

Environmental risk and foreign direct investment: the role of financial deepening, access and efficiency

Foreign direct investment

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Abstract

Purpose – This study aims to decompose financial development into its three key components (depth, access and efficiency) to investigate whether they can help to overturn the negative impact of foreign direct investment (FDI) on the environment.

Design/methodology/approach – The study uses a dynamic panel of 43 economies from 1982 to 2018 and decomposed financial development into its three key components: depth, access and efficiency.

Findings – The results from the various estimations indicate that financial deepening and efficiency reduce environmental risk and can overturn the negative impact of FDI on the environment. In addition, the study finds that low levels of financial access worsen environmental risk but doubling financial access is likely to reduce it which makes the relationship between access and environmental risk non-monotonic. After splitting the data set into high and low financially developed economies, the study reports that FDI is more environmentally depressive among low financially developed economies.

Practical implications – The practical implications are that improvement in financial efficiency guarantees high returns on savings and investment and can reduce environmental risk. So, central governments should invest in financial technologies and formulate financial regulations through monetary and fiscal policies to enhance financial efficiency and depth.

Social implications – If inward FDI to Africa continues the business-as-usual trend, the environmental risk in the region may continue to rise, environmental conditionalities for FDI must be strengthened.

Originality/value – The study uses a comprehensive measure of financial sector development and decomposes financial development indicators to assess their efficacy in mitigating the relationship between FDI and environmental quality.

Keywords Financial development, Depth, Access, Efficiency, FDI, Environmental risk

Paper type Research paper

1. Introduction

Environmental risk is the probability and consequence of an unwanted environmental accident (Ustohalova, 2011). Ustohalova (2011) further elucidates that the likelihood of environmental risk occurrence is due to deficiencies in waste management, waste transport and waste treatment and disposal, which cause serious threats to human health. Additionally, Xu and Liu (2009) explain environmental risk as the risk that an organization's (human) activities may emit toxic gasses or deplete resources in such a way that it brings actual or potential negative effects on the ecological system. Accordingly, the impact of



environmental risk can be assessed at two levels: global and local impacts (Ustohalova, 2011). The global impact of environmental risk is where carbon dioxide, methane and other harmful gases are released into the ecosystem and their effects go beyond the borders of the emitting country. These dangerous gases contribute to the increasing threat of climate change. The local impact of environmental risk on the other hand contributes to the contamination of the immediate environment. This often occurs through the release of harmful chemicals into the soil which affects groundwater, carbon monoxide from cars and reactive waste substances, among others. The local impact of environmental risk usually comes with immediate health and environmental complications.

Additionally, scientists believe that economic activities are the main drivers of environmental risk. This is the main reason why advanced economies deteriorate the environment more than developing economies (Dasgupta *et al.*, 2002). However, environmental risk affects developing countries more than developed nations (Sonwa, 2018). Of course, Africa contributes less than 4% to the annual global greenhouse gas emission but it is the worst affected by climate change (Ritchie, 2019). Shephard (2019) reports that Africa is a climate change hotspot and every addition to the greenhouse gas emission increases the region's environmental risk in the form of heatwaves, droughts, crop failures and food insecurities, among others.

Meanwhile, Africa's low greenhouse gas emission is changing in recent times partly due to the enhancement in the hunt for more capital (Figure 1). The level of greenhouse gas emissions from Africa is expected to go up further, as it continues to mobilize more capital. Leke and Signé (2019) suggest that Africa requires a capital investment of US\$1tn to be fully industrialized and become the world's next great manufacturing hub. This proposed capital requirement can hardly be financed from domestic revenue (Sachs *et al.*, 2004; Burnside and Dollar, 2000). As a result, the need for foreign capital, especially foreign direct investment (FDI) has become eminent. Although, there are other forms of foreign capital the region is tapping into; however, FDI inflow stands out and is becoming a major talking point in Africa's international capital debate. FDI is different in several ways. First, unlike government borrowing and other official development assistance, FDI does not come with immediate repayment conditions. Second, there are no prior open stringent requirements to meet before hosting FDI. Third, there are also no third parties to review and approve a country's economic performance before FDI is granted. Fourth, FDI comes with more flexibility relative to the other

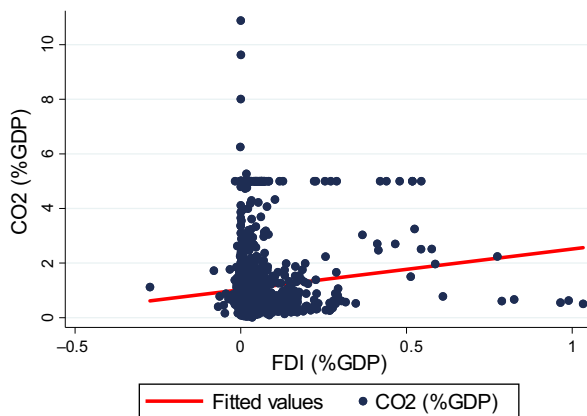


Figure 1.
Bivariate in FDI and
carbon dioxide (CO₂)
emission in Africa

Source: Authors' computations

forms of foreign capital. Although FDI is not free capital, it brings mutual benefits to both the home and the host economy. FDI forms a significant part of Africa's economic growth. For instance, in the past decade, the average annual FDI flow to Africa as a percentage of gross domestic product (GDP) is above 2.5% (World Bank, 2019). In 2019 alone, the region recorded an 11% increase in FDI despite the global downturn in inward FDI (UNCTAD, 2019). The relevance of FDI in Africa's growth struggles is evidenced in the region's attempt to restructure its taxes, trade laws, governance, infrastructure and human capital, among others to be a key host to inward FDI (Boachie-Yiadom and Mensah, 2021; Odusola, 2016).

