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China's Greenfield Investment and African Countries' Green Growth Under the Belt and Road Initiative

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Abstract

Though in recent years African countries have experienced rapid economic growth, there is a growing need for them to accelerate the process of green growth to address challenges like climate change and depletion of natural resources. Under the framework of Belt and Road Initiative, this paper empirically examines the impact of China's greenfield investment on green growth of African countries based on the STIRPAT model, using panel data of 37 African countries from 2003 to 2020. The results show that China's greenfield investment can significantly contribute to green growth of African countries, including the improvement of energy productivity, CO_2 productivity and non-energy material productivity, which confirms the validity of the "Pollution Halo Hypothesis" in the African region, and improvements in institutional quality can increase the contribution of greenfield investments. Compared with global greenfield investment, China is playing an important role in the green growth of African countries. The research in this paper expands the existing literature on investment and green growth, helps to grasp the reality of the environmental effects of China's greenfield investment in Africa, and provides empirical evidence and policy support for Sino-African economic and trade cooperation and the high-quality green development of the "Belt and Road".

Keywords: Africa, greenfield investment, green growth, STIRPAT model, institutional quality

1. Introduction

At the opening ceremony of the 3rd Belt and Road Forum for International Cooperation on October 18, 2023, the President Xi Jinping announced eight major actions that China would take to support the joint pursuit of the Belt and Road Initiative, among which, the fourth action was to promote green development. Promoting Chinese Greenfield investment in Africa not only enhances the level of employment in Africa, but also takes an important role in building an ecological civilization and sustainable development. Sustainable development, economic growth and climate action are critical to Africa, while the realization of these priorities requires a commitment to the green growth path. A common definition of green growth in the international development community is that creation of employment opportunity or economic growth is compatible with or driven by the reduction of emissions, the efficient use of natural resources and the protection of ecosystems (Organization for Economic Co-operation and Development, 2011; World Bank, 2012; United Nations Environment Programme, 2011). In Africa, the green growth means inclusive economic growth through investment in sustainable infrastructure, better management of natural resources, and so on. In contrast to the green growth agendas of industrialized countries, African countries also emphasize sustaining rapid growth and reducing poverty.

One possible way to promote green growth of African countries is foreign direct investment (FDI) and trade. Foreign investment is critical to the future development of Africa, not only to raise the living standards of the continent, but also to promote sustainable economic development by facilitating the transfer of new technologies and production methods, providing access to international markets, increasing efficiency in the use of resources and reducing wastes and pollution. Greenfield investment, also known as new investment, is a form of investment in which a multinational enterprise invests in a host country or region by embedding itself in the industrial chain, to fully develop overseas human resources, technology and R&D resources, to learn from the local market and management experience, and to set up factories or R&D centers overseas. Research results from McKinsey show that most of China's investment projects in Africa are greenfield investments, only a few projects are in the form of joint ventures or mergers and acquisitions. From 2017 to 2022, China's direct

greenfield investment in Africa was $74 billion, accounting for 18% of foreign direct greenfield investment in Africa, making China a major source of greenfield FDI in Africa. In the future, The African Continental Free Trade Area (ACFTA) will provide significant opportunities for increased greenfield direct investment in the region, and by reducing tariffs and non-tariff barriers to trade, Chinese enterprises could widely access to the expanded goods and services market across Africa.

2. Literature Review

2.1 Research on Evaluation of Green Growth

Although African countries have experienced rapid economic growth in recent years, the acceleration of economic growth has indirectly led to higher energy consumption and environmental damage, and in view of this, the Belt and Road Initiative has put forward a new concept and a new version known as the Green Belt and Road (Chin, Ong, Ooi, & Puah, 2022). Regarding the research on green growth, the scientific community has not yet developed a universal assessment methodology, Kwilinski, Lyulyov, and Pimonenko (2023) summarize three main measurement methods in use currently: (1) the method based on the world indexes SDG Index, Global Sustainable Competitiveness Index and Global Green Economy Index (Adamowicz, 2022); (2) the method based on green GDP (Song, Zhou, & Jia, 2019); (3) the method based on desirable and undesirable outcomes (Kalantaripor & Najafi Alamdarlo, 2021). This paper uses green growth indicator data from the OECD database to measure green growth in terms of environmental and resource productivity of a country.

