]. Except for the addition of the variable digital economy (DE), the variables in the model (2) are consistent with those in the model (1), and also interact with terms within the globalization index.

As previously mentioned, Metcalfe's Law affects the development of the digital economy, and there are marginal spillover effects. As a result, the article hypothesizes that the digital economy's influence on renewable energy development in globalized B&R nations is nonlinear, which is to say that as the digital economy develops, globalization introduces inconsistencies and changes to the development of renewable energy. The following threshold effect model is built referring to the research [38]:

$$RED_{it} = \alpha_0 + \alpha_1 KOFEGI_{it} \times F(DE_{it} \leq q) + \alpha_2 KOFEGI_{it} \times F(DE_{it} \geq q) + \alpha_3 X_{it} + \varepsilon_{it} \quad (3)$$

In model (3), F (*) represents the index function, q is the threshold value, and the rest of the variables are the same as those in models (1) and (2).

3.2. Variable Selection

3.2.1. Explanatory Variables

Globalization (KOFEGI): Globalization can be classified as economic globalization, political globalization, or cultural globalization. However, this paper uses economic globalization to refer to globalization by considering that the measurability of political and cultural globalization is relatively weak. Existing research mainly measures economic globalization by foreign trade volume or foreign investment. Given that economic globalization is gradually diversified, more comprehensive indicators are needed to measure globalization. This paper selects the Economic Globalization Index (EGI) issued by KOF Swiss Economic Institute to measure economic globalization [31], which contains the data of several international institutions and measures economic globalization from a more comprehensive and objective perspective.

3.2.2. Explained Variables

Renewable Energy Development (RED): the utilization of renewable energy is mainly through electricity generation, so existing studies primarily measure its development by electricity generation or renewable energy consumption. Since these two measures are unlimited data, they will increase in line with the economic expansion so they cannot measure renewable energy development accurately. In that context, this study uses the index of renewable energy consumption as a fraction of the total final energy consumption, which is more objective and accurate than the research of Bigerna et al. [40].

3.2.3. Moderating Variables

Digital economy (DE): Currently, the study on the digital economy's development level in country-specific studies usually refers to the Internet penetration rate and mobile Internet penetration rate per 100 people. Nonetheless, the connotation of the digital economy is complex, and a single variable cannot accurately measure it. As a result, this paper has established the index system of digital economy development evaluation from five aspects: ICT goods exports (% of total goods exports), Internet penetration rate, mobile cellular subscriptions (per 100 people), fixed broadband subscriptions (per 100 people), and fixed telephone subscriptions (per 100 people) by referring to the research by Junyan and Yida [41], Mitrović [42], and Godwin et al. [43], and by considering the data available. The paper also employs the improved entropy method of Li and Zhichun [44] to determine the digital economy's stage of development. In this regard, the study provides a complete and impartial assessment of the digital economy's progress in the B&R countries. The index system of digital economy development evaluation in the B&R countries is shown in Table 1.

Table 1. Digital economy development evaluation index system of the B&D countries.

Variable	Indicator Composition	Attributes
Digital Economy (DE)	ICT goods exports (% of total goods exports)	+
	Internet penetration rate (%)	+
	Mobile cellular subscriptions (per 100 people)	+
	Fixed broadband subscriptions (per 100 people)	+
	Fixed telephone subscriptions (per 100 people)	+

Note: + represents positive effect.

3.2.4. Control Variables

To analyze the influence of globalization and the digital economy on renewable energy development in the B&R countries more comprehensively, this paper takes GDP per capita (GDPC) at constant (2015) prices, and net foreign direct investment (FDI) inflows as a share of the GDP and the oil price (OP) at constant 2020 US dollars as the primary control variables by referring to the research of Gozgor et al. [18].

