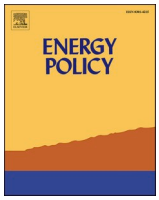
Energy Policy 192 (2024) 114198

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol



The impact of Chinese investment on energy independence in Africa

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ARTICLE INFO

Keywords:
Chinese investment
China-Africa engagement
Energy independence
Africa
Foreign direct investment
Natural resources

ABSTRACT

This paper examines the relationship between Chinese investment and energy independence in Africa. We use panel data from 28 African countries between 2003 and 2022. We employ robust econometric identification strategies, including fixed effect ordinary squares and the Two-step System Generalised Method of Moment. Our results are as follows. First, we find a positive and significant relationship between Chinese investment and energy independence, suggesting that the flow of Chinese monies in Africa is increasing the domestic energy production capacity. Second, the results are more pronounced in resource-rich countries, consistent with the expectation that China is attracted to resource-endowed countries. Third, we also found that institutional quality does not significantly moderate the relationship between Chinese investment and African energy independence. The results imply that contrary to the negative publicity on China-Africa engagement, China may be a good partner for promoting energy independence and attainment of sustainable development goals and commitment to sustainable energy for all initiatives. The results are robust to alternative measurement and not sensitive to potential endogeneity.

1. Introduction

Over the last decades, China has built a complex and multifaceted relationship with Africa, encompassing economic, political, diplomatic, and cultural dimensions (China Africa Research Initiative, 2023; Jiang, 2009; V. Tawiah, Kebede et al., 2022). Through these relationships, China has invested billions of money into the African economy (Omolere, 2023; United Nations Environment Programme, 2023). According to the China-Africa Research Initiative by John Hopkins University, the amount of Chinese investment in Africa increased from US$ 75 million in 2003 to US$ 5 billion in 2021 (China-Africa Research Initiative, 2023). While these investments and other interventions, such as loans and foreign aid by China, have brought economic opportunities and development to some African countries, it has also raised important questions and challenges that both China and African nations continue to grapple with as they navigate their evolving partnership (Omolere, 2023; W. Shen, 2020).

The energy sector remains a crucial point for discussion in these mixed feelings about Chinese investment in Africa. On the one hand, China claims to be the relevant and ultimate partner for solving Africa's energy problems through its numerous investments in alternative energy production (United Nations Environment Programe, n.d.; Voice of America, 2023). On the other hand, critics suggest that the rapid growth of China and its industrialization agenda in Africa is accelerating energy demand in the continent at an increasing rate (Omolere, 2023; W. Shen, 2020). Further, China is in the business of extracting and exporting finite natural resources including oil and gas in Africa (Jiang, 2009; Marsh, 2015). The increasing energy consumption combined with extra oil and gas resource extraction could threaten Africa's energy independence. However, the huge investment in various energy projects including hydropower, solar and wind farms also suggest that the presence of China in Africa could offer energy independence.

Chinese investment is likely to increase energy independence in Africa through numerous channels including the following. First, many energy infrastructure are developed from Chinese investment (United Nations Environment Programme, 2023; Voice of America, 2023). Due to the Chinese likeness for natural resources most energy infrastructure are developed outside the cities which increases energy independency. Another channel through which Chinese investment increase energy independency is diversifications. Chinese investment encourage different energy mix including renewable and non-renewable (Fung et al., 2004; Kang et al., 2018). Further more, Chinese investment brings

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https://doi.org/10.1016/j.enpol.2024.114198
Received 27 November 2023; Received in revised form 2 May 2024; Accepted 22 May 2024
Available online 4 July 2024
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advanced technologies and know-how that improve energy efficiency and enhance the utilization of domestic energy resources, reducing the need for energy imports (Li et al., 2020; Rui et al., 2016).

Based on this complex and contrasting relationship between Chinese investment in the energy sector in Africa, we examine the impact of Chinese investment on energy independence in Africa. Energy independence refers to a country's ability to meet its energy needs primarily from domestic sources without relying heavily on imports (Deutch, 2005). Therefore, we measure energy independence by the total amount of imported energy as percentage of total energy consumption. Chinese investment is m the amount of direct Chinese investment stock in the country (V. Tawiah, Kebede. We collect data from 28 sample countries between 2003 and 2014. We employ robust econometric identification strategies including the fixed effect ordinary least squares and the Two-step System Generalised Method of Moments to control for potential endogeneity issues.

Our results are as follows: first, we find a positive and significant relationship between Chinese investment and energy independence, suggesting that the flow of Chinese monies in Africa is increasing the domestic energy production capacity. Second, we find that the result is more pronounced in resource rich countries, which is consistent with the expectation that China is attracted to resource endowed countries. Third, we also found that institutional quality does not significantly moderate the relationship between Chinese investment and energy independence in Africa. The results imply that, contrarily to the negative publicity on China-Africa engagement, China may be good partner for promoting energy independence and attainment of sustainable development goal and commitment to sustainable energy for all initiative.

Our studies extend prior studies on energy independence and consumption (Flores-Chamba et al., 2019) with new perspectives from Africa. In addition to the African angle, our analysis on the Chinese investment offers a new insight on how international business influence energy independence. Existing studies on international business-sustainability nexus largely focus on energy consumption (Paramati et al., 2016; Sarkodie and Strezov, 2019) and carbon emission (Huang et al., 2022; Shahbaz et al., 2015, 2017; V. K. Tawiah et al., 2021). For example, Huang et al. (2022) examine the impact of Sino-African trade on carbon intensity. The findings of these prior studies are dominated by the negative results of foreign direct investment increasing energy consumption and carbon emission. These studies pay little attention to how foreign direct investment could increase domestic energy production and enhance energy independence. Energy independence is a critical component of sustainable development and hence requires attention. Furthermore, unlike prior studies (Ekwueme et al., 2021; Kivyiro and Arminen, 2014; Sarkodie and Strezov, 2019) which considered FDI from multiple countries, our studies focuses on foreign direct investment from a single country. China presents an interesting phenomenon. On the one hand, extraction and exporting of natural resources such as oil and gas is crucial in China-African engagement. On the other hand, China is putting significant investment in the energy sector of most African countries consistent with its commitment to international sustainability via reduction of fossil fuel consumption (McKinsey & Company, 2017; Voice of America, 2023). These contrasting unique of Chinese international engagement offers interesting insights on how foreign direct investment from a single country affect energy independence.

