

# Dissertation Title: Comprehensive Analysis of China-Africa Power Cooperation

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## Abstract

Power cooperation has emerged as a fundamental component of the collaboration between China and Africa over the past three decades, during which both regions have collaborated on initiatives pertaining to economic development and the advancement of emerging nations. The effect has significantly altered the connection between China and Africa. Extensive discourse has transpired within academic and policy spheres on China's engagement in Africa, particularly concerning energy and infrastructure. This topic has been extensively debated. This article aims to examine the intricate dynamics of China-Africa power cooperation, focusing specifically on the impact of China's Outward Foreign Direct Investment (OFDI) and the Belt and Road Initiative (BRI) on trade, economic growth, and sustainable development across the African continent. The paper will specifically examine the impact of these two initiatives on trade. This study will focus on the roles of these two influences in the circumstance. This study aims to examine the trade implications, economic contributions, and regional effects of Chinese investments in Africa's electricity sector. The project will specifically focus its efforts on the electrical sector. The achievement of this objective is realized through the integration of theoretical frameworks and empirical approaches. The findings reveal that this relationship offers numerous opportunities, as well as challenges. Numerous obstacles are currently being faced, including potential technological spillovers, environmental concerns, and debt sustainability issues. Immediately following the conclusion of the paper, policy recommendations are presented to enhance the reciprocal advantages associated with the energy collaboration between China and Africa. These ideas underscore the importance of inclusive growth, sustainability, and transparency within the growth process.

## Keywords

China-Africa Relations; Power Cooperation; Belt and Road Initiative (BRI); Foreign Direct Investment (FDI); Sustainable Development; Renewable Energy.

## 1. Introduction

Currently, it is widely acknowledged that the economic and geopolitical connection between China and Africa is a pivotal element in the discourse of global expansion. In recent years, this truth has attracted significant global attention. Since the mid-20th century, bilateral relations have evolved into a comprehensive partnership that includes infrastructure, energy, and industrialization. Initially, these links were confined to business transactions; however, they have now broadened to encompass all these domains. The enhancement of bilateral relations was the catalyst for this transformation. China's engagement in Africa's power industry is seen as one of the most significant aspects of this partnership. This collaboration is motivated by several considerations, including China's quest for energy security and worldwide economic influence, alongside the continent's critical energy requirements. The Belt and Road Initiative

(BRI), launched in 2013, has expanded formalized collaboration throughout the African continent. This has been achieved by channeling investments into projects that integrate hydropower, solar, wind, and thermal energy throughout the African continent. The objective of this study is to elucidate the intricacies of China's power collaboration with Africa by examining three principal concerns, which are as follows: What are the implications of Chinese foreign direct investment (FDI) on trade expansion and economic growth in Africa within the framework of the Belt and Road Initiative (BRI)? How do the several areas of Africa vary in energy investments, and how are these disparities linked to the development objectives set by Africa?

Considering this link, what challenges and risks have emerged, and what strategies may be implemented to address these issues to ensure the sustainability of the outcomes throughout time?

This research employs a combination of theoretical models, including the Heckscher-Ohlin trade theory, and empirical evidence derived from econometric analysis to assess the complementary effects of Chinese investments on Africa's trade volumes and industrial productivity. The study aims to examine the influence of Chinese investments on trade volume and industrial output in Africa. Case studies performed in certain localities provide insight into the numerous ramifications arising from the implementation of these programs. This collection of case studies encompasses a diverse array of subjects, from the solar initiatives developed in North Africa to the hydroelectric supremacy established in Central Africa. The paper critiques the dangers linked to dependence on debt, environmental degradation, and insufficient local involvement. This is an additional point of interest that the essay presents. Furthermore, it advocates for the establishment of equitable policies to optimize the collective advantages for all stakeholders involved. This project aims to synthesize current literature and new data to contribute to the discourse on the role of emerging powers in Africa's development trajectory. This purpose will be reached by synthesizing previously published content. China is reassessing its energy cooperation policy with Africa, aiming to prioritize inclusivity, sustainability, and the long-term economic stability of the continent. The objective of the request is delineated herein.

## 2. Theoretical Framework of China-Africa Power Cooperation

The current academic literature has several perspectives on the connection between the Belt and Road Initiative (BRI) and trade. Certain scholars argue that the Belt & Road Initiative (BRI) and trade can serve as substitutes for one another, while others contend that they are complementary. Lu et al. (2018) [10] assert that the Heckscher-Ohlin model posits that differences in factor endowments will be the primary catalyst for international trade and capital movements. Ma et al. (2019) [11] asserts that foreign direct investment (FDI) serves as a conduit for foreign capital influx, enhancing the manufacturing sector and trade frameworks, hence fostering economic convergence. China's investments in Africa's power sector are essential for enhancing industrial productivity and trade efficiency; thus, these concepts form the basis for understanding the energy partnership between China and Africa.