The descriptive statistical critical variables in this paper are shown in Table 2, including the globalization index (KOFEGI), digital economy (DE), renewable energy development (RED), GDP per capita (GDPC), foreign investment inflow (FDI), and oil price (OP). In terms of the average, the largest is GDP per capita, followed by oil price, the globalization index, renewable energy development, net foreign investment inflows, and the digital economy. In terms of variance, GDP per capita has the largest variance, which indicates to a certain extent that the economic growth of the selected 36 countries along the B&R is quite different, followed by oil price, the globalization index, renewable energy development, foreign investment inflow, and the digital economy.

Table 2. Descriptive statistical results of variables.

Variables	Obs.	Mean	Std.dev	Min	Max
KOFEGI	648	64.663	12.739	31.604	94.629
DE	648	0.263	0.172	0.001	0.717
RED	648	19.404	16.220	0.473	83.022
GDPC	648	9091.526	9600.018	514.854	61,056.584
FDI	648	5.172	6.792	−40.330	55.070
OP	648	66.622	28.687	24.440	111.670

3.3. Data Sources

The economic globalization index is from KOF Swiss Economic Institute, the oil price is from BP [1], and other data is from the Development Indicators Databank of the World Bank.

4. Empirical Results

Through the Hausman Test, it was found that the influence of different countries and times on renewable energy development cannot be ignored in the process of model setting. Therefore, all of the subsequent studies were controlled in terms of the time effect and individual effect. To facilitate the analysis, all the indicators were standardized before regression due to the differences of each unit.

4.1. The Direct Impact of Globalization on Renewable Energy Development

The benchmark regression analysis is given in Table 3, column 1, and demonstrates that globalization has a beneficial influence on the development of renewable energy in B&R countries, statistically significant at the 1% level. Renewable energy development will grow by 0.095% at the local level for every 1% increase in globalization. After integrating different control variables, one can see that the influence of globalization on renewable energy development locally has not diminished but has steadily risen, as seen in columns 2, 3, and 4 of Table 3. When per capita GDP, foreign investment inflow, and oil price are controlled, the renewable energy development at the local level will increase by 1.06% for every 1% increase in the level of globalization, which is about 10% higher than that in column 1. Hence, the research Hypothesis H1 is proved. This result is in line with the studies of Gozgor et al. [18], Subramaniam, and Masron [26].

Table 3. Baseline regression results.

Explanatory Variables	(1)	(2)	(3)	(4)
	RED	RED	RED	RED
KOFEGI	0.095 ***	0.098 ***	0.106 ***	0.106 ***
	(2.653)	(2.754)	(3.018)	(3.018)
GDPC		0.199 **	0.208 **	0.208 **
		(2.417)	(2.56)	(2.560)
FDI			−0.154 ***	−0.154 ***
			(−4.098)	(−4.098)
OP				−0.096 ***
				(−2.709)
_ cons	0.199 ***	0.178 ***	0.245 ***	0.245 ***
	(10.872)	(8.739)	(9.448)	(9.448)
Observations	648	648	648	648

Note: The values in parentheses are T-values, *** represents $p < 0.01$, ** represents $p < 0.05$.

Per capita GDP, foreign investment, and oil price all have a significant influence on renewable energy development locally. A 1% increase in per capita GDP will result in a 0.2% increase in renewable energy development, indicating that economic growth is conducive to renewable energy development. With economic development and enhancing

people's awareness of environmental protection, the B&R countries will enhance renewable energy use to reduce carbon emissions and improve sustainable economic and social development to achieve the purpose of green development [45]. However, the foreign investment inflow and rising oil prices have hurt renewable energy development in those countries. According to the 'Pollution Haven Hypothesis', foreign investors generally transfer domestic industries with more significant pollution to other countries [46], and in a short period, foreign investment mainly flows into industries such as the service industry or mining industry, not industries such as the renewable energy industry [47]; as a result, foreign investment may not have had a favorable impact on renewable energy when we conducted our study. The B&R countries are some of the most significant energy exporters reigning globally, as they contain more fossil energy sources such as oil and gas. The increase in oil prices will drive oil importers to explore renewable energy and look for energy alternatives. However, as for the energy exporters, intensified exploitation of fossil energy to increase local incomes will adversely affect renewable energy development in these countries [48].