The topic of energy independence has never been more important and interesting than recent times. Given the global tension and the use of fossil fuel as a war weapon (Rodríguez-Fernández et al., 2020; Shepard & Pratson, 2022, 2022, 2022; Żuk and Żuk, 2022), it is increasing important for countries to examine the injectors and linkages of their energy independency. Further energy independency is one of the significant routes towards sustainable development and the achievement of Goal 7 of the sustainable development goals (Dmytrów et al., 2022). Energy independency is also relevant for the attainment of Sustainable Energy for all Initiative, a commitment of which many African countries are signatories (Aluko et al., 2023).

The remainder of the paper are as follows. In the next section, we present case studies of Chinese energy projects in Africa. The concept and literature review on energy independency are presented in Section 3. In Section 4, we discuss the research methods, including the sample selection, description of variables and econometric modelling. The results and discussion of the empirical estimations are presented in Section 5. The paper concludes in Section 6 with policy implications, limitations, and suggestions for future research.

1.1. Case studies on the Chinese investment in the energy sector of Africa

In this section, we present three cases that showcase some major Chinese investment in the energy sector. We choose these three projects to represents the different facets of Chinese energy investment in Africa. We focus more on the renewable energy infrastructure which forms a significant part of Chinese investment in Africa (China-Africa Research Initiative, 2023). The first, Lake Turkana Wind Power Project in Kenya project represent the largest non-hydro renewable energy infrastructure in Africa. The second case, Kariba North Bank Extension in Zambia highlight how China engage with different stakeholders and undertake projects even in areas with some resistance. The project also show the ongoing Chinese investment in the Southern part of Africa. The third case, Grand Ethiopian Renaissance Dam (GERD) highlight project where China partially invested and collaborated with other investors including the host government.

1.2. Lake Turkana Wind Power Project in Kenya

The Lake Turkana Wind Power Project, located in northern Kenya, is one of the largest wind farms in Africa and a flagship renewable energy initiative supported by Chinese investment. The Lake Turkana Wind Power Project has a capacity of 310 MW (MW) and is expected to provide approximately 17% of Kenya's electricity needs. By harnessing wind energy, the project contributes to reducing greenhouse gas emissions and mitigating climate change. The construction and operation of the wind farm have created employment opportunities for local communities and stimulated economic development in the region. Additionally, the project enhances energy security by reducing reliance on imported fossil fuels.

The project faced financing challenges and contractual disputes during the construction phase, leading to delays and cost overruns. Resolving these issues required close collaboration between the Kenyan government, Chinese investors, and project developers. The Lake Turkana Wind Power Project exemplifies the potential of Chinese investment to drive renewable energy development and contribute to energy independence in Africa. While facing challenges, the project underscores the importance of strategic partnerships, sound governance, and robust infrastructure planning to realize the full benefits of renewable energy investments.

1.3. Kariba North Bank Extension project - Zambia

The Kariba North Bank Extension Project, located on the Zambezi River in Zambia, is a major hydroelectric initiative supported by Chinese investment. The Kariba North Bank Extension Project adds 360 MW of clean, renewable energy capacity to Zambia's electricity grid, contributing to energy security and reducing reliance on imported fossil fuels. The project strengthens Zambia's position as a regional energy hub, with the potential to export surplus electricity to neighbouring countries. Hydroelectric projects involve substantial upfront investment and complex project management processes. Ensuring adequate financing, effective project governance, and transparent procurement practices are essential for the successful implementation of such projects. The Kariba North Bank Extension Project demonstrates the transformative potential of Chinese investment in hydroelectric development in Zambia and

across Africa. While facing challenges, the project highlights the importance of sustainable development principles, stakeholder engagement, and effective project management to maximize the benefits of hydroelectric investments for energy independence and economic growth.

1.4. Grand Ethiopian Renaissance Dam (GERD)

One notable example of Chinese investment in African energy is the construction of the Grand Ethiopian Renaissance Dam (GERD). China's involvement in the GERD project illustrates both the opportunities and challenges associated with Chinese investment in Africa's energy sector. The GERD project, financed partially by Chinese banks and constructed by Chinese companies, aims to become Africa's largest hydropower dam upon completion. It promises to provide Ethiopia with a reliable source of electricity, thereby boosting industrialization and economic growth. The GERD project has the potential to enhance regional cooperation and energy integration, as Ethiopia plans to export surplus electricity to neighbouring countries, including Sudan and Egypt.

However, Chinese financing for energy projects in Africa may involve concessional loans with favourable terms, but it also exposes recipient countries to debt sustainability risks and potential dependency on Chinese creditors. Also, the GERD project has sparked geopolitical tensions between Ethiopia, Sudan, and Egypt over water rights and downstream impacts, highlighting the complexities of managing transboundary water resources.

The above three case studies evidence the potential impact of Chinese investment on sustainable energy production and energy independence in Africa. The case studies also highlight the significant risk associated with Chinese investment in the region.

1.5. Literature review

Energy independence refers to a state or condition in which a nation or region is not overly reliant on external sources for its energy needs. Instead, it produces a significant portion of its energy domestically, reducing its vulnerability to supply disruptions, price fluctuations, and geopolitical tensions related to energy imports (Deutch, 2005; Jewell et al., 2016; Yemelyanov et al., 2019). The relevance of energy independence to national growth cannot be overemphasized (Hakes, 2008). First, energy independence enhances national security by reducing a country's exposure to external energy supply disruptions (Mara et al., 2022; Shepard and Pratson, 2022). Relying heavily on energy imports from politically unstable regions or countries can leave a nation vulnerable to economic and strategic threats (Jewell et al., 2016). Further, the Russia-Ukraine war has highlighted the importance of energy independence in relation to geopolitics (Shepard and Pratson, 2022). Prior studies show that geopolitical risk has a negative impact on investment in energy (Abbas et al., 2023). Also, a stable and secure energy supply is crucial for economic stability and growth (Pao and Fu, 2013; Yemelyanov et al., 2019). Energy independence helps insulate a country's economy from the volatility of global energy markets and price fluctuations (Ebrahim et al., 2014). Regarding climate change, energy independence provides an opportunity to prioritize cleaner and more sustainable energy sources (Bang, 2010; Jewell et al., 2016). Liu et al. (2023) suggest that a country can invest in renewable energy and reduce its reliance on fossil fuels, which contributes to mitigating climate change and reducing environmental impacts. Energy independence also increases energy affordability and access in the country (Sovacool and Saunders, 2014).