2.2 Research on the Environmental Effects of Foreign Investment

There are two opposing theories on the environmental effects of OFDI, namely the "Pollution Haven Hypothesis" and the "Pollution Halo Hypothesis". The "Pollution Haven Hypothesis" argues that gaps in national environmental standards attract the dirtiest industries of foreign companies to developing countries, thereby degrading the environmental quality of the host country and creating a "pollution haven". "Pollution Halo Hypothesis" counters that global market forces spread best management practices and that the introduction of foreign investment creates a "pollution halo" in developing countries by upgrading the production technologies of local firms and optimizing pollution emissions. In countries with below-average capital-labor ratios but less lax environmental regulations, foreign direct investment is associated with reduced pollution, and the "Pollution Halo Hypothesis" dominates (Zugravu-Soilita, 2015).

For empirical studies, Opoku and Boachie (2020) used data of 36 African countries from 1980 to 2014 to reveal the negative impact of FDI on environmental quality. Some studies find that FDI increases air pollution, including carbon emissions, and the findings support the "Pollution Haven Hypothesis" (De Pascale, Sardaro, Faccilongo, & Cont`o, 2020; Shahbaz, Gozgor, Adom, & Hammoudeh, 2019; Sarkodie & Strezov, 2019). The impact of FDI on economic growth, industrial structure and environmental pollution control positively affects industrial pollution control and environmental conditions in China (Ayamba, Haibo, Ibn Musah, Ruth, & Osei-Agyemang, 2019). FDI can act as a driver of technological innovation, and implement greener and cleaner production modes, thus realizing positive environmental spillovers (Pazienza, 2019). The impact of FDI on carbon emissions is negative, and after sorting out impacts on countries at different development levels and different pollutants, the results remain strongly support the "Pollution Halo Hypothesis" (Zhu, Duan, Guo, & Yu, 2016; Demena & Afesorgbor, 2020).

There are few research literatures on the environmental effects of foreign greenfield investment. The foreign greenfield investment has a positive impact on regional green technology specialization (Castellani, Marin, Montresor, & Zanfei, 2022), has a significant positive impact on the extent and quality of Transnational Corporations' (TNCs') sustainable technological innovation capability. In the long run, newly created subsidiaries funded by greenfield investments contribute more to innovation and greenness than foreign firms acquired (Amendolagine, Lema, & Rabellotti, 2021). Along with greenfield investments, both economic openness and public governance efficiency have a positive impact on green economic growth in countries, attracting greenfield investments to increase green innovation in renewable energy thereby promoting green economic growth (Kwilinsk et al., 2023). Well-institutionalized greenfield investments can improve environmental performance, i.e., sound institutions and regulation can mitigate the "Pollution Haven Hypothesis" in Asian region (Nepal, Taghizadeh-Hesary, & Musibau, 2020).

Based on the above literature, this paper proposes research hypothesis 1: China's greenfield investments in Africa can promote green growth of African countries.

2.3 Research on the Facilitation Role of Institutional Quality

A study by Zhao et al. (2023) found a significant positive relationship between positive shocks of institutional

quality and environmental performance. Institutional quality has a significant negative moderating effect on carbon emissions, each 1% increase in institutional quality reduces pollution in South Asian countries by 0.114% (Zakaria & Bibi, 2019). With regard to the environmental effect promotion role of investment, the promotion role of foreign investment on green total factor productivity (GTFP) is further enhanced with the improvement of the overall institutional quality, the political system quality, the economic system quality, and the legal system quality (Qiu, Zhang, Wu, Irfan, & Ahmad, 2021; Wu, Ren, Yan, & Yu, 2020). The negative impact of FDI on carbon dioxide emissions can be ameliorated by sound governance (Bakhsh, Yin, & Shabir, 2021; Bouchoucha, 2024). In terms of specific mechanisms, higher level of regional corruption can lead to a gradual decline in the effect of green investment on reducing environmental pollution, while improvements in marketization and intellectual property protection can increase the positive impact of green investment on reducing environmental pollution (Ren, Hao, & Wu, 2022).

Based on the above literature, this paper proposes research hypothesis 2: improved local institutional quality can increase the contribution of greenfield investments to green growth in African countries.