Numerous empirical studies have been undertaken to examine the influence of China's Belt and Road Initiative (BRI) on Africa's economic performance. Meyersson et al. (2008) [13] demonstrate that the export of natural resources from Africa to China has positively influenced investment and economic growth. This contrasts with the exportation of these resources to other places. Similarly, Busse et al. (2016) [3] discovered that economies in Sub-Saharan Africa (SSA) that export resources to China benefit from enhanced trade. This occurs despite the Belt and Road Initiative (BRI) of China lacking a significant influence on the growth of the African economy. Balamoune-Lutz (2011) [1] posited that Chinese purchases of primary products from Africa yield greater benefits than African exports of basic products to China.

Drummond and Liu (2015) [6] emphasized that increasing trade with China has diversified Africa's export markets, hence reducing the continent's dependence on Western economies. However, they highlighted the peril of Africa's overwhelming reliance on China, rendering the region susceptible to economic disruptions originating from China. This underscores the importance of sustaining a balanced trade strategy within the framework of China-Africa power cooperation.

The BRI has significantly influenced trade relations between China and Africa. Between 2004 and 2014, Lu et al. (2018) [10] examined the impact of the Belt and Road Initiative (BRI) on 48 countries participating in the BRI. They concluded that China's BRI creates opportunities for trade by enhancing the total export volume. Ma et al. (2019) [11] found that the Chinese Belt and Road Initiative (BRI) promotes trade growth in European BRI countries, significantly affecting Chinese exports. The Belt and Road Initiative (BRI) of China has predominantly stimulated exports, while its influence on imports has been negligible. The collaborative power between China and Africa is enhanced by the synergistic impact of trade in BRI nations, demonstrating the initiative's ability to advance infrastructure and energy projects in Africa.

Investigations of the determinants of the Chinese Belt and Road Initiative (BRI) in Africa indicate a pronounced inclination towards nations abundant in natural resources. Kolstad and Wiig (2011) [8] posited that the principal motivators for Chinese investments are resource availability and the existence of favorable institutional settings. Furthermore, Cheung et al. (2012) [4] asserted that the Chinese Belt and Road Initiative (BRI) is motivated by substantial market potential, risk assessments, and elevated trade volumes. Furthermore, Sanfilippo (2010) [15] noted that the accessibility of raw materials and the potential for economic agreements are supplementary variables influencing Chinese investments in Africa. These findings indicate that China's engagement in Africa's energy sector aligns with its overarching economic objectives. China prioritizes energy security as it seeks to build its industrial sector.

In Africa's power industry, the advantages of China's Belt and Road Initiative (BRI) are both direct and indirect. Weisbrod and Whalley (2011) [20] demonstrate that Chinese investments accelerated economic growth in several African nations, particularly in the years preceding and succeeding the global financial crisis. Doku et al. (2014) [5] noted that from 2003 to 2012, Africa had significant economic growth due to a rise in Chinese foreign direct investment. Negash et al. (2020) [14] emphasized the productivity spillover effects of Chinese investments in Ethiopia's manufacturing sector, illustrating the advantages of technical transfers for local firms. Nonetheless, other studies argue that China's Belt and Road Initiative (BRI) has exerted a minimal influence on Africa's economic growth. The studies encompass Zhang et al. (2014) and Busse et al. (2016) [21,3]. These research indicate that more policy adjustments are necessary.

### **3. Overview of Chinese BRI and Trade Relations with BRI African Countries**

The Belt and Road Initiative, which includes both the "Silk Road Economic Belt" and the "Maritime Silk Road," has resulted in an expansion of China's economic power across the continent of Africa. Research estimates that 72.7% of African states are engaging in the BRI framework, even though there are no official figures identifying the countries that are formally participating in the infrastructure. From a modest beginning in the 1950s, China's participation in Africa has seen tremendous expansion, with bilateral trade volumes increasing from USD 12.14 million in the 1950s to over USD 204.03 billion in 2018. This expansion has occurred throughout the course of the past several decades.

The amount of goods that China sells to Africa, more specifically to South Africa and Nigeria, has been steadily increasing, reaching a total of USD 15.22 billion and USD 12.15 billion

respectively by the year 2017. Angola and South Africa were the two countries that exported the most goods to China, with the total value of their exports being 20.70 billion USD and 8.67 billion USD, respectively. South Africa, Nigeria, and Angola are the primary recipients of the Chinese Belt and Road Initiative (BRI), which has undergone significant expansion across African nations. The BRI has increased from a total of 0.075 billion US dollars in 2003 to a total of 47.40 billion US dollars in 2017.

The cooperation between China and Africa in the field of energy has been an essential component of the economic relationship between the two continents. China has made significant investments in the building of power plants, hydropower ventures, and renewable energy installations in Africa. These efforts are in recognition of the continent's significant energy deficit. The combination of government-backed financing and Chinese state-owned companies (SOEs) has allowed for the successful completion of large-scale energy projects in several African countries.

China's investments have primarily been directed toward hydroelectric projects, such as the Grand Renaissance Dam in Ethiopia and the Kariba North Bank Extension in Zambia. Additionally, Chinese investments have been made in coal, solar, and wind energy projects. The emphasis placed on energy infrastructure is in line with the growing demand for power in Africa, which is intended to support industrialization and economic development through the continent. In addition, Special Economic Zones (SEZs) in Africa have been able to allow improvements in energy supply and efficiency, which have been bolstered by Chinese investment.