Given the central importance of energy independence in economic growth and sustainable development, it has become a top priority for countries to reduce their dependency on the international energy market. For instance Flores-Chamba et al. (2019) suggest that various policies in the EU reduce energy consumption and thereby increase energy independence. Arguably, reducing dependency on energy imports requires an increase in domestic energy production, which is both capital-intensive and has a long gestation period. Over the last decades, China has positioned itself as the best partner for most developing countries in terms of energy infrastructure. Indeed, China is considered by many as the ultimate partner to help Africa overcome its energy crisis (McKinsey & Company, 2017; Voice of America, 2023). According to the Voice of America (2023). The transition from fossil fuels in Africa is part of China's aims to deliver its international climate commitments. These claims are evidenced in the large Chinese investments in many energy projects on the continent. Among the numerous Chinese energy projects are hydropower in Ghana and Zambia, photovoltaic power generation in Kenya, and wind power in Ethiopia. (Bociaga, 2023), suggest that China has increased its investment in the energy sector of Africa by tenfold in the last decade.

These Chinese investments in energy may potentially contribute to the energy independency of many African countries. First, Chinese investments encourage the diversification of a country's energy mix (Fung et al., 2004; Kang et al., 2018). For example, investment in renewable energy projects such as the hydropower and solar can increase the share of clean and domestically-produced energy in the country's energy portfolio (Baker, 2015; Eshchanov et al., 2011). This diversification can enhance energy independence by reducing reliance on imported fossil fuels. Second, the Chinese investment often brings advanced technologies and know-how to the host country (Landry and Chen, 2021; V. K. Tawiah et al., 2021; Xia, 2019; Yunnan et al., 2016). These technologies can improve energy efficiency and enhance the utilization of domestic energy resources, reducing the need for energy imports (Li et al., 2020; Rui et al., 2016). Prior studies shows that there is technological transfer with Chinese trade (Huang et al., 2017, 2022). Huang et al. (2022) reports that Chinese import to Africa is negatively associated with carbon intensity through technology spill over. Third, Chinese investment can also lead to developing energy infrastructure, such as power plants, pipelines, and distribution networks (United Nations Environment Programme, 2023; Voice of America, 2023). This can enhance a country's domestic energy production capacity, making it less dependent on energy imports. Finally, Chinese investments have contributed to increasing access to electricity in many rural parts of African countries (Aluko et al., 2023; Byaro and Mmbaga, 2022). Given its likeness for to natural resources, some Chinese projects are done in rural areas. Though some of these projects may not be energy-related, the Chinese will need to develop energy production to ensure the operation is running in rural areas. This can improve energy security and promote energy independence (Ren et al., 2022, 2024) by reducing the dependence on traditional and often imported fuels such as diesel generators.

Notwithstanding these potential benefits of Chinese investment, it is also likely that the flow of Chinese investment in Africa is increasing energy dependency in the African countries. First, it is well established that China is in Africa because of its natural resources, including oil and gas (Omolere, 2023; W. Shen, 2020; X. Shen, 2015). Indeed, most of the largest recipients of Chinese investment are oil and gas-endowed countries (China Africa Research Initiative, 2023; Gong et al., 2023; V. Tawiah et al., 2022; V. K. Tawiah et al., 2021). Therefore, the extracting and exporting of oil and gas may lead to the depletion of these resources, reducing long-term energy independence (Jiang, 2009; Pegg, 2012). Chinese investments may prioritize energy exports to China over domestic consumption in some cases, potentially hindering a country's efforts to achieve energy independence. Second, although China is building modern energy production units with advanced technology, most these are operated by Chinese themselves, hence it may also make the host country dependent on foreign technology providers, potentially compromising energy security (Song, 2011; Tan-Mullins et al., 2017). In some cases, Chinese investors may have significant ownership and control over energy assets, which could affect a country's ability to make sovereign decisions about its energy resources (Klaver and Trebilcock, 2011; W. Shen, 2020; X. Shen, 2015). Third, the critics suggest that the rapid growth of China and its industrialization agenda in Africa is

accelerating energy demand in continent at an increasing rate. Most Chinese investment is energy-intensive industries, hence energy importation will increase to meet the increasing energy consumption of Chinese industries in Africa (W. Shen, 2020; V. K. Tawiah et al., 2021).

These contrasting arguments and rising dominance of China in the energy sector of many African countries provides intriguing perspective of how the ever growing China-Africa relationship either promote or hamper energy independency in the continent. Arguably, these unique characteristics of China-Africa engagement with regards to the energy sector offers a research gap worthy of empirical investigations.

Despite the compelling arguments of the potential downside of Chinese investment on energy independence in Africa, the huge investment in energy projects to date offers more positive evidence on the topic (Omolere, 2023; United Nations Environment Programe, n.d.; Voice of America, 2023). These large investments in the energy sector showcase Chinese commitment to the energy independency in Africa. Consequently, we expect the flow of Chinese investment into African countries to decrease energy import and hence increase energy independence. We therefore hypothesis that.

H1. *Chinese investment is associated with increase in energy independency in Africa.*

2. Research methods

2.1. Sample selection

Given the objective of this study is to examine the impact of Chinese investment on energy independence in Africa, we begin our sample selection from all countries recognised by the African Union within the continent. Currently the African Union recognised 55 African countries (African Union, 2023). We drop five (5) countries because of missing data from the China African Research Initiative. Next, we drop 17 countries with missing data on the main variable, energy independence proxied by energy imports. We also drop countries with insufficient data on the control variables. Our final sample selection yields 28 African countries between 2003 and 2022. Our sample period begins in 2003 because it is the earliest date at which data on Chinese investment is available at the China African Research Initiative. We also source data from the World Governance Indicators. The list of countries is presented Table 1.