2.4 Marginal Contribution

The current researches on the environmental effects of investment in Africa provide a research basis for this paper, and the possible marginal contributions of this paper are as follows: In terms of research content, although the relationship between foreign investment and green growth has been studied in the literature, most of existing literature focuses on foreign direct investment, while there are few researches on foreign greenfield investment, and there are few studies on the African region among the Belt and Road-related studies. In terms of data selection, in the study of greenfield investment in Africa, the existing literature uses data of global greenfield investment in Africa collated by UNCTAD database, while this paper collates the data of China's greenfield investment in Africa from FDI Markets and makes a comparative study with the environmental effect of global greenfield investment. In terms of research methodology, regional heterogeneity is taken into account, and due to the imbalance of green economy development among African countries, suggestions for foreign investment and development should be provided in the light of local conditions; at the same time, this paper analyzes the threshold effect of institutional quality, and explores what institutional quality can facilitate the greenfield investment to better contribute to the green growth of African countries. Finally, in terms of reality, the research in this paper helps to understand the relationship between foreign greenfield investment and green growth, and provides empirical evidence and policy support for Sino-African economic and trade cooperation and the green and high-quality development of the "Belt and Road", then contributes to the promotion of global environmental governance with Chinese programs and Chinese wisdom.

The rest of the paper is organized as follows: section 3 describes characteristics of China's greenfield investments in Africa, section 4 presents the modeling methodology and data sources, section 5 discusses the regression results, and section 6 presents conclusions and insights.

3. Characteristics of Greenfield Investments of China in African Countries

3.1 Overall Characteristics

As shown in Figure 1, from 2013 to 2020, China's greenfield investments in African countries had fluctuated widely, generally showing a trend of increasing first and then decreasing. There were 17 greenfield investment projects in 2013, with an investment value of approximately 600 million US dollars. In 2016, the number of greenfield investment projects increased to 61, and the amount of investment increased to approximately 36 billion US dollars. After 2019, the number and value of greenfield investment projects declined slightly due to the impact of the COVID-19. Compared to global greenfield investment in Africa, after the conclusion of the Belt and Road Agreement, proportion of greenfield investment made by China has increased first and then decreased.

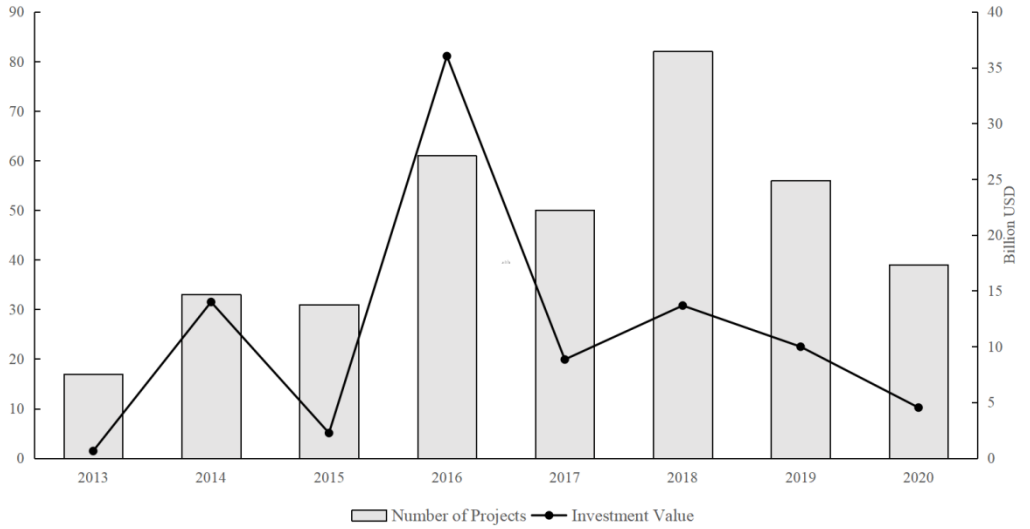

Figure 1. Scale and quantity of China's greenfield investment in African countries

Source: Calculated based on FDI Markets.

3.2 Industry Structure

According to Table 1, the industry structure of China's greenfield investment in African countries mainly focuses on construction, energy and other fields. Over the past two decades, coal, oil and gas in Africa have attracted the largest share of greenfield FDI, but recent trends show that market-seeking investments in African service sectors, such as environmental technology and ICT & electronics, are on the rise. Compared to China's investments in other regions, greenfield investments in Africa are more concentrated in transportation infrastructure and energy.