In descriptive statistics, per capita GDP has the most significant standard deviation, which implies that the economic development among the B&R countries is quite different. Countries at varying levels of development may have specific disparities in terms of the influence of renewable energy in their globalization. The relevant heterogeneity analysis was conducted to verify whether such a discrepancy exists.

A country's economic growth is judged concerning the resident income level published by the United Nations. Low, lower-middle, upper-middle, and high-income countries are included in this paper's selection of 36 countries along the B&R. If i is a low-income country, code = 0; if i is a lower-middle-income country, code = 1; if i is an upper-middle-income country, code = 2; if i is a high-income country, code = 3.

Due to present economic growth and energy use in lower-middle-income countries, globalization has a negligible negative influence on renewable energy development, as illustrated in Table 4. Globalization, on the other hand, has a considerable beneficial influence on low, upper-middle, and high-income countries. Countries at different economic stages have varied influence coefficients on renewable energy development in globalization. It can be found that the influence coefficient is highest in high-income countries, followed by upper-middle-income countries and low-income countries; this demonstrates that the higher economic growth, the greater the impact of globalization on renewable energy development [4].

Table 4. Benchmark regression heterogeneity test results.

Explanatory Variables	Code = 0	Code = 1	Code = 2	Code = 3
	RED	RED	RED	RED
KOFEGI	0.117 *	−0.069	0.183 ***	0.184 **
	(1.966)	(−0.805)	(2.818)	(2.56)
GDPC	−0.567 ***	−0.372 ***	−0.728 ***	−0.434 ***
	(−5.195)	(−2.917)	(−4.095)	(−4.403)
FDI	−0.018	−0.468 ***	−0.051	−0.219 *
	(−0.428)	(−5.581)	(−0.906)	(−1.682)
OP	0.323 *	−0.028	0.200 ***	0.405 ***
	(1.867)	(−0.17)	(2.733)	(5.747)
_ cons	0.659 ***	0.798 ***	0.287 ***	0.39 ***
	(28.08)	(14.759)	(7.159)	(5.19)
Observations	36	162	234	216

Note: The values in parentheses are T-values, *** represents $p < 0.01$, ** represents $p < 0.05$, * represents $p < 0.1$.

4.2. The Moderating Role of the Digital Economy in Globalization and Renewable Energy Development

The digital economy has a moderating influence on globalization and the development of renewable energy, as seen in Table 5. As can be observed, the regression coefficient for

the interaction term between the digital economy and globalization index is considered positive, indicating that digital economic growth may aid in the development of renewable energy in the globalization of B&R nations. The advancement of the digital economy has the potential to magnify the beneficial effects of globalization on renewable energy, hence supporting regional green sustainable development. As a result, the study Hypothesis H2 is established.

Table 5. Results of moderating effect.

Explanatory Variables	(1)	(2)	(3)	(4)
	RED	RED	RED	RED
KOFEGI	0.109 ***	0.109 ***	0.118 ***	0.118 ***
	(3.089)	(3.086)	(3.354)	(3.354)
DE	0.095 ***	0.095 ***	0.084 ***	0.084 ***
	(3.056)	(3.054)	(2.719)	(2.719)
DE × KOFEGI	0.773 ***	0.773 ***	0.754 ***	0.754 ***
	(10.377)	(10.043)	(9.842)	(9.842)
GDPC		0.002	0.014	0.014
		(0.030)	(0.184)	(0.184)
FDI			−0.111 ***	−0.111 ***
			(−3.201)	(−3.201)
OP				−0.122 ***
				(−3.021)
_ cons	0.145 ***	0.145 ***	0.194 ***	0.194 ***
	(8.275)	(7.655)	(7.99)	(7.99)
Observations	648	648	648	648

Note: The values in parentheses are T-values, *** represents $p < 0.01$.