Dependent variable (Energy independence): Energy independence refers to a country's ability to meet its energy needs primarily from domestic sources without relying heavily on imports. Consistent with prior studies, we measure energy independence by energy imports. According to the World Development Indicators, Energy import is net energy imports are estimated as energy use less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport. Therefore, a country needs to lower its energy imports to achieve energy independency. Consequently, for the purpose of this study, lower import figures indicate independency. Energy import is measured as the percentage of energy use. This approach is also consistent with prior studies (Flores-Chamba et al., 2019; Shahbaz et al., 2019) Data on energy imports is sourced from World Development Indicators by the World Bank. Given the nature of the dependent variable as a decrease indicating energy independence, a negative coefficient of the independent variable implies positive effect on the dependent variable.

Table 1
List of sample countries.

Algeria	Mauritius
Angola	Morocco
Benin	Mozambique
Botswana	Namibia
Cameroon	Niger
Congo, Dem. Rep.	Nigeria
Congo, Rep.	Senegal
Cote d'Ivoire	South Africa
Egypt, Arab Rep.	Sudan
Eritrea	Tanzania
Ethiopia	Togo
Gabon	Tunisia
Ghana	Zambia
Kenya	Zimbabwe

Independent variable (Chinese investment). The main independent variable of this study is investment from China into African countries. Consistent with prior studies (bring at least 4 citations), we measure Chinese investment as the stock of foreign direct investment from China into a sample country in a sample year. In line with prior studies (Kolstad and Wiig, 2011; V. Tawiah et al., 2022; V. K. Tawiah et al., 2021) we use the natural logarithm format of the amount to mitigate the effect of country size on the stock of investment. Following prior studies we source data on Chinese investment from the China-African relationship Research Initiative by John Hopkins University.

Control variables. We admit that energy independence could be driven by host of factors and any attempt to control for all these factors is nearly impossible. However, we follow prior studies to include some salient factors found to influence energy independence (Atalla and Bean, 2017; Demski et al., 2018). First, we include economic development and economic growth measured by GDP per capita and GDP growth respectively. High GDP per capita indicates high level of development and capacity for the country to developed domestic energy production (Atalla and Bean, 2017). However economic growth means that the country might need more energy to power its industrialization and infrastructure development, hence increasing energy imports and decreasing energy independence (Chu et al., 2023). Therefore, we predict a positive and negative outcome for economic development and economic growth respectively. Second, we include population and population growth to control demographic factors. Prior studies suggest that large populated and fast-growing countries will need external source of energy to support domestic consumption. Hence we expect these demographic factors to exert negative impact on energy independence (Atalla and Bean, 2017; Demski et al., 2018). Third, energy independency depends on the ability of the country to construct energy infrastructures in the country, hence capital formation and credit are relevant factors that drive energy independency (Pimonenko et al., 2022). Therefore, we include gross domestic savings and credit to private sectors to control the effect of availability of finance in the country. We include energy consumption as the final set of control variable. Arguably, the level of energy consumption in the country is a significant factor in any discussion of energy independence. High energy consumption will lead to high energy imports which hampers energy independence. Data on control variables are collected from World Development Indicators. Table 2 presents the description and sources of the variables.

2.2. Econometric modelling

Although most studies on international business and energies rely on the fixed effect estimations, it is not always the case. Hausman (1978) suggest that the choice of particular model should be based on empirical evidence of the suitability of the dataset. Inappropriate choice of the modelling could lead to bias results. Consequently, to allay any concern of bias and super furious results, we perform different econometric test to determine the appropriate estimation strategies based on the sample data. Consistent with prior studies, we perform the (Hausman, 1978) test to choose between the random and fixed effect ordinary least squares. The selection of particular model depends on the null

Table 2
Description and source of variables.

Variable name	Description	Sources
Energy independence	Energy independence is measured by energy imports which is net energy imports are estimated as energy use less production, both measured in oil equivalents. A negative value indicates that the country is a net exporter. Energy import is measured as percentage of energy use.	World Development Indicators
Chinese investment	The natural logarithm of the amount of foreign direct investment stock in year per a sample country.	China-Africa Research Initiative
Control variables		
Economic development	Economic development is measured by gross domestic product (GDP) per capita. GDP per capita is gross domestic product divided by midyear population. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current U.S. dollars.	World Development Indicators
Economic growth	Economic growth is measured by gross domestic product growth (GDP growth). Annual percentage growth rate of GDP at market prices based on constant local currency. Aggregates are based on constant 2015 prices, expressed in U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products.	World Development Indicators
Population	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	World Development Indicators
Population growth	Annual population growth rate for year t is the exponential rate of growth of midyear population from year t-1 to t, expressed as a percentage. Population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship.	World Development Indicators
Gross domestic savings	Gross domestic savings are calculated as GDP less final consumption expenditure (total consumption).	World Development Indicators
Domestic credit	Domestic credit to private sector refers to financial resources provided to the private sector by financial corporations, such as through loans, purchases of nonequity securities, and trade credits and other accounts receivable, that establish a claim for repayment.	World Development Indicators
Energy consumption	Energy use refers to use of primary energy before transformation to other end-use fuels, which is equal to indigenous production plus imports and stock changes, minus exports and fuels supplied to ships and aircraft engaged in international transport.	World Development Indicators
Variables for further analysis		
Institutional quality	This average of the six World Governance Indicators namely; control of corruption, political stability, government effectiveness, rule of law; regulatory quality; voice and accountability.	World Governance Indicators
Resource rent	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	World Development Indicators

hypothesis that there is no correlation between the unique errors and the repressors in the model. Our un-tabulated results leads to rejection of the null hypothesis indicating that the fixed effect is more appropriate than the random effect. We specify our baseline model as follows;

$$\begin{aligned} Energy\ independence_{it} &= \alpha + \beta_1 Chinese\ investment_{it} \\ &+ \beta_2 Economic\ develoment_{it} + \beta_3 Economic\ growth_{it} \\ &+ \beta_4 Population_{it} + \beta_5 Population\ growth_{it} + \beta_6 Gross\ domestic\ savings_{it} \\ &+ \beta_7 Domestic\ credit_{it} + \beta_7 Energy\ consumption_{it} + \varepsilon_{it} \end{aligned} \quad \text{EQ1}$$

3. Results and discussion

3.1. Descriptive statistics

The descriptive statistics of all the variables used in the econometric estimations are presented in Table 3. The descriptive statistics include the mean, standard deviation, 25th percentile, median and the 75th percentile. The mean of the energy independence is −69.86% suggesting that on average over the sample period most African country net energy export from the sample countries is equivalent to 70% of their energy consumption. However, there is large variation across the sample as evidence by the high standard deviation and the significant difference between the mean and the median. This variation indicates that the countries are at varying levels of energy independence which is worthy of empirical investigations. Regarding the main independent variable, Chinese investment, the mean of 4.365 (log form) is equivalent of US$ 365 million US dollars investment stock per year across the sample period. Similar to the dependent variable, the high standard deviation of 2.018 indicate significant variation among the sample countries.