Table 1. Industry structure of China's greenfield investment in African countries (Unit: Million USD)

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Construction		7433.7	1396.1	20663.0	2312.1	1168.2	4447.8	647.9	38068.8
Energy		1339.2		7362.8	1984.1	4250.6	31.7		14968.4
Wood, Apparel & Related Products		511.7	40.0	463.4	2434.4	1238.7	1152.1		5840.3
Environmental Technology	92.0	2299.7	20.4	1368.1	215.5	869.0	30.0	548.0	5442.7
ICT & Electronics	170.0		145.5	203.9	84.9	756.7	661.1	3181.0	5203.1
Transportation & Warehousing	152.8	1183.4	138.2	524.2	752.9	948.2	1399.4		5099.1
Life Sciences		73.5		339.2	706.0	3167.0	332.7		4618.4
Industrial	80.1	161.5	415.7	1461.4	177.8	919.6	551.1	20.0	3787.2
Agribusiness	94.4	622.3	10.0	119.4	89.8	91.9	255.0	15.0	1297.8
Consumer Goods	35.1	276.3	24.5	38.4	36.6	78.4	220.8	12.4	722.5

Source: Calculated based on FDI Markets.

3. Methodology and Data

3.1 STIRPAT Model

In order to study the relationship between foreign greenfield investment and green growth, this paper adopts the STIRPAT model and IPAT theoretical framework widely used in the existing literature, and uses a multiple regression approach, according to the IPAT model:

$$I = PAT \tag{1}$$

It has the general form of:

$$I_{it} = \alpha P_{it}^{\beta_1} A_{it}^{\beta_2} T_{it}^{\beta_3} \varepsilon_{it} \tag{2}$$

In the formula, I (Impact) is the annual carbon emissions of the study area, while this paper uses the green growth indicators provided by the OECD database, which further extends the IPAT framework and avoids the bias resulted from the single indicator of carbon dioxide emissions, and thus provides a more reliable

measurement method of green growth in a country (Trinh, Squires, Mccord, & Lo, 2022); *P* (Population) is the population size in the region; *A* (Affluence) is the per capita affluence in the region, and this paper selects GDP per capita to represent it; *T* (Technology) is the overall technological level in the region, and this paper selects development of environment-related technologies to represent it.

Logarithmizing both sides of the equation yields:

$$\ln I_{it} = \alpha + \beta_1 \ln P_{it} + \beta_2 A_{it} + \beta_3 T_{it} + \ln \varepsilon_{it} \tag{3}$$

Taking into account the characteristics of the African region, this paper uses green growth as the explanatory variable, which includes energy productivity (*EP*), production-based CO_2 productivity (CO_2P), and non-energy material productivity (*NMP*) respectively from the Environment and Resource Productivity Indicators (ERPI) of the OECD database. Taking greenfield investment (*GI*) as the core explanatory variable and with reference to previous literature, introducing economic and social factors, namely population size (*POP*), GDP per capita (*AGDP*), environment-related technology (*ET*), trade volume (*Trade*), human development index (*HDI*), and energy intensity (*EI*) as the influencing factors, an extended STIRPAT model is obtained as shown below:

$$\ln EP_{it} = \alpha + \beta_1 \ln GI_{it} + \beta_2 \ln POP_{it} + \beta_3 \ln AGDP_{it} + \beta_4 \ln ET_{it} + \beta_5 \ln Trade_{it} + \beta_6 \ln HDI_{it} + \beta_7 \ln EI_{it} + \mu_{it} + \varepsilon_{it} \tag{4}$$

$$\ln CO_2P_{it} = \alpha + \beta_1 \ln GI_{it} + \beta_2 \ln POP_{it} + \beta_3 \ln AGDP_{it} + \beta_4 \ln ET_{it} + \beta_5 \ln Trade_{it} + \beta_6 \ln HDI_{it} + \beta_7 \ln EI_{it} + \mu_{it} + \varepsilon_{it} \tag{5}$$

$$\ln NMP_{it} = \alpha + \beta_1 \ln GI_{it} + \beta_2 \ln POP_{it} + \beta_3 \ln AGDP_{it} + \beta_4 \ln ET_{it} + \beta_5 \ln Trade_{it} + \beta_6 \ln HDI_{it} + \beta_7 \ln EI_{it} + \mu_{it} + \varepsilon_{it} \tag{6}$$

In the formula, α is a constant term, subscripts *i* and *t* represent country and time respectively, μ_{it} controls country fixed effects, and ε_{it} represents a random error term.