In spite of the progress that has been made in China-Africa energy partnership, there are still barriers to overcome. As a result of the fact that various projects are financed by loans from Chinese financial organizations, one of the key problems is the debt sustainability of African governments. Concerns about economic dependence have arisen because of the difficulties that many African governments have experienced in managing their debts.

In addition, there are concerns regarding the effects that power projects will have on the environment as well as the social situation. There is a correlation between extensive hydropower projects and the relocation of communities as well as ecological issues. In addition, the dominance of Chinese businesses in these projects has occasionally led to a reduction in the number of employment opportunities available in the local area as well as the distribution of technology information.

The prospects for China and Africa to work together on power projects are bright, as seen by the continued investments in renewable energy and the advancement of infrastructure. African governments are required to negotiate favorable terms in order to ensure that projects contribute to the development of sustainable practices over the long run. The enhancement of regulatory frameworks, the advancement of local capacity development, and the cultivation of public-private partnerships will be essential to maximize the benefits that can be gained from collaborations involving electricity.

In the opposite direction, China ought to prioritize environmentally sustainable activities and improve the transparency of its investment procedures. A more fair and mutually beneficial collaboration could be fostered through the promotion of more African involvement in the implementation of projects and decision-making processes involved in such projects.

#### **4. North Africa: Solar and Wind Energy Growth**

A region that is ideal to produce solar and wind energy is North Africa, which is distinguished by its broad desert terrains. Both the Noor Solar Complex in Morocco and the Benban Solar Park in Egypt are largely dependent on the contributions of Chinese enterprises. A strategic

concentrate on regions with substantial sun irradiation, where extensive renewable energy activities are pooled, is emphasized with geographic information system (GIS) mapping.

The region of North Africa, which is defined by its substantial fossil fuel reserves and significant potential for renewable energy, has attracted significant investment from China in energy projects. These countries, which include Egypt, Algeria, and Morocco, have been among the most successful recipients. According to Dubey and Biswas (2016) [7], China has given its approval to a number of projects in Egypt. These projects include the Hamrawein coal-fired power plant as well as various renewable energy enterprises, such as wind and solar farms. Morocco, a leader in the field of renewable energy, has formed a partnership with China in order to improve its skills in the areas of solar and wind energy.

The Noor Ouarzazate Solar Complex is the precise location in question. At the same time, Algeria has been making investments in hydrocarbon-based power generation, which has helped to strengthen the country's position as a regional energy convergence point.

The Egyptian government has been successful in attracting Chinese investments in wind and solar energy as part of its aim to promote sustainable energy. Chinese businesses provided financial support and technical aid to the Benban Solar Park in Egypt, which is counted among the largest solar parks in the world. Chinese assistance was utilized in the construction of the Sidi Krir Power Plant, which is a thermal plant located in Egypt.

### 5. The Benban Solar Park in Egypt

The Benban Solar Park in Egypt, a large-scale solar photovoltaic facility, has a nominal capacity of 1.8 gigawatts (GW) and produces approximately 3.8 terawatt-hours (TWh) of electricity annually, with financial support from various international lenders.

**Table 1.** Comparative Data (Global Benchmark)

Metric	Benban (Egypt)	Noor Ouarzazate (Morocco)	Bhadla (India)
Capacity (GW)	1.65	1.77	2.25
Cost (\$ billion)	4.0	2.5	1.3
Cost/Watt (\$)	0.42	0.35	0.25
PPA Rate (\$/kWh)	0.084	0.12	0.038

### 6. West Africa: Expanding Thermal and Hydropower Capacity

Ghana, Nigeria, and Côte d'Ivoire are the three countries in West Africa that are carrying out power projects. Taking advantage of its vast natural gas reserves, China has provided funding for a number of gas-fired power plants in Nigeria. The expansion of hydropower is demonstrated by the Bui Dam in Ghana, which was built with funding from Chinese investors.

The use of GIS technologies demonstrates the clustering of projects in close proximity to coastal towns and large rivers, which corresponds to energy demand centers. West Africa is experiencing significant power shortfalls, which has made it a focal point for Chinese investments in both energy infrastructure and energy infrastructure. [18] Trines, Stefan, in the year 2019. In terms of electricity efforts that are financed by China, the countries of Nigeria, Ghana, and Côte d'Ivoire are the biggest beneficiaries. The Zungeru Hydroelectric Power Plant

is one example of the large hydropower initiatives that have been backed by China and have been implemented in Nigeria, the most populous nation in Africa.

These activities are intended to help Nigeria overcome its ongoing electricity shortages. Ghana's hydroelectric capacity has increased as a result of China's financial support for the Bui Dam project, which has been beneficial to the country. Côte d'Ivoire has been successful in securing funding for thermal and hydroelectric projects, which will help the country stabilize its electricity supply and encourage the expansion of its industrial sector. In the year 2020, Chigozie N. Udensi [19] Through the construction of transmission lines and the provision of money, China has been an essential contributor to the improvement of electricity supply throughout the area. In order to alleviate the effects of energy shortages, Nigeria and Ghana have been successful in attracting investments in gas-fired power facilities and solar energy.