3.2. Correlation matrix

As part of the pre-estimation check, we perform the pair wise correlation matrix among the independent and control variables. Prior studies suggest that high correlation among the independent and control variables possess threat of multicollinearity which could bias the results (Tabachnick and Fidell, 2013). The Pearson pairwise correlation matrix is presented in Table 4. It can be observed from the results that, the highest coefficient is 0.43 which is lower than the standard threshold (0.8) to posse any potential multicollinearity threat (Field, 2000; Tabachnick and Fidell, 2013).

3.3. Baseline results

The results of the econometric estimations are presented in Table 5. To ensure robustness of the results and allay the concern that the results are driven by particular set of control variables, we follow prior studies (Alam et al., 2019; V. Tawiah et al., 2022) to run equation (1) (EQ (1)) in

Table 3
Descriptive statistics.

VARIABLES	(1)	(2)	(3)	(4)	(5)
	mean	sd	p25	p50	p75
Energy independence	−69.86	225.4	−26.26	5.738	29.92
Chinese investment	4.365	2.018	3.096	4.479	5.976
Natural resources	12.42	11.74	3.963	7.995	16.43
Domestic credit	26.28	29.07	9.962	15.17	26.36
Energy consumption	72.02	220.3	9.962	15.93	28.84
Economic growth	4.754	4.359	2.964	5.091	6.851
Gross domestic savings	20.02	18.11	8.998	17.18	30.44
Institutional quality	−0.596	0.635	−1.059	−0.612	−0.256
Economic development	7.292	1.043	6.510	7.244	8.150
Population growth	2.393	0.882	1.810	2.630	2.946
Population	16.56	1.261	15.83	16.78	17.43

Table 4
Correlation matrix.

	1	2	3	4	5	6	7
Chinese investment	1						
Economic development	0.28	1					
Economic growth	0.1	−0.07	1				
Population	0.33	−0.32	0.18	1			
Population growth	0.07	−0.43	0.22	0.2	1		
Gross domestic savings	0.22	0.38	0.14	−0.03	0.14	1	
Domestic credit	0.15	0.30	−0.12	−0.04	−0.31	−0.09	1
Energy consumption	0.19	0.28	−0.07	0.13	−0.26	0.35	0.04

Table 5
Baseline results.

VARIABLES	(1)	(2)	(3)
	No control	With controls	With Year/Country effect
Chinese investment	−6.945[c]	−4.221[c]	−1.619[b]
	(-3.362)	(-2.891)	(-2.313)
Economic development		−17.434[c]	−9.066[b]
		(-2.735)	(-2.322)
Economic growth		−0.828	−0.546
		(-0.937)	(-0.588)
Population		3.188[c]	4.719[c]
		(4.671)	(3.890)
Population growth		4.541[c]	4.787[c]
		(3.780)	(3.716)
Gross domestic savings		−0.230[b]	−0.589[c]
		(-2.357)	(-2.828)
Domestic credit		−1.200[a]	−1.077
		(-1.832)	(-1.542)
Energy consumption		0.723[c]	0.751[c]
		(5.127)	(5.174)
Constant	−9.740[c]	−5.125[c]	−7.032[c]
	(-10.147)	(-4.869)	(-3.836)
Year effect			Yes
Country effect			Yes
R-squared	0.036	0.251	0.262
Number of countries	28	28	28

t-statistics in parentheses.
[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

three specifications. First, we estimate the relationship between Chinese investment and energy independence without the control variables and the results are presented in column 1 of Table 5. In the second specification, we include controls as describe in the methodology and the results are presented in column 2. Finally in the third specification we consider the country and year effect and the results are presented in column 3. The variable of interest in all the three columns is Chinese investment. The coefficient of Chinese investment is negative and enters into significant at 5% or better. The is indicate a significant negative relationship between Chinese investment and energy imports in the sample countries. Given that, energy independence is about decreasing energy imports, the results imply that the flow of Chinese investment decrease energy importation thereby boosting energy independence. The results provide empirical support to the acceptance of the hypothesis that Chinese investment is associated with increase in energy independence. The results evidence the huge investment in the energy sector by China in Africa. For example, China has been involved in major energy projects such the Buai Dam in Ghana and Kafue Gorge hydroelectric station in Zambia, the Garissa photovoltaic power generation in Kenya and Sakai Photovoltaic Power Station in Central Africa Republic and the Aysha Wind Farm in Ethiopia. These investments in the energy sectors have not only boost domestic energy production but also increase clean and sustainable energy supplies. These projects and investments are also in line with China's aims to deliver its international climate commitments through the transition from fossil fuels (Voice of America, 2023). In sum the econometric estimations are consistent with prior studies that, some of the China-Africa partnership offers positive effect on the continent, particularly in sustainable development (X. Chu et al., 2023; Mol, 2011; V. K. Tawiah et al., 2021). China is potential partner for the achievement of the Goal 7 of sustainable development, affordable and clean energy and the fulfil of commitment of the Sustainable Energy for all Initiative.

The results of the control variables are consistent with prior studies and standard assumptions. For instance, demographic factors such as population and population growth increases energy imports and decrease energy independence. Similarly high energy consumption hampers energy independence.

3.4. Endogeneity check

The common source of potential endogeneity is situation where the dependent variable could significantly drive the changes in the independent variable (Arellano and Bond, 1991). This is phenomena is commonly referred to reverse causality. Arguably the probability for Chinese investment in Africa to significantly depend on the level of energy import is less plausible because these investment are done mostly on economic, political and diplomatic rationale. Nevertheless, there could be other sources of potential endogeneity such as the contemporary effect of the dependent variable (Arellano and Bond, 1991; Hausman, 1978). That is the current year level of energy imports is likely to be dependent on the previous year imports. Therefore in this section we employ two econometric identification strategies to address these potential endogeneity issues.