Notwithstanding, FDI has received a backlash as being a major contributor to environmental risk spread in Africa and other parts of the world (Bokpin, 2017; Zheng and Sheng, 2017; Omri *et al.*, 2014). The bivariate analysis between FDI and carbon dioxide emission in Figure 1 confirms the existing positive relationship between FDI and carbon emissions in the literature.

Although too early in this study to establish a causal effect from FDI to carbon dioxide emissions (in this case environmental risk), Figure 1 shows that the two variables slope upwards over time; and therefore, a likely positive relationship between the two. Figure 1 is further supported by theory and empirical studies that conclude that an upshoot in the capital (FDI) resources result in an increase in economic activities and subsequently aggravates environmental risk (Boachie-Yiadom and Mensah, 2021; Singhania and Saini, 2021; Shahbaz *et al.*, 2018; Grossman and Krueger, 1991).

The question research is still attempting to answer is how to correct the negative impact of FDI on the quality of the environment. In the past, Boachie-Yiadom and Mensah (2021) and Bokpin (2017) proposed tax policies and institutions, respectively, as intervening variables to overturn the negative effect of FDI on the environment.

Furthermore, extant research on environmental quality believes that the level of financial development can directly reduce environmental risk (Ntow-Gyamfi *et al.*, 2020; Acheampong, 2019; Shahbaz *et al.*, 2018; Riti *et al.*, 2017). Kirikkaleli, Güngör and Adebayo (2022) investigate the effect of financial development on environmental risk. Their findings reveal that financial development reduces the environmental risk in Chile. Further, Acheampong *et al.* (2020) use a comprehensive panel data set of 83 countries over the period 1980–2015 to investigate the impact of financial market development on environmental risk, taking into account the various stages of financial development among countries. The results from their instrumental variable generalized method of moment approach show that the overall financial market development and its sub-measures (depth and efficiency) reduce environmental risk in the developed and emerging financial economies. Khan and Ozturk (2021) test both the direct and indirect effects of financial development on environmental pollution using the Environmental Kuznets Curve (EKC) framework among 88 developing countries during the 2000–2014 period and report findings similar to Acheampong (2020).

Other empirical studies have also drawn a strong relationship between financial development and FDI. For example, Osei and Kim (2020), Agbloyor *et al.* (2013) and Alfaro *et al.* (2004) share the view that the financial sector development is a gatekeeper both to the entrance of and exit of FDI. Thus, the financial sector development influence where the FDI goes. This point is well articulated by the allocative efficiency function of the financial system. The financial system channels the FDI into the most productive sectors of the economy which can make profitable use of it. The financial system then becomes the conduit through which FDI influences economic outcomes. However, inefficiencies in the financial system compromise its allocative abilities and may divert financial resources from deserving firms.

Based on the linkages reasoned by earlier studies that financial development influences FDI and environmental risk, we argue that financial development can moderate the effect of FDI on

environmental risk. Particularly, this study set itself apart from existing studies by adopting a comprehensive measure of the financial development index compiled by [Sahay et al. \(2015\)](#) and decomposing it into the three sub-units: financial deepening, access and efficiency. This offers the current study the opportunity to investigate first-hand how FDI affects the quality of the environment in the presence of the decomposed financial development indicators. By decomposing the financial sector development index into its subcomponents, the study can address which particular aspect of the financial development indicators drive environmental risk or can mitigate the negative effect of FDI on the environment. Subsequently, this research avoids the wholesale recommendations on financial sector development in the existing literature.

According to [Sahay et al. \(2015\)](#):

[. . .] financial development is defined as a combination of depth (size and liquidity of markets), access (the ability of individuals to access financial services), and efficiency (ability of institutions to provide financial services at low cost and with sustainable revenues, and the level of activity of capital markets).

By decomposing financial development into depth, access and efficiency, we can meet the full definition of financial development and we suspect that the three components will react differently to the relationship between FDI and environmental risk.

Besides, the numerous studies on financial sector development and environmental risk largely use one aspect of financial sector development – mostly financial deepening variables – such as private-sector credit; pension fund assets; mutual fund assets and stocks traded ([Osei and Kim, 2020](#); [Riti et al., 2017](#); [Shahbaz et al., 2016](#); [Tamazian et al., 2009](#)). As these variables do not fully represent the majority of the indicators for financial sector development, findings and recommendations from such studies could be biased and misleading. The lack of a comprehensive measure for financial development has led to some studies even suggesting that a highly developed financial sector will automatically harm the environment due to an increase in financial access ([Shahbaz et al., 2016](#)). We correct this distortion in the literature by examining the separate effect of the three components (access, depth and efficiency) of financial development on the relationship between FDI and environmental risk. The study specifically tests whether the decomposed financial development indicators make the nexus any better. The specific objectives of the study are as follows:

- to examine the individual effect of the three dimensions of financial development on environmental risk;
- to examine the moderating effect of the three dimensions of financial development on the FDI-environmental risk nexus;
- to test whether “too much finance” harm the environment; and
- to investigate how environmental risk responds to financial depth, access efficiency and FDI in high and low financially developed countries.

The remaining sections of the study are as follow. Section 2 gives a brief overview of the existing literature. Sections 3 and 4 explain the empirical strategy and the findings, respectively. Conclusions and recommendations are included in Section 5.