### 6.1. Hydropower Project

The Souapiti Hydropower Project in Guinea, constructed by the China Three Gorges Corporation, adding 450 MW to the national grid.

**Table 2.** Comparison with Other African Hydropower Projects

Project	Cost (USD)	Capacity (MW)	Main financier
Souapiti (Guinea)	\$2B	450	China Exim Bank
Grand Ethiopian Renaissance Dam (GERD)	\$4.8B Bonds	5,150	Ethiopian Govt
Inga III (DRC) (est.)	14B	11,050	Mixed (China, World Bank)

## 7. East Africa: Renewable Energy Hub

Ethiopia and Kenya are two of the countries in East Africa that have implemented significant renewable energy projects that have received funding from China. Significant hydropower development is being accomplished with the construction of the Grand Ethiopian Renaissance Dam (GERD), which is partially funded and built by Chinese companies. Kenya makes use of the Rift Valley's geothermal potential in order to profit on the enormous investment that China has made in geothermal energy. There is a cluster of projects that are located in close vicinity to large river basins and geothermal hotspots, as revealed by GIS mapping. China has made significant investments in the energy sector, particularly in hydropower and renewable energy initiatives, and East Africa has emerged as a key destination for these efforts. China played a crucial part in the financing and construction of the Grand Ethiopian Renaissance Dam (GERD), which is one of the largest hydroelectric projects in Africa. Ethiopia has benefited significantly from this project. The author is Margaret Seymour (2020) [16]. Geothermal and wind energy have both been the subject of Chinese investments in Kenya. One example of this is the Lake Turkana Wind Power Project, which has benefited from Chinese aid. The countries of Tanzania and Uganda have been successful in obtaining financing from China for their hydropower and thermal power projects because of the growth of their various industrial sectors. The region is a main target for Chinese energy projects because of its strategic relevance, which is a result of the region's potential for economic expansion and the requirements for infrastructure development.

A number of countries, including Ethiopia, Kenya, and Tanzania, have benefited from geothermal and hydropower projects. The construction of the Grand Ethiopian Renaissance Dam (GERD), which was carried out with the assistance of Chinese contractors, is certainly a huge endeavor. The Gibe III Hydropower Project in Ethiopia is an endeavor that comprises

1,870 megawatts of power and is funded by Chinese funding. Kenya's Kipeto Wind Power Project is a 100 megawatt (MW) effort that was built in collaboration with Chinese manufacturing enterprises. In Kenya, there are initiatives to generate geothermal energy, and China is involved in drilling and the creation of transmission infrastructure.

## 8. Central Africa: Hydropower Dominance

Hydropower is the primary source of energy for Central African countries, particularly the Democratic Republic of the Congo (DRC) and Cameroon for the most part. The Inga Dam projects in the Democratic Republic of the Congo, which are backed by China, are poised to transform the energy capacity of the region. It is common for political volatility to have an effect on project timelines, as demonstrated by the postponement of efforts that were funded by China. The concentration of projects along the Congo River and other key waterways is depicted on geographic information system (GIS) maps.

The region of Central Africa, which is rich in natural resources but suffers from inadequate energy infrastructure, has been the target of China's involvement in power efforts. The Democratic Republic of the Congo (DRC) has been successful in luring Chinese funding for hydropower projects, most notably the Inga Dam series, which is intended to make use of the enormous hydroelectric capacity of the Congo River. There have been hydroelectric projects in Cameroon and Gabon that have been financed by China. These projects have the intentions of increasing the availability of power and stimulating industrial development. Taking into consideration the political instability and logistical challenges that the region faces.

In recent years, Chinese businesses have adopted a sensible strategy, which involves routinely combining energy efforts within broader infrastructure contracts. Imboulou Hydropower Plant, located in the Republic of Congo, is responsible for providing 120 megawatts of electric to the national grid. Located in the Democratic Republic of the Congo (DRC), the Zongo II Hydroelectric Project is an effort totaling 150 megawatts (MW) that is financed by China.

### 8.1. Zongo II Hydroelectric Project in the Democratic Republic of Congo (DRC)

**Table 3.** Expected Returns & Economic Impact

Metric	Value
Installed Capacity	150 MW
Annual Energy Output GWh Estimated ROI (Return on Investment)	1000 8-12% (long-term)
Job Creation (Direct & Indirect)	~5,000 jobs

## 9. Southern Africa: Diversified Energy Mix

Southern Africa encompasses a combination of coal, hydroelectric, and renewable energy initiatives. China's participation in South Africa's coal-fired power facilities, including Medupi and Kusile, corresponds with the nation's established coal infrastructure. Simultaneously, Zambia and Mozambique derive advantages from hydropower initiatives financed by China.