A heterogeneity analysis is also carried out on the moderating effect. As shown in Table 6, the interaction coefficient between globalization and the digital economy in low-income countries is not significant. In contrast, that in lower-middle, upper-middle, and high-income countries is significantly positive at a statistical level above 5%. The results also show that the development of the digital economy in low-income countries has no moderating effect on renewable energy development in the process of local globalization, but has an obvious moderating effect on lower-middle, upper-middle, and high-income countries. The improvement of the digital economy can promote renewable energy development in the globalization process of lower-middle, upper-middle, and high-income countries along the B&R road, and has no impact on low-income countries.

Table 6. Heterogeneity test of moderating effect.

Explanatory Variables	Code = 0	Code = 1	Code = 2	Code = 3
	RED	RED	RED	RED
KOFEGI	0.099	−0.230 **	0.220 ***	0.373 ***
	(1.381)	(−2.251)	(3.707)	(5.487)
DE	0.117	0.088	0.083	−0.177 **
	(0.552)	(0.808)	(1.25)	(−2.541)
DE × KOFEGI	−0.106	0.915 **	1.232 ***	0.823 ***
	(−0.388)	(2.368)	(8.304)	(7.484)
GDPC	−0.505 ***	−0.657 ***	−0.544 ***	−0.778 ***
	(−2.758)	(−4.218)	(−3.462)	(−7.288)
FDI	−0.013	−0.385 ***	0.014	−0.093
	(−0.296)	(−4.458)	(0.278)	(−0.807)
OP	−0.060	0.105	0.188 **	0.720 ***
	(−0.078)	(0.552)	(2.32)	(6.612)
_ cons	0.660 ***	0.886 ***	0.172 ***	0.294 ***
	(24.024)	(14.85)	(4.599)	(4.11)
Observations	36	162	234	216

Note: The values in parentheses are T-values, *** represents $p < 0.01$, ** represents $p < 0.05$.

4.3. The Threshold Effect

Table 7 demonstrates that the single threshold test for the digital economy is significant at 10%, whereas the double threshold test fails at 10%, indicating that the digital economy has a single threshold effect on globalization's impact on renewable energy development. Moreover, whether the control variables are added to the corresponding threshold model, the panel threshold model rejects the null hypothesis of no threshold impact, demonstrating that the digital economy is a threshold variable for B&R countries' globalization to influence renewable energy development.

Table 7. Threshold effect test.

Threshold	RSS	MSE	Fstat	Prob	Crit10	Crit5	Crit1
Single	1.511	0.002	60.100	0.027	41.897	51.382	86.950
Double	1.460	0.002	21.690	0.313	36.618	45.092	96.627

Table 8 shows that the single threshold impact of the digital economy is 0.0611. Table 9 summarizes the findings of the threshold regression. The impact coefficient of globalization on renewable energy development is 0.283 when the digital economy is below the threshold value of 0.0611, and drops to 0.09 when the digital economy develops over the threshold value of 0.0611, but remains significant at the statistical level of 1%. The findings reveal that although globalization has always benefited renewable energy growth in B&R nations, its effect has waned as the digital economy has grown. This reveals that in the digital economy era, those countries can make technological advances in the exploitation of renewable energy, reduce their dependence on other countries, and promote their renewable energy development with the help of digital products, such as the Internet.

Table 8. Estimation of single threshold value.

Mode 1	Threshold	Lower	Upper
Threshold 1	0.0611	0.0596	0.0622

Table 9. Regression results of the threshold effect.

Threshold Effect Parameter Estimation Results	RED
GDPC	0.107 * (1.701)
FDI	−0.196 *** (−5.786)
OP	−0.005 (−0.784)
$KOFEGI_{it} \times F(DE_{it} \leq 0.0611)$	0.283 *** (6.917)
$KOFEGI_{it} \times F(DE_{it} \geq 0.0611)$	0.09 *** (2.947)
_ cons	0.257 *** (11.672)
Observations	648
R-squared	0.145

Note: The values in parentheses are T-values, *** represents $p < 0.01$, * represents $p < 0.1$.