3.2 Data Source and Processing

Based on data availability, this paper selects panel data of 37 countries in Africa from 2003 to 2020. The data of China's greenfield investment in Africa comes from the FDI Markets database of the Financial Times of the United Kingdom, which is the most comprehensive database on greenfield investment available at present. This paper sums up the amount of all investment projects from China to each country in Africa by year, to get the data on China's greenfield investment (*GI*) in Africa of each year. Data representing green growth, including energy productivity (*EP*), CO_2 productivity (CO_2P), non-energy material productivity (*NMP*), and environment-related technology (*ET*), energy intensity (*EI*) are from the OECD database; population size (*POP*) and GDP per capita (*AGDP*) are from the World Development Indicators (WDI) database of the World Bank; trade volume is measured by imports from China, and the data is from Johns Hopkins University's China Africa Research Initiative (2020); and Human Development Index (*HDI*) is from the data center of United Nations Development Program (UNDP). Descriptive statistics of each variable are shown below:

Table 2. Descriptive statistics of data

Variable Name	Observed Value	Average Value	Standard Deviation	Minimum	Maximum
Year	666	2011.5	5.192	2003	2020
ln*EP*	504	8.818	0.556	7.482	9.759
lnCO_2P	476	2.206	0.649	0.300	3.601
ln*NMP*	607	-0.486	0.661	-1.772	1.169
ln*GI*	666	1.568	2.468	0.000	10.034
ln*POP*	666	16.540	1.197	13.600	19.155
ln*AGDP*	656	7.083	0.933	4.769	9.237
ln*ET*	538	0.060	0.140	0.000	0.871
ln*Trade*	655	4.829	2.777	-13.816	10.421
ln*HDI*	646	-0.678	0.199	-1.280	-0.290
ln*EI*	504	-0.625	0.623	-2.207	1.089

4. Results

4.1 Results of Basic Model

The results of Hausman test and F-test show that the original hypothesis of random effect is rejected, so this

paper selects the fixed effect model to analyze, controlling the country fixed effect and time fixed effect, to explore the impact of China's foreign greenfield investment on the green growth of African countries, and obtains the regression results as shown in Table 3:

Table 3. Overall regression results

Variable	Energy Productivity		CO_2 Productivity		Non-energy Material Productivity	
	(1)	(2)	(3)	(4)	(5)	(6)
ln*GI*	0.006*	0.003**	0.011***	0.002	0.001	0.005*
	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
ln*POP*		-0.214**		-2.077***		-1.053***
		(0.099)		(0.193)		(0.204)
ln*AGDP*		0.199***		0.177***		0.090***
		(0.017)		(0.032)		(0.035)
ln*ET*		0.106**		0.191**		0.086
		(0.043)		(0.084)		(0.089)
ln*Trade*		-0.005		0.008		0.024***
		(0.003)		(0.007)		(0.007)
ln*HDI*		1.182***		0.899***		0.525**
		(0.120)		(0.234)		(0.248)
ln*EI*		-1.039***		-0.610***		-0.239***
		(0.038)		(0.074)		(0.078)
Constant Term	8.708***	11.141***	2.251***	35.689***	-0.569***	16.664***
	(0.028)	(1.666)	(0.033)	(3.248)	(0.024)	(3.427)
Time Fixed Effect	YES	YES	YES	YES	YES	YES
National Fixed Effect	YES	YES	YES	YES	YES	YES
Observations	504	412	476	412	607	411
R-squared	0.177	0.837	0.107	0.463	0.128	0.269

Note. *** ,**,* indicate the significance level at 1%, 5%, 10% respectively. Standard errors are in the parentheses. The same below.

Column (1) and (2) of the Table show that China's foreign greenfield investment has a significant positive impact on the energy productivity of African countries. Specifically, after controlling influencing factors, 1% increase in China's greenfield investment in Africa will boost energy productivity in African countries by 0.3% at the 5% significance level. The subsequent columns of the Table show that China's foreign greenfield investment also has a positive impact on CO_2 productivity and non-energy material productivity in African countries. Specifically, 1% increase of China's greenfield investment in Africa would increase CO_2 productivity and non-energy material productivity in African countries by 1.1% and 0.5% respectively. The results of the study verify hypothesis 1: China's greenfield investments in Africa can contribute to green growth of African countries, confirming the validity of the "Pollution Halo Hypothesis" in the African region.

The signs of most control variables are as expected. The signs of GDP per capita, environment-related technology and human development indices of African countries are positive and significant, which suggests that economic growth, technological advancement and increased human development level play an important role in promoting green growth in African countries. The significantly negative sign of population size and energy intensity indicates that they impede green growth in African countries, and imports from China do not play a significant role in green growth in African countries.