Kariba North Extension. GIS research indicates a significant link between resource deposits and project sites. Southern Africa, possessing a comparatively developed energy industry, has attracted Chinese investments in both conventional and renewable energy sources. South Africa, the economic leader of the continent, has partnered with China on coal-fired power stations, including the Medupi and Kusile plants, in addition to renewable energy initiatives.

Zambia has gained advantages from hydropower initiatives supported by China, notably the Kafue Gorge Lower Hydropower Station. Zimbabwe has obtained Chinese assistance for the enhancement of its thermal power facilities, notably the Hwange Expansion Project. China's involvement in the region is defined by enduring collaborations, frequently associated with extensive economic deals pertaining to mining and infrastructure development.

Investments in coal and hydropower projects have been observed in South Africa, Zambia, and Zimbabwe. The Hwange Thermal Power Station Expansion in Zimbabwe is a 600 MW coal-fired project funded by China. The Kariba South Hydropower Expansion in Zimbabwe is augmenting electric output by 300 MW. The De Aar Wind Farm in South Africa, significantly influenced by Chinese companies.

### 9.1. Kariba South Hydropower Expansion in Zimbabwe

**Table 4.** Comparison with Regional Hydropower Projects

Project (Country)	Capacity Added	Cost (USD)	Funding Sources
Kariba South (Zimbabwe)	300 MW	\$533m	AfDB, World
Cahora Bassa (Mozambique)	1,075 MW	\$2.3bn	China Exim
Grand Ethiopian Renaissance Dam (Ethiopia)	6,450 MW	\$4.8bn	Govt. Bonds, China

## 10.. Econometric Model, Data Sources, and Empirical Approach

### 10.1. Empirical Results

#### 10.1.1. Descriptive Statistics of the Main Variables

**Table 5.** Descriptive Statistics of the Main Variables

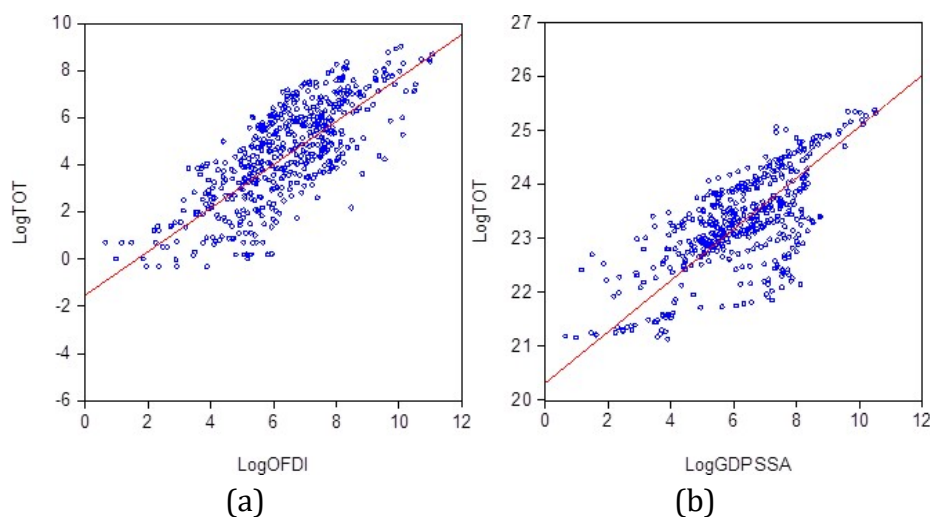
Variable	Obs.	Mean	Media n	Maximu m	Minimu m	Std. Dev.
$\ln ToT_{ijt}$	560	6.3708	6.3896	11.0855	0.6626	1.7922
$\ln BRL_{ijt}$	559	4.3644	4.6056	9.0412	-3.9120	2.2712
$\ln GDP_{jt}$	560	23.3453	23.271	26.8746	20.9058	1.2576
			1			
$\ln$ GDPPC <sub>it</sub>	560	7.9105	7.9105	10.6057	6.3249	0.9547
$\ln$ GDP <sub>it</sub>	560	29.425	29.425	30.0103	28.6971	0.4087
			1			
$\ln$ GDPPC <sub>it</sub>	560	9.1445	9.2020	9.6916	8.4562	0.3852
$\ln DS_{ij}$	560	9.2973	9.3294	9.4684	9.0264	0.1146
$\ln PG_{jt}$	560	16.255	16.375	19.0929	13.4396	1.2490
			3			
$\ln ER_{ijt}$	560	5.5391	6.1591	25.0267	-0.3592	3.2893
$BRL_{ijt}$	560	0.9500	1.0000	1.0000	0.0000	0.2181

Source: Authors' computation.