2. Literature review

2.1 Environmental risk measurement

Environment, environmental quality, environmental performance, environmental degradation, environmental pollution, ecological footprint, carbon footprint, emissions, carbon dioxide emissions and carbon intensity are the different terminologies used in the

literature to represent environmental risk. Carbon dioxide emission is widely used to proxy for environmental risk in the literature (Acheampong *et al.*, 2020; Acheampong, 2019; Shahbaz *et al.*, 2018; Riti *et al.*, 2017; Bokpin, 2017; Shahbaz *et al.*, 2016). Shahbaz *et al.* (2016) also used the per capita carbon emissions to proxy carbon emissions in Pakistan and reported that financial development promotes environmental degradation.

The anthropogenic components of greenhouse gases are contributed by carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O) and other gasses such as hydrofluorocarbons, perfluorocarbons and sulfur hexafluoride. Carbon dioxide emissions from the burning of fossil fuels and the manufacture of cement, iron and steel contribute the largest (about 80%) to global greenhouse gas emissions (World Bank, 2019). It is of no surprise that the literature is almost concluding that the most appropriate measure of environmental risk is carbon dioxide emissions. Again, this study has defined environmental risk as the risk that an organization's (human) activities may emit toxic gasses or deplete resources in such a way that it will bring actual or potential negative effects on the ecological system. The anthropogenic nature of carbon dioxide emissions best fits this definition; hence, this study uses carbon emissions to proxy environmental risk.

2.2 Interrelationship between foreign direct investment, environmental risk and financial sector development

The rush for international capital is making the race-to-the-bottom (RTB) theory more profound among developing countries. Countries are deregulating the business environments, cutting down taxes and relaxing environmental laws to attract more foreign investors (Singhania and Saini, 2021; Shahbaz *et al.*, 2018; Grossman and Krueger, 1991). The RTB is reinforced by the pollution haven hypothesis (PHH). As long as countries relax business policies and environmental laws to attract more foreign capital, those countries will end up becoming a destination for toxic multinational companies that want to avoid the cost of damaging the environment. Bokpin (2017) believes that countries that have weak environmental governance will attract dirty firms that will deteriorate the quality of the environment. Boachie-Yiadom and Mensah (2021) on the other hand investigated the PHH through tax policies. They conclude that countries that deliberately relax tax policies to attract more FDI will have their environment destroyed by the same FDI. The practicality of the negative effect of the RTB and the PHH can both be mitigated by a sound financial system. The financial system is a key player in sourcing and disbursing funds for economic activities. The financial sector is the mediator between capital resources and the investment sectors of an economy. So, whether capital will be invested in environmentally destructive sectors or not depends on the eco-friendliness of the financial sector. A novel work by Schumpeter reveals that a well-developed financial sector facilitates capital accumulation and advanced technology to spur economic activities (King and Levine, 1993). Thus, the financial sector plays an intermediary (mediator) role between capital and the environment.

Climate financing is critical in mitigating emissions and building resilience in the ecosystem to minimize climate change impact vulnerabilities. Without adequate financing the much talked about climate change mitigation and adaptation will only remain academic jargon. FDI can step up to fill the fiscal gap in local economies, especially in developing countries. However, whether FDI will serve the climate financing purpose or not depends on prevailing local factors. Even for FDI to be growth-enhancing, local factors such as institutions, financial markets, human developments and infrastructure among others must come to play (Agbloyor *et al.*, 2016; Agbloyor *et al.*, 2013). In the same way, this study believes that for FDI to facilitate climate resilience, these same factors must be present and

strong in the domestic economy. We are particularly interested in how the subcomponents of financial developments are helping redirect FDI into efficient climate financing.

Financial development is the conduit that carries the financial resources (FDI) to the various sectors of the economy and therefore can influence the location of the funds. A weak financial development leads to inefficient financial allocation (Alfaro *et al.*, 2010). Some studies have proceeded to test the direct effect of financial development on the environment and report favourable outcomes (Acheampong, 2019; Shahbaz *et al.*, 2018; Riti *et al.*, 2017). We build on the findings of these studies to hypothesize that different aspects of financial development influence the FD–environment nexus differently.

2.3 The role of access, depth and efficiency in the foreign direct investment–environment nexus

There is an upward surge in the overall financial sector development as well as the sub-components (IMF, 2020). This is good for the region, as the upward trend in financial development is expected to improve capital accumulation and subsequently economic growth (Nazmi, 2005). Financial depth stands tall among the three dimensions of financial development in the region. Also, Appendix shows the factors inducing growth in financial depth, access and efficiency. Financial depth measures the size and liquidity of the financial institutions and markets within the economy. Thus, financial deepening increases the size of the financial sector in terms of value and volume and promotes market liquidity. According to Sahay *et al.* (2015), financial depth is predominantly measured by nine main proxies. These include private-sector credit, pension fund assets, mutual fund assets, insurance premiums (life and non-life), stock market capitalization, stocks traded, international debt securities of government, total debt securities of nonfinancial corporations and total debt securities of financial corporations. These indicators of financial depth primarily influence capital accumulation, availability and investment. It is of no surprise that it constitutes a significant proportion of the overall financial sector development. It also means that financial depth influences economic outcomes more than access and efficiency. Given the positive relationship between finance and economic growth; financial depth inadvertently can increase environmental risk. This point is well articulated by Omri *et al.* (2021), Khan and Ozturk (2021) and Shahbaz *et al.* (2016). It can also be argued that financial deepening may not necessarily spur environmental risk depending on the sectors of the economy the capital resources are invested. But it is clear in the literature that the choice of variables for financial development greatly influences the research outcomes. For example, studies that measure financial development using financial depth indicators tend to find a negative relationship between financial development and environmental quality (Omri *et al.*, 2021; Khan and Ozturk, 2021; Shahbaz *et al.*, 2016). Another classical confusion in the empirics is the opposite findings reported by Acheampong (2019) and Acheampong *et al.* (2020). Acheampong (2019) employ the generalized method of moments (GMM) technique and use financial depth-driven variables to investigate the effect of financial development on carbon dioxide emissions and find that financial development is bad for the environment. A year on, the same author uses the same GMM estimating technique to study the relationship between financial development and carbon dioxide emissions but changed the choice of the financial development variables to the International Monetary Fund (IMF) financial development index and argue that financial development and its sub-measures rather improve the quality of the environment (Acheampong *et al.*, 2020). Kirikkaleli *et al.* (2022) also use the IMF financial development index and find similar results that affirm the study of Acheampong *et al.* (2020).