5. Robustness Test

The digital economy involved in this paper comprises of multiple indicators, and so does the economic globalization index referring to globalization. Hence, the two variables will intersect in the process of index construction. Although the corresponding multicollinearity test shows that there is no multicollinearity, it will still have a particular impact on the empirical results of this paper. To improve the accuracy of the regression results,

the variable of the digital economy is replaced, and a robustness test is conducted. The development of the digital economy is mainly affected by Internet penetration rate (INT), so the robustness test employs it instead of the digital economy development index. As shown in Table 10, after the robustness test of replacing the digital economy with the Internet penetration rate, the relevant results are still stable, which indicates that the digital economy has a durable moderating effect on renewable energy development in the globalization process of the B&R countries and thus verifies the Hypothesis H2.

Table 10. Robustness Test-Internet Penetration Rate.

Explanatory Variables	(1)	(2)	(3)	(4)
	RED	RED	RED	RED
KOFEGI	0.075 **	0.074 **	0.080 **	0.080 **
	(2.35)	(2.304)	(2.522)	(2.522)
INT	0.163 ***	0.165 ***	0.157 ***	0.157 ***
	(7.452)	(7.550)	(7.131)	(7.131)
KOFEGI × INT	0.544 ***	0.571 ***	0.559 ***	0.559 ***
	(11.399)	(11.245)	(11.015)	(11.015)
GDPC		−0.120	−0.107	−0.107
		(−1.549)	(−1.383)	(−1.383)
FDI			−0.094 ***	−0.094 ***
			(−2.782)	(−2.782)
OP				−0.289 ***
				(−6.242)
_ cons	0.170 ***	0.182 ***	0.223 ***	0.223 ***
	(10.406)	(10.128)	(9.635)	(9.635)
Observations	648	648	648	648

Note: The values in parentheses are T-values, *** represents $p < 0.01$, ** represents $p < 0.05$.

The effect of the digital economy on globalization and renewable energy development has a time lag to a certain extent due to technological diffusion. Therefore, we have lagged the digital economy for one period and conducted corresponding robustness tests to enhance the accuracy of the results, which are shown in Table 11. The regression results demonstrate that the impact of the digital economy lagging behind one period on renewable energy development in the process of globalization remains significant at the statistical level of 1%. This indicates that the development of the digital economy has a significant moderating effect on renewable energy development in the B&R countries, and once again verifies the Hypothesis H2.

Table 11. Robustness test-digital economy lagging behind one period.

Explanatory Variables	(1)	(2)	(3)	(4)
	RED	RED	RED	RED
KOFEGI	0.069 *	0.069 *	0.079 **	0.079 **
	(1.857)	(1.849)	(2.122)	(2.122)
DE_Lag	0.129 ***	0.128 ***	0.118 ***	0.118 ***
	(4.105)	(4.094)	(3.732)	(3.732)
KOFEGI × DE _ Lag	0.745 ***	0.751 ***	0.733 ***	0.733 ***
	(9.536)	(9.357)	(9.153)	(9.153)
GDPC		−0.025	−0.012	−0.012
		(−0.313)	(−0.150)	(−0.150)
FDI			−0.089 ***	−0.089 ***
			(−2.630)	(−2.630)
OP				−0.130 ***
				(−3.274)
_ cons	0.157 ***	0.160 ***	0.199 ***	0.199 ***
	(8.912)	(8.205)	(8.164)	(8.185)
Observations	612	612	612	612

Note: The values in parentheses are T-values, *** represents $p < 0.01$, ** represents $p < 0.05$, * represents $p < 0.1$.

6. Discussions

The development of renewable energy in the B&R countries has improved the globalization process, according to the findings of benchmark regression in Table 3. This demonstrates that the B&R countries' degree of globalization is substantially connected to their level of renewable energy development and that there is a considerable influence at the 1% statistical level. Renewable energy development will rise by 0.095% if globalization expands by 1%. If the former grows by 1% after incorporating the relevant control factors, the latter will increase by 1.06%, which is nearly 10% greater than the outcome without the control variables. Globalization and the increased free movement of cash and technology have aided the development of renewable energy in the B&R countries [18].