This study examines the bilateral trade and Belt and Road Initiative (BRI) between China and Sub-Saharan African (SSA) countries, encompassing a 16-year period before and after the initiative's introduction. Table 5 displays the descriptive statistics for all primary variables assessed in the gravity model empirical investigation. Bilateral trade served as the dependent variable in all estimation models (Table 5). The descriptive statistics indicate that there is no significant difference between the median and the mean of the dependent and independent variables, suggesting that our dataset follows a normal distribution. The overall count of observations indicated a satisfactory quantity of data for all variables. A well-balanced panel dataset was utilized. Nevertheless,

Because of the logarithmic transformation of the variable, the BRI observation was significantly different. As a consequence, the software did not take into account the negative BRI values. Based on the low dispersion of the distance variable, it can be deduced that the study sample, which consisted of countries in sub-Saharan Africa, had a minimal amount of geographical heterogeneity among the countries that were chosen.

The key independent factors, which include the Chinese Belt and Road Initiative (BRI), the Gross Domestic Product (GDP) of countries in Sub-Saharan Africa, and additional variables that were not mentioned for the sake of brevity, are shown to have a positive correlation with the dependent variable, which is bilateral trade, as shown in Figure 1. An opportunity to deepen our empirical inquiry was presented to us by the scatter plots, which merely demonstrated the degree of correlation that existed between the variables that were dependent and those that were independent. This study makes use of the TGM in order to investigate the effects of bilateral trade in conjunction with the independent variables and the countries that are part of the SSA border region.



**Figure 1.** Scatterplots Showing the Relationship Between Trade and Chinese BRI to the SSA BRI Countries

Notes: Figure 1(a) presents the scatterplot of the relationship between BRI and trade; Figure 1(b) shows the scatterplot of the relationship between trade and the SSA GDP growth.

## 10.2. Results and Discussions

Through the utilization of the well-established econometric models described in the empirical method, we were able to estimate the equations of the TGM model by making use of a panel dataset. Both random effects and fixed effects econometric regression models were utilized by us in order to facilitate comparison and validate reliable results. Furthermore, in order to ensure that our empirical findings are reliable, we proceeded to reevaluate the econometric models by employing the generalized method of moments (GMM) technique. This evaluation

included the use of both random and fixed-effect models. The outcomes of the estimations that are given in column 5 of Table 7 and 4 reveal that the variables BRI, GDP<sub>j</sub>, GDP<sub>i</sub>, GDPPC<sub>j</sub>, GDPPC<sub>i</sub>, and DS have an impact on the volume of bilateral trade that is statistically significant. The findings have provided additional evidence that our confidence in the validity of the findings is justified. These results indicate that there is no significant difference between the outcomes of the random and fixed effect estimations. While Table 6 exhibits the findings of the random effects and the system of GMM estimation, Table 7 displays the results of the fixed effects with GMM estimation. Both tables are presented beside one another. The results of the complete model (1–5) that were presented in Tables 7 and 6 (the models with random effects and fixed effects, respectively) demonstrated that bilateral trade is positively and significantly explained by countries in Sub-Saharan Africa are participating in the Belt and Road Initiative of China. The coefficient results for the primary explanatory variable of (ln BRI) demonstrated a positive and statistically significant effect across all models I to IV, including both fixed and random effect estimations (Tables 7 and 6). This indicates that Chinese BRIs significantly increase the volume of bilateral trade through their implementation. The calculated coefficient for Chinese BRI was 0.193 in the fixed effect model I (Table 7, column 1), which indicates that a 10% increase in the number of Chinese BRIs in SSA countries would result in a 1.93% increase in the overall volume of trade.

**Table 6.** Random Effect Regression Analysis Results Dependent variable: ln TOT

Variables	(1) Model I	(2) Model II	(3) Model III	(4) Model IV	(5) GMM <sup>a</sup>
Constant	-72.858 (12.817)	-49.061 (13.578)	-36.899 (4.223)	1221.565 (321.171)	1500.957 (163.078)
ln(BRI <sub>ijt</sub> )	0.205 (0.026)	0.205 (0.027)	0.569 (0.023)	0.305 (0.033)	0.131 (0.026)
ln(GDP <sub>jt</sub> )	0.883 (0.113)			0.294 (0.311)	0.216 (0.778)
ln(GDPPC <sub>jt</sub> )		0.997 (0.147)		0.299 (0.290)	0.365 (0.820)
ln(GDP <sub>it</sub> )	1.946 (0.110)			0.452 (0.336)	0.401 (0.267)
ln(GDPPC <sub>it</sub> )		1.047 (0.120)		1.996 (7.300)	0.475 (0.788)
ln(DS <sub>ij</sub> )	-3.247 (1.332)	-2.885 (1.397)	-4.059 (0.430)	-3.194 (0.412)	-0.404 (1.545)
ln(PG <sub>it</sub> )		0.645 (0.136)	0.230 (0.230)	0.304 (0.309)	0.404 (0.784)
ln(ER <sub>ijt</sub> )			-0.068 (0.144)	-0.032 (0.013)	-0.022 (0.0124)
BRI <sub>ijt</sub>	0.319 (0.308)	0.252 (0.310)	0.333 (0.233)	0.387 (0.232)	0.273 (0.299)
Obs.	559	559	559	559	559
R-Squared	0.758	0.756	0.609	0.702	0.810
Wald X <sup>2</sup>	348.294	285.646	172.322	143.039	

Notes: Values in the parentheses represent the robust standard errors used to correct the hetero- scedasticity; p < 0.10; p < 0.05, and p < 0.01 significance level.