Again, some studies argue that financial development worsens environmental quality (Shahbaz *et al.*, 2016). They contend that financial sector development promotes financial access which in turn increases economic activities, thereby worsening environmental risk. But, these studies fail to recognize that an increase in financial access does not necessarily translate into environmental risk but rather it depends on the direction of the financial access. Financial access is measured by the number of bank branches, automatic teller machines (ATM) to the number of adults, account ownership and the total number of issuers of debt. These variables are the same as financial inclusion variables (Sahay *et al.*, 2015). Financial inclusion influences savings, investment and consumption (Yiadom *et al.*, 2021). Therefore, it is true that financial access may cause an upward surge in economic activities, it is, however, unclear that every economic activity aggravates environmental risk. This is because, there are chances that, the increase in financial access could spill over into climate-resilient economic activities. Unfortunately, financial access in the sub-Saharan Africa region is low relative to the financial deepening and efficiency components of financial development (IMF, 2020). Two implications can be deduced from the low financial access. One, chances are that majority of the people in the region do not have access to funds which can influence savings and consumption patterns. And obviously, savings and consumption affect economic activities and environmental quality. Finally, low financial access can lead to financial concentration among a few people. Over-concentration of funds among a few people makes it easy for them to determine what is produced and consumed; hence, influencing environmental outcomes becomes easy. This may not be healthy for the environment if a few people do not have concern for the environment.

Sahay *et al.* (2015) acknowledge that the development of the financial sector not only increases financial deepening and access but also promotes financial efficiency. Sahay *et al.* (2015) further explain that financial efficiency is the ability of institutions to provide financial services at low cost and with sustainable revenues and the level of activity of capital markets. Financial efficiency is measured by net interest margin, lending-deposits spread, non-interest income to total income, overhead costs to total assets, return on assets, return on equity and stock market turnover. These indicators of financial efficiency can be categorized into two: cost and profitability. When the financial system is efficient, funds are allocated at a lower cost to economic sectors that offer higher returns. Greater financial efficiency is likely to promote the quality of the environment. This is because, as the cost of funding declines, climate-resilient ventures that were not lucrative to FDI will begin to be profitable, thereby receiving equal attention from investors. If the overall cost of funding declines, chances are that financing climate-worsening activities may decline thereby eroding possible gains from the climate-resilient sectors. To avoid this from happening, the relative cost of financing climate-resilient activities should be cheaper than financing climate-worsening activities. And this is where deliberate public policies should augment financial efficiency to promote climate-resilient activities.

Largely, financial deepening influences production, financial access influences consumption and financial efficiency influence the direction of the investment. These three dimensions of financial development work together to deliver a sound financial sector that promotes economic growth and environmental health. It is therefore important to measure their effect on economic and environmental outcomes. This makes the literature incomplete since the available studies ignore both financial access and efficiency.

To a large extent, FDI forms part of the larger financial sector. FDI contributes to capital accumulation and investment. This means that FDI increases the financial depth of a country. If financial depth negatively influences the environment (Shahbaz *et al.*, 2016), then it is of no surprise that FDI also worsens the quality of the environment (Singhania and Saini, 2021; Shahbaz *et al.*, 2018; Zheng and Sheng, 2017; Omri *et al.*, 2014). Again, FDI is

profit-oriented funding and will move into economic sectors that offer higher returns. If the profit sectors of the economy are environmentally destructive, FDI will end up destroying the environment and vice versa. [Levine \(2005\)](#) argues that the financial system assists the real sectors of the economy by providing information *ex-ante* about investment and capital allocation, monitoring investment and enforcing corporate governance, aiding trading, diversification and risk management, mobilization and pooling savings and easing the exchange of goods and services. The efficient provision of information about investment opportunities minimizes the over-concentration of funds in a few areas ([Omri et al., 2021](#)). According to [Acheampong et al. \(2020\)](#) if the financial system is developed to improve information efficiency, the amount of FDI that goes into environmentally destructive sectors may be minimized. The World Bank's 2020 report on climate-smart investment opportunities around the globe estimates the potential of the sub-Saharan Africa region to be \$1.5tn over 10 years and is expected to increase further. The absence or inadequate information about the existence of climate-smart investment opportunities is contributing to the low investment in those sectors by FDI. For an economy to reap the full benefit of FDI and also assess its environmental impacts, a comprehensive measure of financial development should be used as suggested by [Sahay et al. \(2015\)](#). This forms the basis for why this study uses the IMF financial development index in this study. Most importantly, examining the role of the three dimensions of financial development will improve policy prescriptions about the effect of FDI on the environment.

3. Methodology

3.1 Data, variables and model specification

The study uses a data set of 43 sub-Saharan African countries over the 1982–2018 period. The 43 countries include Angola, Burundi, Benin, Burkina Faso, Botswana, Central African Republic, Cote d'Ivoire, Cameroon, Congo, Dem. Rep., Congo, Rep., Comoros, Cabo Verde, Eritrea, Ethiopia, Gabon, Ghana, Guinea, Gambia, Guinea-Bissau, Equatorial Guinea, Kenya, Liberia, Lesotho, Madagascar, Mali, Mozambique, Mauritius, Malawi, Namibia, Niger, Nigeria, Rwanda and Senegal. The financial development data is compiled by [Sahay et al. \(2015\)](#) and hosted by the IMF. All other cross-country variables were collected from the World Bank's World Development Indicators. To overcome the issue of missing data, the study periods and the countries were carefully selected on the basis of data availability.