First, we consider the lagged effect of the dependent variable in model and include one year lag of energy independence as control variable in equation (1) (EQ (1)). The results are presented in column 1 of Table 6. The coefficient of Chinese investment remains negative and highly significant at 1 percent. The results confirm the baseline results that Chinese investment decrease energy importation and thereby increase energy independence in Africa. That is lagged of the dependent variable do not affect our baseline estimations.

In the second endogeneity check, we employ the Two step-System Generalised Method of Moment (S-GMM) by (Arellano and Bover, 1995). The Two-step S-GMM mitigate the contemporary effect of the dependent variable by differencing and using the lagged values as instruments for the endogenous variable (Arellano and Bond, 1991; Huang et al., 2022; V. Tawiah et al., 2022). The Two-step S-GMM is more preferrable over the ordinary two-stage least squares and generalised method of moments because it overcome the challenge of weak instruments suffered by these models (Arellano and Bond, 1991; Arellano and Bover, 1995). The results of the Two-step S-GMM are presented in column 2 of Table 6. The coefficient of the variable of interest, Chinese investment is negative and enters significant at 1%.

In the third robustness, we use Instrumental Variable Two Stage Least Square (IV 2SLS) to address possible bidirectional relationship between Chinese investment and energy independence. We use corruption as instrumental variable. Prior studies indicate that corruption in Africa is associated with Chinese investment (V. Tawiah et al., 2022). The results are presented in column 3 of Table 6.

In the fourth and final robustness check we follow (Ikpesu et al., 2019) to employ the Panel Corrected Standard Errors (PCSE). The results are reported in column 4. The results are qualitatively similar to the baseline results that Chinese investment are associated with increase in the energy independence. The econometric estimations in Table 6, therefore confirm our main results are not sensitivity to potential endogeneity issues.

Table 6
Endogeneity check.

VARIABLES	(1)	(2)	(3)	(4)
	Lagged effect	S-GMM	IV 2SLS	PCSE
Chinese investment	−1.988[c]	−1.262[c]	−225.824[b]	−0.900[b]
	(-2.734)	(-3.942)	(-2.410)	(-2.539)
Lagged of dependent variable	0.858[c]	0.904[c]		0.928[c]
	(28.397)	(55.900)		(14.121)
Economic development	−10.690[c]	−0.064[b]	373.613[b]	0.941
	(-2.887)	(2.040)	(2.548)	(0.125)
Economic growth	−1.420[c]	−1.809[c]	6.168	−1.432
	(-3.252)	(-40.231)	(1.007)	(-1.282)
Population	3.992[c]	0.134[b]	201.347[c]	−0.990
	(2.784)	(2.141)	(2.714)	(-0.649)
Population growth	18.634[c]	4.597[c]	135.440	−2.552
	(2.856)	(9.700)	(1.474)	(-0.361)
Gross domestic savings	−0.101	−0.154[c]	−12.969[c]	−0.030
	(-0.328)	(-3.583)	(-4.296)	(-0.086)
Domestic credit	−0.050	−0.060[a]	−0.201	−0.063
	(-0.141)	(-1.721)	(-0.156)	(-0.589)
Energy consumption	0.165[b]	0.011[c]	0.081	−0.007
	(2.305)	(7.210)	(0.577)	(-0.615)
Constant	−5.923[c]	−16.357[c]	−5.927[c]	21.689
	(-2.889)	(2.681)	(-2.576)	(0.268)
Observations	333	333	333	333
R-squared	0.848		0.543	0.879
AR (1)		0.065		
AR (2)		0.262		
Hansen test		0.337		
Number of countries	28	28	28	28

t-statistics in parentheses.
[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

3.5. Natural resources

Natural resources have had a significant impact on Chinese investment in Africa. China's growing demand for natural resources to support its rapid economic development and industrialization has driven its interest in African countries with abundant resources (Tuman and Shirali, 2017). Some African countries are rich in various natural resources, including oil, minerals, timber, and agricultural products, which are of great interest to China's rapidly growing economy (Kolstad and Wiig, 2012). Natural resources have been a primary driver of Chinese investment in Africa, shaping the nature and scale of China's economic engagement with the continent (Shan et al., 2018). Therefore, the amount of Chinese investment to particular country is likely to depend on the resource endowment of the country and the consequences of these investment will also likely to vary accordingly (V. Tawiah et al., 2022). Hence one may argue that our results of positive association between Chinese investment and increase in energy independence in Africa may be driven by resource-rich country.

Therefore, in this section we run additional analysis to ascertain whether our results differ between resource rich and non-resource rich countries. To do this we classify the sample into resource rich and non-resource rich countries based on World Bank groupings. We run separate regression for each group of countries. The results are presented in Table 8. Column 1 contains the result of resource rich countries, and the estimations of non-resource rich countries are presented in column 2. The coefficient of Chinese investment is negative and significant in both columns suggesting that Chinese investment is significantly associated with increase in energy independence, regardless of the resource endowment. However, the coefficient of Chinese investment is large and at high significant level in resource rich countries than non-resource rich countries.

Following our findings that the impact of Chinese investment on energy independence is stronger in natural resource-rich countries, we perform further estimation to assess whether natural resources mediate the relationship between Chinese investment and energy independence we perform mediation analysis. Consistent with (Liu et al., 2023)To do this we create a mediation term between natural resources and Chinese investment (Chinese investment*natural resources = *Mediating term)*. If institutional quality significantly meditates the association between Chinese investment and energy independence then we expect the *Mediation term* to be larger and more significant than the main dependent variable – *Chinese investment*. We include the *Mediating term* as explanatory variable in Eq (1). The results are presented in column 3 of Table 7. The coefficient of *the Mediation term* is negative and significant with larger coefficient than *Chinese investment* (12.383*** > 8.291**). The result confirm that the presence of natural resources signficatly mediate the relationship between Chinese investment and energy independence. The results imply that the effect of Chinese investment on energy independence is more pronounced in resource-rich countries compared with non-resource rich countries. This is unsurprising, given the significant of natural resources in Chinese foreign relationship (Kolstad and Wiig, 2012; Shan et al., 2018).