During the process of gradually including all of the control and explanatory variables into model IV, the estimated coefficient of the BRIs decreased and demonstrated a tendency toward stability. The estimated coefficient of the BRI was 0.109 in Model IV, Table 7. This indicates that a 10% increase in the number of Chinese BRIs in SSA countries will result in a 1.09 percentage point increase in the total volume of trade. At a confidence level of 99%, the estimation of the BRIs variable consistently indicates a positive and statistically significant effect. This is the case across all four models. Based on the findings, it was determined that the connection between the Belt and Road Initiatives of China and the bilateral commerce in the countries of Sub-Saharan Africa demonstrates a complementary effect.

Our findings are consistent with those of Lu et al. (2018)[10], who found that the Chinese Belt and Road Initiative has a favorable affect on the total trade volume with countries that are part of the BRI. In particular with regard to overall exports, the Chinese Belt and Road Initiative has the capability of generating commerce rather than the The effect of substitution! According to the findings of the authors, the Chinese Belt and Road Initiative (BRI) did not considerably improve the number of export product categories. This indicated that the benefit of the Chinese Belt and Road Initiative (BRI) on trade creation is primarily derived from an increase in the intensive margins, rather than the extended margins (Lu et al., 2018)[10]. In addition, the conclusions of our research were validated by the research conducted by Ma et al. (2019)[11], who investigated the Belt and Road Initiative (BRI) and the Chinese BRI in the trade gravity market of European countries. According to their findings, the Belt and Road Initiative (BRI) that China has implemented in European countries has greatly boosted international trade between China and European markets.

Specifically, the Belt and Road Initiative (BRI) of China has been equally successful in promoting the export of Chinese products to the European market. However, it has not been successful in encouraging Chinese imports from the European market.

In addition, we investigated the robustness of both random and fixed models by employing the system GMM technique in model IV. As a result, the findings of the GMM estimation were roughly comparable for both models; hence, it is further obvious that our results were reliable. The results of our study provided additional evidence to support the theoretical and empirical arguments that foreign direct investment (FDI) plays a significant role in fostering international trade for the countries that are hosting it. In a study conducted by Martínez et al. (2012)[12], an empirical investigation was conducted to determine whether international commerce and foreign direct investment (FDI) had a complementary or substitutive impact within the European Union. A favorable and significant influence of international trade and foreign direct investment was shown to exist across a variety of cross-country samples in Europe, according to the findings of the research. Because of this, the authors claimed that European commercial trade and foreign direct investment mutually strengthen one another. This suggests that there is a complementing link between the two economic variables in Europe, rather than a replacement influence. According to the findings of our investigation, the assumption that the Belt and Road Initiative (BRI) of China and world trade have mutually reinforced one another is further supported by our findings. This finding is in line with the findings of previous empirical study on the objectives of the Chinese BRI in connection to trade. An investigation into the Chinese Belt and Road Initiative (BRI) and its export dynamics with developing nations was carried out by Li and Liang (2012) [9]. Their findings demonstrated that the BRI has a strong capacity to increase exports. Because of this, the authors claimed that the two economic factors have a relationship that is complementary to one another.

**Table 7.** Fixed Effect Regression Analysis Results Dependent variable: ln TOT

	(1)	(2)	(3)	(4)	(5)
Variables	Model I	Model II	Model III	Model IV	GMM
Constant	-47.913 (3.849)	-36.051 (8.109)	-42.393 (5.253)	1461.269 (149.545)	-43.569 (4.691)
ln(BRI <sub>ijt</sub> )	0.193 (0.040)	0.191 (0.027)	0.332 (0.025)	0.109 (0.023)	0.174 (0.066)
ln(GDP <sub>jt</sub> )	0.384 (0.224)			0.197 (1.033)	0.687 (2.565)
ln(GDPPC <sub>jt</sub> )		1.166 (0.232)		1.653 (1.021)	1.938 (2.539)
ln(GDP <sub>it</sub> )	0.769 (0.145)			0.133 (7.718)	0.570 (0.468)
ln(GDPPC <sub>it</sub> )		1.467 (0.227)		1.042 (8.146)	1.500 (0.110)
ln(PG <sub>jt</sub> )		0.659 (0.580)	0.918 (0.326)	0.435 (1.176)	0.648 (3.194)
ln(ER <sub>ijt</sub> )			-0.016 (0.014)	-0.127 (0.011)	0.029
BRI <sub>ijt</sub>	0.315 (0.334)	0.349 (0.338)	0.081 (0.361)	0.127 (0.279)	0.041 (0.700)
Obs.	559	559	559	559	559
R-Squared	0.923	0.921	0.908	0.947	0.918
Wald X <sup>2</sup>	164.051	204.320	136.173	222.329	

Values in the parentheses represent the robust standard errors used to correct the heteroscedasticity; p < 0.10; p < 0.05, and p < 0.01 significance level.