The study follows [Acheampong \(2019\)](#) and [Tamazian et al. \(2009\)](#) to estimate a dynamic panel model where the carbon emission (*ENVTR*) is a function of the foreign direct investment (*FDI*), financial developments components (*COMP*), squared of the components of the financial development ($COMP^2$) and other control variables (*X*) consistent with the literature ([Boachie-Yiadom and Mensah, 2021](#); [Acheampong, 2019](#); [Shahbaz et al., 2016](#); [Tamazian et al., 2009](#)). The control variables include the financial sector regulation index (*FR*) which is used to control for financial institutional quality, GDP per capita growth rate (*GDP*), the growth rate of the urban population (*URBAN*) and the growth rate in domestic investment (*DINV*). The use of carbon dioxide emissions to proxy for environmental risk is informed by the literature ([Acheampong et al., 2020](#); [Acheampong, 2019](#); [Shahbaz et al., 2018](#); [Riti et al., 2017](#); [Bokpin, 2017](#); [Shahbaz et al., 2016](#)).

The financial development components are made up of financial depth (*DEP*), financial access (*ACC*) and financial efficiency (*EFF*). These variables are highly correlated; therefore, they are placed in the models separately. Financial depth (*DEP*), access (*ACC*) and efficiency (*EFF*) are computed by [Sahay et al. \(2015\)](#) from a complex variable and they are measured on a scale of -1 (low) and 1 (high). The measurements, descriptions and sources of the data are included in [Table 1](#).

Variable	Description	Source	Mean	SD	Skewness	Kurtosis
envtr	Carbon dioxide emissions (% of GDP). The cost of damage due to carbon dioxide emissions from fossil fuel use and the manufacture of cement is estimated to be US\$30 per ton of CO2 emitted.	World Bank (2019)	1.08	1.20	2.79	12.01
fdi	Value of Foreign direct investment, net inflows in US \$ (% of GDP)	World Bank (2019)	0.04	0.09	5.83	50.51
dep	Financial deepening Index (measured from -1 = low to 1 = high)	IMF database	0.07	0.11	3.71	19.75
acc	Financial access Index (measured from -1 = low to 1 = high)	Sahay et al. (2015) IMF database	0.05	0.10	2.74	10.12
eff	Financial efficiency Index (measured from -1 = low to 1 = high)	Sahay et al. (2015) IMF database	0.25	0.11	-0.26	3.55
fr	Financial sector regulation index. It assesses the structure of the financial sector and the policies and regulations that affect it. (1 = low to 6 = high)	Sahay et al. (2015) World Bank (2019)	0.88	1.39	1.01	2.19
urban	The growth rate of the Urban population refers to people living in urban centres	World Bank (2019)	36.80	16.08	0.33	2.85
gdp	GDP per capita growth rate (annual %)	World Bank (2019)	4.16	6.91	5.61	134.17
divv	The growth rate in domestic investment	World Bank (2019)	7.18	3.14	-1.51	4.02

Source: Authors' computations

Table 1.
Variable measurements and descriptive statistics

The environmental cost of carbon emission in dollar terms as a percentage of GDP, per capita carbon emission, carbon emission in metric tons and carbon emission in kilotons are the different variants of carbon dioxide emission that can be used to proxy the dependent variable, environmental risk (ENVTR). This study adopts the first measurement of carbon emission because it is in line with the contextual definition of environmental risk as suggested by [Ustohalova \(2011\)](#), [Xu and Liu \(2009\)](#) and [Meadows et al. \(1992\)](#). The [World Bank \(2019\)](#) measures carbon emissions as a percentage of GDP. The value of the carbon emission is the cost of damage to the environment due to carbon dioxide emissions from fossil fuel use and the manufacture of cement. The World Bank estimates the environmental cost of CO₂ emission to be US\$30 per ton of CO₂ (the unit damage in 2014 US\$ for CO₂ emitted in 2015) times the number of tons of CO₂ emitted ([Table 1](#)). Further the use of carbon emission as a proxy for environmental risk is justified due to its extensive usage in the literature [Kirikkaleli et al. \(2022\)](#), [Omri et al. \(2021\)](#), [Khan and Ozturk \(2021\)](#), [Acheampong et al. \(2020\)](#), [Acheampong \(2019\)](#), [Zaidi et al. \(2019\)](#) and [Shahbaz et al. \(2018\)](#).

FDI is measured as the net inflows in US\$. This helps in assessing whether inward FDI improves or worsens environmental quality. The financial sector regulation index (FR) measures the robustness of regulations in the financial sector. GDP is measured by the gross domestic product per capita (GDP). Urban population (URBAN) measured as the growth rate of the urban population refers to people living in urban centres. Domestic investment (DINV) is measured as the total value of an investment within the fiscal year.

Except for the measurement of the financial development variables which is new to the literature, all other variables are purely inspired by existing studies ([Ntow-Gyamfi et al., 2020](#); [Osei and Kim, 2020](#); [Riti et al., 2017](#); [Shahbaz et al., 2016](#); [Tamazian et al., 2009](#)). [Sahay et al.'s \(2015\)](#) measurement of financial development although rare, however, it is the most comprehensive dataset source that captures the wider financial system:

$$ENVTR_{it} = \beta ENVTR_{it-1} + \zeta FDI_{it} + \eta COMP_{it} + \theta COMP_{it}^2 + \gamma FR_{it} + \varphi GDP_{it} + \tau URBAN_{it} + \rho DINV_{it} + v_i + \varepsilon_{it} \quad (1)$$

for $i = 1 \dots 43$ and $t = 1982 \dots 2018$.