4.2 Analysis of Regional Heterogeneity

This paper further conducts group regressions based on geographic regions of Africa to better study the impact of China's foreign greenfield investment on green growth in different geographic regions of Africa. In this section, energy productivity is selected as a proxy for green growth, and the regression results are obtained as shown in Table 4 by dividing the African countries based on geographic location into: East Africa, South Africa, Central Africa, North Africa and West Africa:

Table 4. Regional heterogeneity analysis results of energy productivity

Category	East Africa	South Africa	Central Africa	North Africa	West Africa
ln*GI*	0.005**	0.007**	0.001	0.003*	0.001
	(0.002)	(0.003)	(0.004)	(0.002)	(0.003)
ln*POP*	-0.076	0.676***	-0.885	-0.847***	-1.434***
	(0.972)	(0.182)	(0.567)	(0.143)	(0.380)
ln*AGDP*	0.106***	0.121***	0.357***	0.102***	0.284***
	(0.037)	(0.038)	(0.055)	(0.020)	(0.030)
ln*ET*	0.012	-0.177*	-0.005	-0.005	0.261
	(0.305)	(0.100)	(0.072)	(0.052)	(0.254)
ln*Trade*	-0.047***	0.057***	-0.005	-0.023**	0.008*
	(0.013)	(0.014)	(0.018)	(0.010)	(0.005)
ln*HDI*	2.652***	0.911***	1.165***	1.115***	0.422
	(0.169)	(0.332)	(0.317)	(0.218)	(0.280)
ln*EI*	-1.017***	-1.119***	-1.159***	-1.067***	-0.976***
	(0.181)	(0.098)	(0.055)	(0.061)	(0.066)
Constant Term	10.367	-3.289	20.146**	23.274***	30.342***
	(16.685)	(3.119)	(8.794)	(2.440)	(6.483)
Time Fixed Effect	YES	YES	YES	YES	YES
National Fixed Effect	YES	YES	YES	YES	YES
Observations	78	92	58	75	94
R-squared	0.981	0.885	0.976	0.914	0.907

In general, China's greenfield investments in East Africa, South Africa and North Africa can better promote local green growth, which may be due to richer energy resources, higher foreign capital absorption capacity, higher levels of human capital, technology and innovation, and more complete institutional systems in countries in North Africa and South Africa, and the greenfield investments of Chinese enterprises help to promote the effective development and utilization of local energy and meet the energy needs of their green growth. Economic growth and increased human development level are significant drivers of green growth in every geographic region of Africa, with China's imports from Africa being boosted mainly in South Africa and West Africa, while the increase in population size has only played a dominant role in South Africa.

4.3 Robustness Test

Since the environmental effects brought by foreign greenfield investment may have a hysteresis, this paper selects the one-period lagged variable of China's greenfield investment in Africa ($\ln GI_{t-1}$), re-estimates the panel fixed effects, and sets up the lagged variable model as follows:

$$\ln Green\ growth_{it} = \alpha + \beta_1 \ln GI_{it-1} + \beta_2 \ln POP_{it} + \beta_3 \ln AGDP_{it} + \beta_4 \ln ET_{it} + \beta_5 \ln Trade_{it} + \beta_6 \ln HDI_{it} + \beta_7 \ln EI_{it} + \mu_{it} + \varepsilon_{it} \quad (7)$$

The estimation results in Table 5 are basically consistent with Table 3, and China's foreign greenfield investment with one period lagged still has a significant positive impact on the green growth of African countries, mainly in promoting energy productivity and CO_2 productivity. The sign and significance of control variables also have no obvious change, confirming the robustness of the obtained conclusions.

Table 5. Robustness test results based on the one-stage lag of greenfield investment