Globalization's influence on renewable energy production varies in severity depending on where the economy is in its growth cycle. Table 4 illustrates that globalization has a statistically significant influence on renewable energy development in low, upper-middle, and high-income countries at a 5% statistical level. High-income countries are impacted the most, followed by middle- and lower-income countries, and lastly low- and middle-income countries in terms of the influence on economic development. The globalization process has a bigger influence on renewable energy production at higher levels of economic growth [4]. Globalization has little effect on renewable energy growth in lower-middle-income countries, according to the Heterogeneity study, which attributes this to the countries' existing economic development strategies and energy use. Egypt, Georgia, India, Indonesia, Pakistan, Ukraine, and Vietnam make up the majority of the low-middle-income countries studied in this research.

Egypt is Africa's biggest non-OPEC oil producer, producing fossil fuels such as coal, oil, and natural gas, and is critical to satisfying the world's energy needs. Local energy plays an increasingly vital role in economic growth as the economy develops, yet the energy structure is extremely irrational. According to the conversion rate of energy to electricity, up to 90% of local power is generated using fossil fuels such as oil. Renewable energy accounts for less than 1% of power generation. Due to Egypt's illogical energy structure, it will be difficult to create a big change in a short period, and globalization will have little effect on the country's local renewable energy growth [49].

The energy development and utilization in Georgia are seriously unbalanced due to its relatively low energy resources, efficiency, and problems such as differences in economic development levels. With the development of globalization, the disparities in its local economic growth levels are further widened, hindering the development of energy resources, including renewable energy [50].

India is the world's fourth-largest user of energy. The usage of fossil fuels such as coal and oil has grown by 700% of economic progress [51]. The energy supply is increasingly tight, and India gradually relies on energy imports. However, due to geopolitical issues, the country's energy imports have been seriously hindered [52]. Although India boasts a certain amount of renewable energy, such as hydropower, wind power, and nuclear energy, its complex geological features and unpredictable monsoon climate [53], hampered local renewable energy production and development [52]. In addition, in the process of transforming renewable energy into power resources, India is also faced with problems such as weak power demand, high transmission loss, difficult loans for enterprises, and uncertain policies, which leads to the decline of the investment attractiveness of renewable energy in the country from the third place in the world to the seventh place [51]. India's renewable energy development has been negatively impacted and slow due to this fact.

Significant flaws have been found in Indonesia's energy structure. It mainly relies on imported fossil energy such as oil and lacks suitable policies for the promotion of renewable energy development with the relevant logistics measures and targeted subsidies primarily aimed at the import of oil [54]. Solar and wind power are available in the country; however, they are still in the early stages of development [55].

Pakistan mainly relies on thermal power to generate energy, accounting for nearly 35% of the total power generation [56]. The country's resources and population are concentrated

in rural areas. It is a sort of technical support for renewable energy development [57], making it difficult for it to move away from fossil fuels and toward renewable energy [58].

Ukraine is a prominent energy exporter with much non-renewable and renewable energy. However, in the exploitation of renewable energy, it is faced with many obstacles, including the high cost of growth, military conflict with Russia and other countries, residents' unawareness of green development, and insufficient policy support. These issues are detrimental to the country's renewable energy development [59].

Although Vietnam has a comparatively high proportion of renewable energy sources, such as solar and wind, it lacks the legislation to promote the growth and use of renewable energy. That country is heavily reliant on imported fossil fuels such as coal and oil [60], hindering its renewable energy growth.

Generally speaking, in globalization, these countries mainly depend on traditional fossil energy due to policies and utilization preferences of energy, which leads to the relatively backward development of renewable energy. This is also the primary cause for globalization's unclear influence on renewable energy development in these countries.