The squared term of the financial development components ($COMP^2$) tests the reaction of the environmental risk to doubling or increasing the level of each component. The introduction of the squared term also helps in testing the “too much finance” hypotheses. Due to the quadratic nature of the squared term, it offers insight into its curvature which allows computing the turning point of the financial development. The turning point tells the exact threshold at which the effect of financial development on environmental risk changes and can be computed by taking the first differentiation of [equation \(1\)](#) concerning $COMP$ and setting it to zero as shown in [equation \(2\)](#):

$$\frac{\partial ENVTR_{it}}{\partial COMP_{it}} = \eta + 2\theta COMP_{it} \quad (2)$$

$$Turning\ Point(TP) = -\frac{\eta}{2\theta} \quad (3)$$

To explain the indirect effect of the decomposed financial development on the environmental risk, the study includes the interaction term ($COMP \times FDI$) between each of the components of the financial development and the FDI into the linear form of [equation \(1\)](#):

$$ENVTR_{it} = \beta ENVTR_{it-1} + \zeta FDI_{it} + \eta COMP_{it} + \varpi (COMP \times FDI)_{it} + \gamma FR_{it} + \phi GDP_{it} + \tau URBAN_{it} + \rho DINV_{it} + v_i + \varepsilon_{it} \quad (4)$$

for $i = 1 \dots 43$ and $t = 1982 \dots 2018$.

Additionally, due to the complexity associated with the interpretation of the coefficient of the interaction term (ϖ), the study follows the recommendations by [Ntow-Gyamfi et al. \(2020\)](#) and [Alfaro et al. \(2004\)](#) to estimate the net effect of each component of financial development on the environmental risk as shown in [equation \(4\)](#):

$$\frac{\partial ENVTR_{it}}{\partial COMP_{it}} = \eta + \varpi FDI_{it} \quad (5)$$

The net effect of the components of the financial development is computed at their mean values. However, to incorporate the standard deviations (δ) into the marginal effect computation, we followed [Alfaro et al. \(2004\)](#) to modify [equation \(5\)](#) to estimate the final marginal effect of both the components of the financial development and the FDI as follows:

$$\text{The marginal effect of FD components} = \eta \delta_{ENVTR} + (\varpi \times \text{mean}_{FDI} \times \delta_{ENVTR})$$

$$\text{The marginal effect of FDI} = \zeta \delta_{ENVTR} + (\varpi \times \text{mean}_{COMP} \times \delta_{ENVTR})$$

3.2 Estimation techniques and model selection criteria

The study employs the two-step system GMM proposed by [Arellano and Bond \(1991\)](#) to estimate the empirical models. The system GMM is not only widely used in the literature but also helps in addressing issues of autocorrelation, endogeneity and heteroscedasticity. Additionally, the study justifies the consistency of the model and the validity of the exogenous instruments using the Sagan and Hansen tests of over-identification restrictions and the Arellano and Bond test for second-order serial correlation. The dynamic model estimator also provides the most efficient results for our dataset since the time series of 36 years is smaller than the 43 cross sections.

Notwithstanding the justification for the use of GMM, the study uses the [Bond et al. \(2001\)](#) model acceptance criteria to select the appropriate model. The criteria require estimating the model first with the pooled OLS and the panel fixed effect. [Bond et al. \(2001\)](#) suggest that estimating the dynamic model with the pooled OLS will lead to dynamic panel upward bias due to the positive correlation between the lagged dependent variable and the error term. Thus, the coefficient of the autoregressive term will be inflated. Conversely, estimating the dynamic model with the panel fixed effect does not improve its efficiency due to the negative correlation between the autoregressive term and the error term. This makes the coefficient of the lagged dependent variable to be downward biased. For the GMM to be the appropriate model, the coefficient of the autoregressive term in the dynamic model should be symmetrical to the pooled OLS and the panel fixed effect's estimates. Further, the choice between system GMM and difference GMM depends on the estimation technique that improves the dynamic stability of the coefficient of the lagged dependent variable. Thus, if the estimates from the system GMM of the coefficient of the lagged dependent variable lie outside the upper bound (pooled OLS) and the lower bound (panel fixed effect), the difference GMM is appropriate and vice versa ([Roodman, 2009](#)). Also, the moment conditions introduced into the GMM improve the estimates of the predictors but too much of it can lead

to instrument proliferation making the model overfit. The Hansen test for overidentification restriction has been used to check the presence of excessive moment conditions. In addition, to ensure that the errors are serially uncorrected in their levels and achieve validity of the GMM estimates, the first and second-order autocorrelation test is performed. The choice between one-step and two-step GMM is settled by [Bond and Windmeijer \(2005\)](#) favouring the latter because the two-step is asymptotically efficient. To further fortify the robustness of the empirical model, we use the three Andrews-Lu information selection criteria (AIC, BIC and HQIC) to choose the appropriate model that best fits the nature of the data at hand. The results for the model selections have been excluded from the paper due to the length of the paper but can be made available upon request.