Variable	Energy Productivity		CO_2 Productivity		Non-energy Material Productivity	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln GI_{t-1}$	0.007**	0.003*	0.010***	0.001	0.002	0.004
	(0.003)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
$\ln POP_t$		-0.162		-2.110***		-1.011***
		(0.103)		(0.212)		(0.217)
$\ln AGDP_t$		0.199***		0.173***		0.098***
		(0.017)		(0.034)		(0.035)
$\ln ET_t$		0.077*		0.189**		0.072
		(0.041)		(0.085)		(0.087)
$\ln Trade_t$		-0.005		0.010		0.031***
		(0.004)		(0.008)		(0.008)

lnHDI_t		1.141***		0.866***		0.306
		(0.125)		(0.257)		(0.264)
lnEI_t		-1.030***		-0.601***		-0.253***
		(0.038)		(0.079)		(0.081)
Constant Term	8.705***	10.263***	2.256***	36.268***	-0.543***	15.726***
	(0.026)	(1.736)	(0.032)	(3.576)	(0.024)	(3.663)
Time Fixed Effect	YES	YES	YES	YES	YES	YES
National Fixed Effect	YES	YES	YES	YES	YES	YES
Observations	476	386	448	386	572	385
R-squared	0.184	0.835	0.107	0.449	0.122	0.259

4.4 Threshold Effect of Institutional Quality

In order to further discuss the impact of China's foreign greenfield investment on the green growth of African countries under different institutional quality environments, this paper constructs a threshold effect model based on Hansen's (1999) threshold regression model with institutional quality (*IQ*) as the threshold variable. Data on institutional quality is obtained from the World Bank's Global Governance Indicators (WDI, 2019), which includes six dimensions: control of corruption, government effectiveness, political stability and absence, regulatory quality, rule of law, voice and accountability. This paper utilizes Principal Component Analysis (PCA) to extract a principal component from six dimensions, which will be used to measure the institutional quality of African countries.

$$\ln Green\ growth_{it} = \alpha + \beta_1 \ln GI_{it} \times I(IQ \le \gamma_1) + \beta_2 \ln GI_{it} \times I(\gamma_1 < IQ \le \gamma_2) + \beta_3 \ln GI_{it} \times I(IQ > \gamma_2) + \beta_4 Controls_{it} + \varepsilon_{it} \quad (8)$$

In the formula, greenfield investment ln*GI* is the core explanatory variable, institutional quality (*IQ*) is the threshold variable, and *Controls* is the control variable; $I(\bullet)$ is the indicator function, which satisfies the condition in the parentheses, then $I = 1$, otherwise $I = 0$; γ_1 is the first threshold value, and γ_2 is the second threshold value. Results of the threshold effect test are as follows:

Table 6. Threshold effects of institutional quality

Energy Productivity		**CO_2 Productivity**		**Non-energy Material Productivity**	
First Threshold Value	-1.485***	First Threshold Value	0.157**	First Threshold Value	-1.130*
Second threshold value	-0.495*	Second threshold value	1.680*	Second threshold value	-0.392***
Number of Thresholds	Double Threshold	Number of Thresholds	Double Threshold	Number of Thresholds	Double Threshold
ln*GI* (*IQ*≤ -1.485)	-0.005	ln*GI* (*IQ*≤0.157)	0.007	ln*GI* (*IQ*≤-1.130)	0.007
	(0.004)		(0.006)		(0.012)
ln*GI* (-1.485<*IQ* ≤ -0.496)	0.000	ln*GI* (0.157<*IQ* ≤1.680)	0.006	ln*GI* (-1.130<*IQ* ≤-0.392)	-0.000
	(0.003)		(0.004)		(0.005)
ln*GI* (*IQ*>-0.496)	0.009*	ln*GI* (*IQ*>1.680)	0.016**	ln*GI* (*IQ*>-0.392)	0.008*
	(0.005)		(0.006)		(0.004)
Constant Term	-1.370	Constant Term	12.521***	Constant Term	-2.193
	(1.414)		(2.682)		(3.431)
Control	Yes	Control	Yes	Control	Yes
Observations	412	Observations	412	Observations	411
R-squared	0.758	R-squared	0.339	R-squared	0.191

The results in Table 6 show that, taking institutional quality as the threshold variable, under 1% significance, the impact of Chinese greenfield investment on energy productivity, CO_2 productivity and non-energy material productivity in African countries passes the double-threshold test. As can be seen from the regression results, when the institutional quality is lower than the second threshold, the impact of China's greenfield investment on the green growth of African countries is positive but not significant, while when the institutional quality is higher than the second threshold, China's greenfield investment can significantly contribute to the green growth of African countries and the regression coefficient is further increased. The results of the study verify Hypothesis 2: improved local institutional quality can increase the contribution of greenfield investments to green growth in African countries.