3.6. Institutional quality and country risk

Institutional quality plays a significant role in influencing foreign investment, including Chinese investment, in any country or region (Buchanan et al., 2012; F. Chen and Jiang, 2021). Institutional quality refers to the strength and effectiveness of a nation's institutions, including its legal, regulatory, and governance frameworks. High-quality institutions are generally associated with a conducive investment climate, while poor institutional quality can deter investment. Similarly institutional quality plays a crucial role in determining the consequences of Chinese investment (Jude and Levieuge, 2017). Strong institutions generally result in positive outcomes, such as increased in energy independence. Conversely, poor institutional quality can lead to

Table 7
Natural resources.

VARIABLES	(1)	(2)	(3)
	Resource rich	Non-resource rich	Mediation
Chinese investment	−14.778[c]	−0.511[b]	−8.298[b]
	(-3.551)	(-2.360)	(-2.440)
Mediation term			−12.383[b]
			(-3.520)
Natural resources			−0.236[b]
			(-2.140)
Economic development	−7.997[b]	1.722[b]	−5.926
	(-2.470)	(2.215)	(-0.213)
Economic growth	−1.392	−0.333	−0.654
	(-0.812)	(-1.376)	(-0.711)
Population	28.789[c]	22.850[c]	374.316[c]
	(7.784)	(4.762)	(2.887)
Population growth	11.453[c]	−4.927[b]	−50.381[c]
	(-7.654)	(-2.490)	(-3.950)
Gross domestic savings	−1.356	−1.305[c]	−0.692
	(-0.938)	(-7.024)	(-0.983)
Domestic credit	−5.673[a]	−0.110	−1.122
	(-1.862)	(-0.722)	(-1.626)
Energy consumption	1.559[c]	2.159[c]	0.647[c]
	(7.711)	(7.711)	(4.334)
Constant	−45.492[c]	−35.992[c]	−64.262[c]
	(-7.671)	(-2.709)	(-2.839)
Year effect	Yes	Yes	Yes
Country effect	Year	Yes	Yes
R-squared	0.653	0.422	0.282
Number of countries	11	17	28

t-statistics in parentheses.
[a] $p < 0.1$.
[b] $p < 0.05$.
[c] $p < 0.01$.

Table 8
Institutional quality and risk.

VARIABLES	(1)	(2)	(3)	(4)
	High quality	Low quality	Low Risk	High Risk
Chinese investment	−2.409[b]	−2.391[b]	−8.564[b]	−3.734[b]
	(-2.752)	(-2.740)	(-3.319)	(-3.356)
Economic develop.	−61.124[a]	−105.031[a]	43.099	27.321
	(-2.149)	(-2.186)	(1.098)	(0.695)
Economic growth	−2.129	−2.160	0.236	0.501
	(-1.097)	(-1.265)	(0.140)	(0.449)
Population	55.939[b]	61.211[b]	−124.437	502.572[a]
	(2.707)	(5.483)	(-0.688)	(2.479)
Population growth	55.857[a]	56.451[b]	178.068[b]	−69.320[b]
	(2.522)	(2.939)	(4.934)	(-4.754)
Gross domestic sav.	−1.398[a]	−1.078[a]	0.343	−1.652[a]
	(-2.105)	(-1.979)	(0.227)	(-2.005)
Domestic credit	−1.749	−3.396[a]	0.298	−0.396
	(-1.146)	(-2.508)	(0.259)	(-0.391)
Energy consumption	22.873[a]	73.127[a]	0.494[b]	0.776[b]
	(2.595)	(1.119)	(3.546)	(4.959)
Constant	−8.615[a]	2.950[b]	3.189	−9.638[a]
	(-2.601)	(5.513)	(0.437)	(-2.529)
Year effect	Yes	Yes	Yes	Yes
Country effect	Yes	Yes	Yes	Yes
R-squared	0.238	0.408	0.540	0.365
Number of countries	14	14	14	14

t-statistics in parentheses.
*p < 0.1.
[a] p < 0.05.
[b] p < 0.01.

negative consequences, including concerns about resource management and rapid consumption and exportation of domestic energy. However, over the years China has insisted that the domestic governance of the host country is not significant in its investments decision and associated consequences (Zakari and Khan, 2022).

Therefore, in this section, we perform further analysis to establish whether institutional quality significantly moderate the relationship between Chinese investment and energy independence in Africa. Consistent with the analysis on natural resources, we classify the sample into high and low institutional quality countries. Following prior studies (Shang et al., 2023; V. K. Tawiah et al., 2021; Zakari and Khan, 2022) we use the average of six World Governance Indicators to measure institutional quality. The six indicators are control of corruption, political stability, government effectiveness, rule of law; regulatory quality; voice and accountability. After constructing a single variable from these six components we group countries based on the median value. High countries are those above the median value and the remaining are classify as low institutional quality.

We run separate regression for each group and the results are presented in Table 8. Column 1 contains the results of high institutional quality countries and low institutional quality countries are in column 2. The coefficient of Chinese investment is negative and significant in both columns suggesting Chinese investment decrease energy imports leading to energy independence. The coefficient and significant level are similar in both columns indicating that institutional quality does not significant moderate the relationship between Chinese investment and energy independence in Africa. This is unsurprising given that the significance of natural resources in many Chinese international relationships both in Africa and beyond. Interestingly we found that the results are similar regardless of the institutional environment of the country. Arguably unlike other Western countries who cares about the governance and institutional environment of the host country, China has taken a neutral stand on the domestic affairs of the host country.

In addition to institutional quality, prior studies suggest that China consider the country's risk before investment. (V. Tawiah et al., 2023; V. Tawiah et al., 2022). Therefore, it is likely that country risk, including political and market risk, can influence our results on the relationship between Chinese investment and energy independency. Arguably, high country risk will decrease Chinese investment, resulting in low energy independence. We use the political stability of the World governance indicators to measure country risk. Political stability ranges from −2.5 to +2.5 and covers the stability of the country. In line with previous analysis, we classify countries into high and low risk based on the median value of political stability. The results are presented in columns 3 and 4 of Table 8. Although Chinese investment remains negative and significant in both high and low-risk countries, the coefficient is larger and highly significant for low-risk countries than for high-risk countries. The results suggest that country risk influences the outcomes of Chinese investment in the host country.