Both the random effects and fixed effects estimate models (Model I, Tables 6 and 7) have found that the explanatory variables of the SSA nations, namely market size (ln GDP<sub>jt</sub>) and the home country of China (ln GDP<sub>it</sub>), have been positively and statistically significant. This is the case in both models. In terms of the coefficient of influence, the Chinese (ln GDP<sub>i</sub>) were shown to be more than twice as significant as the SSA (ln GDP<sub>j</sub>) coefficient influence on the growth of trade between the two countries? It may be deduced from this that the augmentation of the volume of bilateral trade between China and SSA nations was mostly driven by the growth of the Chinese gross domestic product. The conclusion that was reached was consistent with the theoretical premise that was presented by Lu et al. (2018)[10]. This assumption said that a nation that has a higher GDP has a more significant impact on international commerce in relation to its trade partners. As an alternative line of reasoning, a larger domestic market size in a country often leads in an increased demand for international trade. This suggests that China will import less products from countries in sub-Saharan Africa (SSA) while simultaneously exporting a bigger variety of products to those countries. Particularly noteworthy is the fact that our findings coincide with the most recent report on the China–Africa trade relationship

that was released by the Ministry of Commerce of China. The findings of the report suggested that China has become Africa's most important trading destination. In 2018, the total volume of commerce exceeded 204.03 billion dollars, with China selling 104.75 billion dollars to Africa and purchasing 99.28 billion dollars from Africa.

Because of this, China was considered to have the highest gross domestic product (GDP) of any nation in comparison to the countries of Sub-Saharan Africa. China exported a bigger quantity of commodities to Africa, whilst the countries of Africa only exported a restricted variety of products to China. The Chinese Belt and Road Initiative in Sub-Saharan Africa, on the other hand, has resulted in a large increase in the level of local productivity and output in the nations that are located in this region.

When compared to the findings of Ma et al. (2019) [11], which found that the GDP growth of both the home country and the receiving country has a positive and significant influence on the volume of bilateral commerce between China and the European nations that are participating in the Belt and Road Initiative (BRI), the findings of the present analysis are in agreement with those findings. Furthermore, our findings are in agreement with those of Shahriar et al. (2019) and Lu et al. (2018) [17,10], who found that the Gross Domestic Product (GDP) of China and that of the countries that are hosting the Chinese Belt and Road Initiative have significantly increased exports. According to Lu et al. (2018) [10], the Belt and Road Initiative (BRI) of China and its trade margins had a beneficial impact on the amount of Chinese goods that were exported to the countries that are part of the BRI.

According to the factors that pertain to GDP per capita, it can be observed that the Chinese GDP per capita demonstrates a positive connection and a highly significant influence at the 99% confidence level. This is the case in both the random effects and fixed effects models. In addition, the per capita income of SSA nations has a positive association and is statistically significant at a confidence level of 99%; this is the case in both models. Despite this, the coefficients for the countries in sub-Saharan Africa are lower than the Chinese number, which suggests that the GDP per capita of China may continue to be a key factor in determining the volume of commerce that occurs between China and the countries in sub-Saharan Africa. Furthermore, the appearance of technical spillovers in countries that are destinations of the Belt and Road Initiative (BRI) may take some time.

According to Blanchard and Flint (2017), empirical studies and a large number of policy analysts have brought to light the possibility of significant uncertainties and dangers that could arise between China and the major economic powers of the world. It is [2]. It is possible that the potential uncertainties are related to the potential disagreement that could arise between China and ascendant countries like the United States of America, Japan, India, Russia, and other developing and emerging economies in Sub-Saharan Africa about investment (Li and Liang, 2012; Shahriar et al., 2019). It is [9,17]. Concerns are raised among the opposing parties on both sides as a result of the fact that it is projected that China would surpass the GDP of the United States in the future decades and emerge as the preeminent global economy. In addition, China's initial investments in nations that are part of the Belt and Road Initiative (BRI) need to be carried out with caution. It is necessary for it to include the facilitation of collaboration among existing partners within the frames of the Belt and Road Initiative (Shahriar et al., 2019). It is [17]. It is possible that rising economies would be disproportionately affected by challenges pertaining to finance, governance, society, the environment, geopolitics, and security; hence, it is imperative that all participating countries share in the responsibility for addressing these concerns (Blanchard and Flint, 2017). It is [2]. China is considered to be the initiator of the Belt and Road Initiative (BRI).

A worldwide mission for shared interests and collective prosperity, the ideals of inclusivity, openness, mutual trust, transparency, and cooperation among member countries for equitable

chances constitute not only China's strategy but also a worldwide mission for shared interests and common prosperity.

## 11. Conclusion

The energy collaboration between China and Africa has the potential to drive Africa's economic development through the implementation of innovative energy solutions and strategic collaborations. Future power cooperation projects have the potential to achieve increased efficiency, cost-effectiveness, and ecological sustainability through the utilization of renewable energy, intelligent grid technology, and sustainable finance frameworks. A commitment to capacity building, regulatory changes, and regional integration will strengthen China's energy connections with Africa, so ensuring the continent's continued economic growth and energy security over the long term.

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