4. Results and discussions

4.1 Summary statistics

[Table 1](#) presents the descriptive statistics of the data. The reported standard deviation, skewness and kurtosis of the data justify the usage of the dynamic model used in estimating the empirical model. There is no serious concern in the descriptive statistics that needs special attention. [Table 2](#) provides the results of the correlation matrix. The numerical strength of the association among the datasets is within acceptable thresholds (less than 0.5); hence, there is the absence of multicollinearity. To further dissolve any appearance of multicollinearity problem, financial depth (dep), access (acc) and efficiency (eff) which recorded relatively high correlation values are not included in the same model. Rather, each of the financial development indicators is placed in a separate model. Also, the correlation matrix in [Table 2](#) shows a positive relationship between FDI and environmental risk. The positive relationship supports the upward trend between FDI and CO₂ shown in [Figure 1](#).

[Figure 2](#) offers more insight into the nature of the data set and gives pictorial evidence in support of the correlation matrix. [Figure 2](#) consists of [Figure 2\(a\)](#) and [2\(b\)](#). [Figure 2\(a\)](#) demonstrates the bivariate relationship between the environmental risk (CO₂) and the three components of the financial development indicators. [Figure 2\(a\)](#) suggests a strong positive relationship between CO₂ and financial access. However, a negative relationship is depicted between CO₂ and financial depth and a weak negative bivariate relationship between CO₂ and financial efficiency. This can also be seen in the correlation coefficient of 0.112, -0.102 and -0.0245 for financial access, depth and efficiency respectively in [Table 2](#). It follows that the three components of financial development relate differently to environmental risk.

	envtr	fdi	dep	acc	eff	fr	urban	gdp	dinv
envtr	1								
fdi	0.106***	1							
dep	-0.102***	-0.0254	1						
acc	0.112***	0.216***	0.473***	1					
eff	-0.0245	0.0881***	0.451***	0.391***	1				
fr	-0.0248	0.273***	0.0110	0.0255	0.124***	1			
urban	0.137***	-0.0108	0.143***	-0.0495*	0.107***	-0.0460	1		
gdp	0.0215	-0.0353	-0.0138	-0.0248	-0.0565*	-0.0157	0.0258	1	
dinv	0.0848***	-0.00917	-0.245***	-0.0223	-0.103***	0.000873	-0.00824	0.0299	1

Table 2.
Correlation matrix

Notes: * $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$
Source: Authors' computations

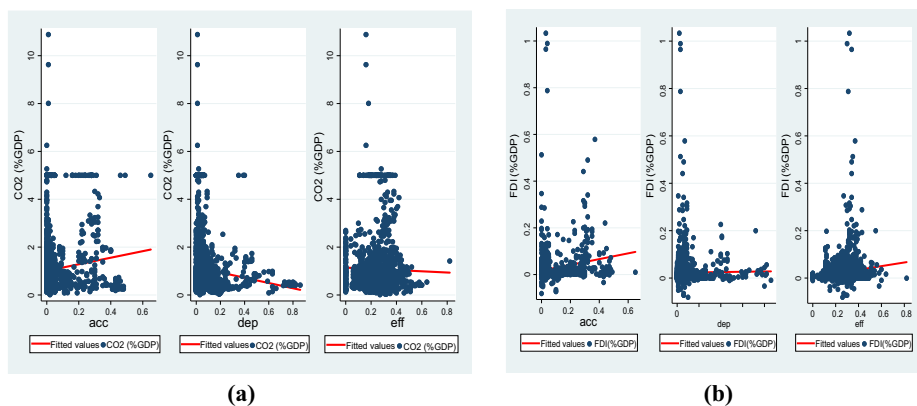


Figure 2. Bivariate relationship between CO₂, FDI, access, depth and efficiency

Notes: (a) Bivariate relationship between CO₂ and access, depth and efficiency; (b) Bivariate relationship between FDI and access, depth and efficiency

It can therefore be inferred that depending on the choice of financial development indicators, a study may either report a positive or negative relationship with the environmental risk.

Hence, this oversight in the existing literature is the more reason why earlier studies reported contradicting and biased results (Ntow-Gyamfi *et al.*, 2020; Acheampong, 2019; Shahbaz *et al.*, 2018; Riti *et al.*, 2017; Tamazian *et al.*, 2009).

Again, Figure 2(B) shows a bivariate relationship between FDI and the three components of financial development indicators. The FDI although has a strong positive relationship with financial access and efficiency; however, has a weak and negative association with financial depth.

Taking Figure 2(a) and (b) together, they offer support for investigating the impact of the three components of financial development on the relationship between FDI and environmental risk.

4.2 Can financial depth, access and efficiency improve the impact of foreign direct investment on environmental risk?

The bivariate relationships are shown in Figure 2 and the correlation matrix do not imply a causal effect, we present the results from the empirical model estimations in Tables 3, 4 and 5.

The baseline results for the study are presented in Columns (1)–(9) of Table 3. In Columns (1), (2) and (3), we test the unilateral effect of the decomposed financial development on the environmental risk. The environmental risk is the environmental cost of carbon emission in dollar terms as a percentage of GDP.

The results in Column (1) show that financial depth recorded a negative coefficient of 1.126 at a 1% significant level. The findings suggest that an increase in financial depth may lead to a reduction in environmental risk; thus, the damage cost of carbon emission may be reduced. Financial depth comprises private sector credit, the value of pension and mutual funds, the value of stock trade, private sector debt securities and government external debts. An increase in these financial depth variables may lead to an increase in economic activities. Therefore, if the economic activities are environmentally destructive, financial depth will result in worsening environmental risk. The findings from this study show that the current direction of financial depth reduces environmental risk. The findings offer insights to policymakers in using the financial depth indicators to regulate the relationship between finance and environmental risk.