4. Conclusion and policy implication

The last decades have seen the rapid rise of Chinese presence across the globe and more specifically in developing countries. However, the dominance of China in Africa has been under intense scrutiny particularly in the areas of the impact of Chinese investment on the African economy (V. Tawiah et al., 2023). China pride itself as the best development partner for Africa with significantly large investment in areas that matter including the energy sector. Critics also claim that China is only in Africa for natural resources and global power (X. Shen, 2015). While some prior studies have showcase the consequence of this complex China-Africa partnership (X. Chen et al., n.d.; Mol, 2011; V. K. Tawiah et al., 2021) on different areas of the economy, little has been done on the energy sector where China pride itself as the fixer. Therefore, in this paper we have examined the impact of China-Africa relationship on the energy independence. We have attempted to answer the burning question, does Chinese investment in Africa lead to energy independence?

To answer this all-important question, we use data from 28 African countries between 2003 and 2022. Our sample countries and period are selected based on data availability. Our robust econometric estimations indicate that the flow of Chinese investment increase energy independence in Africa. The large investment in numerous energy production has significantly reduce energy import and even make some countries net export of energy supplies (see the case studies). We also find that the results are more pronounced in resource rich countries than non-resource rich countries. The results are robust to endogeneity test using the Two-step System Generalised Method of Moments.

Our study contributes to the emerging stream of literature on the China-Africa engagement (X. Chen et al., n.d.; Mol, 2011; V. K. Tawiah et al., 2021). However, it provides new insights on how this ever-growing engagement influence the energy sector, an important sector for both economic and sustainable development. The existing studies provide generic outcomes of Chinese investment without a focus on a single sector. Arguably an analysis of specific sector provides more comprehensive and reliable evidence of the environmental and economic footprint of Chinese presence in Africa. Moreover, the energy sector remains one of the top sector for Chinese investment in Africa.

Our empirical evidence also offers policy implication. The findings showcase that the presence of China in Africa could help many countries increase domestic energy production and thereby decrease the dependency on imports. Such an outcome will enable countries to achieve the Sustainable Development Goals, particularly Goal 7, efficient and affordable energy. Through the development of many renewable energy projects such as the solar and wind farms, China is also supporting African countries to the commitment of Sustainable Energy for All Initiative. Therefore policymakers should create an enabling environment to attract and facilitate foreign investment in energy infrastructure projects, including renewable energy and traditional power generation facilities.

The findings indicating a more pronounced impact of Chinese investment on energy independence in resource-rich countries highlight the importance of leveraging natural resource endowments to attract

foreign investment. Policymakers in resource-rich African countries should develop targeted policies and incentives to attract Chinese investment in energy projects while ensuring sustainable resource management practices and equitable distribution of benefits.

Given the potential benefits of Chinese investment in promoting energy independence in Africa, policymakers should foster partnerships and collaboration between Chinese investors, African governments, international organizations, and local communities. Collaborative initiatives can facilitate knowledge transfer, technology exchange, and capacity building, ultimately enhancing the long-term sustainability and resilience of Africa's energy sector.

While the findings suggest positive outcomes of Chinese investment in energy independence, policymakers should implement robust monitoring and evaluation mechanisms to assess the socio-economic and environmental impacts of investment projects. Regular assessments can help identify potential challenges, address implementation gaps, and optimize the effectiveness of investment strategies in achieving energy independence and sustainable development goals.

Notwithstanding this compelling empirical evidence, we admit that achieving complete energy independence may not be practical or feasible for all countries, as energy resources vary widely by region. Many nations will continue to engage in international energy trade to meet their energy needs. However, reducing excessive dependence on specific sources or regions through diversification and investments in domestic energy production can provide the benefits associated with energy independence while maintaining some degree of energy interdependence with the global community.

Furthermore, while Chinese investment in Africa's energy sector can bring significant benefits, there are also potential negative effects that policymakers and stakeholders should consider.

First, the rapid domestic energy production growth in Africa could shift the attention of many countries to the energy sector at the neglect of relevant traditional sectors. This can lead to greater energy intensiveness per unit of gross domestic product and potentially negating the contribution of other sectors.

Second, Chinese financing for energy projects in Africa often comes in the form of loans with favourable terms, but these loans can also lead to debt sustainability concerns. Excessive borrowing to finance energy infrastructure projects may burden African countries with high levels of debt, potentially compromising their fiscal stability and economic sovereignty.

Third, Chinese investment in energy projects may involve the use of Chinese technology, equipment, and expertise. While this can accelerate project implementation, it may also create dependency on Chinese suppliers and limit technology transfer and knowledge sharing with local industries. Overreliance on Chinese technology and expertise could hinder the development of indigenous capabilities and innovation in Africa's energy sector.

Fourth, Chinese investment in Africa's energy sector is often driven by strategic interests, including access to natural resources, geopolitical influence, and securing energy supply chains. While Chinese investment can enhance energy security in African countries, it may also lead to geopolitical tensions, competition with other international actors, and unequal distribution of benefits among African nations.

Our study is not without any limitations. First our sample countries are limited due to data availability on key variables of interest. Second the sample period is limited due to the short time of the energy imports variable at the World Development Indicators database. Future studies can extend our study by considering other areas of the energy sector such as energy depletion and energy efficiency. Third, we use whole investment instead of investment in energy sector due to lack of data on specific sector. Other area of interest is how different routes of Chinese investment could affect the energy sector.

Funding information

Princess Nourah bint Abdulrahman University Researchers Supporting Project number (PNURSP2024R391), Princess Nourah bint Abdulrahman University, Riyadh, Saudi Arabia.

CRediT authorship contribution statement

KanKan Wen: Writing – review & editing. **Noha Alessa:** Writing – review & editing, Writing – original draft, Funding acquisition. **Vincent Tawiah:** Conceptualization.

Declaration of Competing interest

There is no conflict of interest on the paper titled The impact of Chinese investment on energy independence in Africa.

Data availability

Data will be made available on request.

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