In terms of the moderating impact, the digital economy has a large moderating influence on the B&R countries' development of renewable energy throughout the globalization process. According to Equation (2), globalization's marginal contribution to renewable energy development is determined by the digital economy's growth stage. The outcome of the moderating impact is shown in Table 5. At the statistical level of 1%, the interaction items of the digital economy and globalization have substantial impact coefficients on the growth of renewable energy, indicating that the more developed the digital economy, the larger the moderating effect on renewable energy. The results of the heterogeneity analysis of the moderating effect in Table 6 indicate that the digital economy's moderating effects on the development of renewable energy in the context of globalization are statistically significant at a level of at least 5% in lower-middle, upper-middle, and high-income countries, but not in low-income countries. The reason for this is that low-income countries' economic development and the development environment for the digital economy are comparatively weak in comparison to other countries, making it difficult to leverage the digital economy's moderating effects [32]. The digital economy can provide information and technical support for renewable energy development. Driven by digital technology, more advanced technologies can be applied to the production and utilization management of renewable energy. It will reduce the production cost of renewable energy and increase the proportion of renewable energy in energy development and utilization [35]. In addition, the utilization of digital technology can improve the development efficiency of renewable energy [37]. However, low-income countries are limited by the relatively backward development environment of the digital economy. In the process of economic development, they cannot give full play to the positive role of the digital economy in promoting economic development [61]. Among the 36 B&R countries referred to in this analysis, the low-income countries involved are mainly Cambodia and Kyrgyzstan. Due to the low level of economic growth in Cambodia, it is difficult to narrow the country's digital divide through financial means. With regards to a lack of corresponding financial or policy support for developing digital infrastructure and digital technology, its digital economy is far behind, leading to a severe digital divide with other countries [62]. In the process of developing its digital economy, Kyrgyzstan is confronted with many problems including high network costs and a technology base limited by Russia and Kazakhstan. It is these issues that make the digital economy in Kyrgyzstan lag behind compared with other surrounding countries [63]. Due to the relatively backward digital economy and digital technology in these countries, improving the technology of these countries and playing a positive role in the digital economy in the development of global renewable energy are not conducive.

This paper performs a threshold effect test based on the study of benchmark regression and the moderating impact. Globalization, the research discovered, has a non-linear effect on renewable energy when the digital economy is used as the threshold variable. As indicated in Table 8, the threshold value for the digital economy's single threshold impact is

0.0611. When the digital economy's growth level is less than the threshold value of 0.0611, globalization has a positive effect on renewable energy development of 0.283. When the digital economy's development level exceeds the threshold value of 0.0611, the beneficial effect of globalization on renewable energy development decreases to 0.09 but remains statistically significant at the 1% level. The findings indicate that globalization has always benefited the growth of renewable energy in the B&R countries. Nonetheless, as the digital economy expands at a breakneck pace, its impact is rapidly diminishing. In the digital economy era, countries bordering the B&R may use digital development to advance their renewable energy technology and reduce their reliance on other countries. Given that the effect of the digital economy on the development of renewable energy throughout the globalization process may be influenced by multicollinearity and time lag, this paper further carries out corresponding robustness tests, including replacing the digital economy development index with the Internet penetration rate and taking a one-period lag of the digital economy development index. The research demonstrates that the digital economy continues to play a moderating role in the development of renewable energy during the globalization process, demonstrating that the digital economy has a consistent and beneficial effect on the development of renewable energy in B&R countries during the globalization process.