Table 7. Average institutional quality in African countries, 2003-2020

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011
Average IQ	-0.001	-0.041	-0.103	0.022	0.025	0.015	0.007	0.006	0.011
Year	2012	2013	2014	2015	2016	2017	2018	2019	2020
Average IQ	-0.003	0.001	0.040	0.049	0.006	-0.030	-0.015	-0.017	-0.034

Table 7 describes the average institutional quality of African countries from 2003 to 2020, which shows that the average institutional quality of each country is able to reach the second threshold affecting energy productivity and non-energy material productivity, but is not yet able to reach the second threshold affecting CO_2 productivity, suggesting that there is still demand for continued improvement of the institutional environment in African countries in order to increase the level of support for greenfield investment for green growth.

4.5 Comparative Analysis

Table 8 describes environmental effects of global greenfield investment (*GII*) in Africa, which is little compared to China's greenfield investment in Africa, with no significant relationship between global greenfield investment and green growth in African countries, and may even reduce CO_2 productivity. It is thus clear that China plays an important role in the green growth of African countries and that Sino-African cooperation can help promote the high-quality green development of the "Belt and Road".

Table 8. Regression results of global greenfield investment

Variable	**Energy Productivity**		**CO_2 Productivity**		**Non-energy Material Productivity**	
	(1)	(2)	(3)	(4)	(5)	(6)
ln*GII*	-0.000	0.002	-0.003	-0.001	0.008***	0.004
	(0.004)	(0.002)	(0.004)	(0.003)	(0.003)	(0.003)
Control	NO	YES	NO	YES	NO	YES
Time Fixed Effect	YES	YES	YES	YES	YES	YES
National Fixed Effect	YES	YES	YES	YES	YES	YES
Observations	504	412	476	412	607	411
R-squared	0.172	0.836	0.091	0.462	0.139	0.266

5. Conclusions and Insights

Although there are growing concerns about China's dominance on the African continent and its impact on the sustainable growth of the continent (Gorden, 2012) , there is no economic relationship that can prove China's investment will have an impact on environmental degradation in Africa. Under this background, this paper empirically examines the impact of China's greenfield investment on green growth of African countries based on the STIRPAT model. The empirical results show that China's greenfield investments can significantly contribute to green growth of African countries, confirming the validity of the "Pollution Halo Hypothesis" in the African region. In addition, economic growth, technological progress and increased human development level of African countries contribute to the green growth, while the population size and energy intensity hinder it. Results of tests for sub-regional heterogeneity suggest that China's greenfield investments in East Africa, South Africa and North Africa can better contribute to local green growth. Results of the threshold effect tests for institutional quality suggest that improvements in institutional quality can increase the contribution of greenfield investments to green growth of African countries. Finally, a comparison with results of environmental effects of global greenfield investments reveals that China plays an important role in the green growth of African countries, and that Sino-African economic and trade cooperation can lead to improvements in environmental quality in Africa.

According to the empirical results, policy insights of this paper are as follows: African policymakers should encourage strategic policies regarding foreign greenfield investment and create a favorable investment environment to attract more investments from China. Raise the environmental awareness of foreign investors and promote the investment to transfer to sustainable areas such as renewable energy and environmental technology. Strengthen the institutional improvement, particularly control of corruption, improving government effectiveness, enhancing political stability and absence, strengthening regulatory quality, and reinforcing the rule of law, voice and accountability, to facilitate the contribution of investment to sustainable development. Accelerate the transformation to clean energy by encouraging wider use of solar, wind and thermal energy, to optimize the energy mix to reduce energy intensity. At the same time, it is essential to continue to develop economy,

technology and culture, to raise the per capita income of the local population, to develop environment-related technologies, to enhance the health and education of the population, and to control the negative effects of population growth in order to achieve sustainable development in the African region.

As an important contributor to the construction of the green Belt and Road, China should incorporate objectives of environmental protection, social governance and global partnership into the investment and financing rules of the Belt and Road, and strategically align the Belt and Road construction projects with the sustainable development needs of partner countries. China and Africa should uphold the principles of common business, common construction and sharing, as well as the concepts of greenness, openness and integrity, accurately dovetail the Belt and Road Initiative with the development agenda of Africa, deepen and expand bilateral trade cooperation, and support the development of a green economy in Africa. In the future, the role of the China-Africa Economic and Trade Cooperation Zone (ETZ) as an investment engine should also be brought into full play, so that the ETZ can become an effective tool for attracting foreign investment and realizing the transfer of technology and knowledge, thus enhancing the contribution of China to the sustainable economic development in Africa.

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Competing Interests

The author declares that she has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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