7. Conclusions and Policy Suggestions

7.1. Conclusions

In this paper, based on existing studies [18,26], we incorporate globalization, the digital economy, and renewable energy into a unified framework, and based on the panel data of countries along the Belt and Road from 2008 to 2016, we use benchmark regression, moderated regression, and threshold regression to empirically test the impact of globalization on the development of renewable energy, and analyze the moderating role of the digital economy in the relationship between the two. In addition, considering that there are some differences in the economic development of countries along the Belt and Road, we classify the countries along the B&R into four types: low-income, lower-middle-income, upper-middle-income, and high-income, and conduct a heterogeneity analysis. Globalization, the regression findings indicate, has a beneficial influence on the development of renewable energy in the B&R countries. A 1% increase in globalization results in a 1.06% increase in renewable energy development. The most impacted countries are those with a high-income, followed by those with an upper-medium-income and those with a low-income. While lower-middle-income countries are mostly affected by the current state of renewable energy, they are not by globalization. The digital economy can provide technological support for the development of renewable energy during the globalization process, and it has an obvious moderating effect on the development of renewable energy during the globalization process in Belt and Road Initiative countries. However, this effect is more obvious for low- and middle-income countries, high- and middle-income countries, and high-income countries, but not for low-income countries. For low-income countries, the effect is less clear. Furthermore, in the B&R countries, the digital economy is a threshold variable for the impact of globalization on renewable energy development. When the development level of the digital economy is below the threshold value of 0.0611, the positive impact of globalization on renewable energy development is 0.283; when the development level of the digital economy is above the threshold value of 0.0611, the positive impact of globalization on renewable energy development is decreases to 0.09.

7.2. Policy Suggestions

Based on the previous findings, we make the following policy suggestions. First, they must proactively merge into the tide of globalization and strive to develop renewable energy in an open environment. Globalization's advancement may give financial and technical assistance for generating renewable energy in B&R countries while strengthening their environmental awareness. The abundance of renewable energy in the B&R countries

has attracted investments from several countries. However, some of the B&R countries encounter political instability, inefficient governments, and low levels of accountability, adding to the uncertainty for the host countries to invest [12]. In addition, during the current COVID-19 pandemic, the pressure on public budgets and fiscal deficits of the B&R countries will be increased step by step. Therefore, the host country will be confronted with multiple risks when investing in these initiative countries' renewable energy, which may reduce investment and thus affect the development of renewable energy.

Second, they are intended to bolster the digital economy and energy applications in the digital realm. The development of the digital economy may give technological assistance to the utilization of renewable energy in B&R countries, therefore reducing their reliance on other countries in the process of achieving renewable energy development. As a result, it is critical to foster the indigenous digital economy and establish a 'Digital Silk Road.' By enhancing the digital infrastructure with the Internet at its heart and leveraging the network effect, it is possible to enhance the circulation and exchange of money and technology. Rather than seeing the digital economy just as a technology enabler, governments and corporations along the B&R must fully use the digital economy's role in fostering the growth of energy digitization by closely integrating renewable energy and digitization. Additionally, the digital economy should boost renewable energy production and consumption, expand the breadth and depth of digital use in the area of renewable energy, and boost regional renewable energy efficiency.

Third, they need to promote a balanced development and narrow the gap among regions. According to research, the digital economy contributes significantly to the development of renewable energy in lower-middle, upper-middle, and high-income countries, but not in low-income countries, which are primarily impacted by local energy utilization structures and the development of the digital economy. It is critical to optimize resource allocation throughout the digitalization building process. When consolidating the advantages of a digital economy, countries with a better economy should consider appropriately promoting digital resources and supporting policies for countries with a poor economy to narrow the gap of regional digitalization and promote regional coordinated development. In addition, when formulating energy consumption policies, governments of all countries should take the actual local situation into account and scientifically arrange reasonable measures. By using and promoting local renewable energy development and narrowing the energy development gap, they will achieve a coordinated regional development.

7.3. Limitations of This Research

This paper has studied the impact of the globalization and digital economy on the renewable energy, some limitations exist as follows. Firstly, the globalization index we employed is the economic globalization index. In fact, globalization involves many aspects, such as the political, the economic, and the cultural. Only focusing on economic globalization may result in some bias within the results. Secondly, the measurement of the digital economy development levels lacks widely accepted indicators. Our measurement of the digital economy mainly focuses on the infrastructure, without the commercialization and industrialization factors of the digital economy, and such a measurement may affect our results.

7.4. Future Directions of Study

Based on this paper, the following directions can be further studied. Firstly, globalization value chain status or globalization participation of renewable energy industry can be included in the model to analyze the mechanism of the digital economy on sustainable development. Second, the digitalization of renewable energy industry may be another direction. By considering the digitalization in the renewable energy industry, more interesting results could be found.

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