Table 3.
System GMM
results – full sample

Variables	(1) envtr	(2) envtr	(3) envtr	(4) envtr	(5) envtr
lenvtr	0.894*** (0.0308)	0.801*** (0.0270)	0.895*** (0.0311)	0.890*** (0.0314)	0.936*** (0.0292)
fr	-0.0163 (0.0329)	0.00208 (0.0136)	-0.00185 (0.0333)	-0.0121 (0.0328)	-0.0483 (0.0335)
gdp	0.0912*** (0.0251)	0.0445*** (0.0189)	0.0921*** (0.0254)	0.0919*** (0.0251)	0.0792*** (0.0249)
urban	0.0714*** (0.0132)	0.0243*** (0.0123)	0.0741*** (0.0138)	0.0727*** (0.0130)	0.0591*** (0.0135)
dinvtr	-0.0130* (0.0068)	0.0019 (0.0050)	-0.0078 (0.0066)	-0.0158** (0.0071)	0.0028 (0.0071)
fdi	4.007** (1.555)	0.293 (0.194)	3.990** (1.571)	3.820** (1.554)	3.067* (1.611)
dep	-1.126*** (0.295)			-1.612*** (0.554)	
acc		0.592*** (0.206)			1.323** (0.5834)
eff			-1.278*** (0.344)		
dep ²				0.219 (0.749)	
acc ²					-4.101** (1.656)
eff ²					
dep × fdi					
acc × fdi					
eff × fdi					
Constant	-2.861*** (0.481)	-0.924* (0.500)	-2.782*** (0.478)	-2.853*** (0.453)	-2.740*** (0.488)
Year dummy	Yes	Yes	Yes	Yes	Yes
Observations	1,634	1,634	1,634	1,634	1,634
F Statistics	62.15	68.02	63.15	72.56	67.28
Groups/instruments	43/29	43/28	43/28	43/29	43/29
AR (2)	0.365	0.464	0.382	0.392	0.352
Hansen Statistics	0.286	0.276	0.257	0.286	0.276
Turning point (TP)	n/a	n/a	n/a		0.161
<i>Marginal effect</i>					
FD Comp.	n/a	n/a	n/a	n/a	n/a
FDI	n/a	n/a	n/a	n/a	n/a

Notes: Standard errors in parentheses. ***, **, * are statistical significance at the 1, 5 and 10% levels, respectively

Source: Authors' computations

(continued)

Variables	(6)		(7)		(8)		(9)	
	envtr		envtr		envtr		envtr	
lenvtr	0.865*** (0.0400)		0.894*** (0.0312)		0.914*** (0.0285)		0.911*** (0.0285)	
fr	0.0465 (0.0490)		-0.00567 (0.0394)		0.0742*** (0.0315)		0.0567*** (0.0155)	
gdp	0.105*** (0.0293)		0.0892*** (0.0251)		0.0729*** (0.0237)		0.0802*** (0.0234)	
urban	0.0915*** (0.0192)		0.0729*** (0.0135)		0.0811*** (0.0125)		0.0756*** (0.0114)	
dinvtr	-0.0126 (0.0080)		-0.0141* (0.0075)		-0.0026 (0.0068)		-0.0046 (0.0063)	
fdi	5.122*** (1.893)		5.235* (2.978)		-1.124 (3.005)		6.602*** (1.376)	
dep			-0.491 (0.836)					
acc					1.357*** (0.495)			
eff	-11.95* (7.158)							
dep ²								
acc ²								
eff ²								
dep × fdi								
acc × fdi								
eff × fdi		19.75 (13.23)		-37.11* (22.38)				
Constant								
Year dummy		-2.316*** (0.613)		-2.911*** (0.453)				
Observations		Yes	Yes	Yes	Yes		Yes	
F Statistics		1,634	1,634	1,634	1,634		1,634	
Groups/instruments		59.53	58.24	62.86	64.86		64.86	
AR (2)		43/28	43/30	43/30	43/31		43/31	
Hansen Statistics		0.386	0.625	0.685	0.615		0.615	
Turning point (TP)		0.261	0.326	0.313	0.356		0.356	
<i>Marginal effect</i>			n/a	n/a	n/a		n/a	
FD Comp.		n/a	-1.192*	n/a	n/a		-1.49***	
FDI		n/a	9.4*	n/a	n/a		1.8***	

Table 3.

In Column (3), financial efficiency recorded a negative coefficient of 1.1278 at a 1% level of significance. This also means that a rise in financial efficiency could help reduce environmental risk. Financial efficiency measures the extent to which investors may profit from their investment. Improved financial efficiency ensures that financial resources move to the most efficient firms leading to high returns on investment. Net interest margin, return on equity, lending-deposit spread and stock market turnover ratio are some of the indicators of financial efficiency. The findings show that enhancement in the return on investment is good for the environment. Therefore, financial regulators, such as central banks, may implement policies to eliminate inefficiencies and improve return on investment.

But the findings from the financial access index variable are opposite to the depth and efficiency index. Access recorded a positive coefficient of 0.592 and its statistically significant at 1%. This implies that as people get more access to finance, environmental degradation is worsened. [Sahay et al. \(2015\)](#) description of financial development provides insight into the disparities in the effect of the decomposed financial development indicators on the environment. They explained that financial development is a “combination of depth (size and liquidity of markets), access (the ability of individuals to access financial services), and efficiency (ability of institutions to provide financial services at low cost and with sustainable revenues, and the level of activity of capital markets)”. As the size of the market expands and becomes highly liquid (financial depth), the investment choice of investors increases and can reduce over-concentration in one particular sector. Investment in the African economy is skewed towards the primary extractive sectors which by far worsens environmental risk ([UNCTAD, 2020](#)). [Sahay et al. \(2015\)](#) believe that financial depth diffuses investment over-concentration in a few sectors of the economy. This is the more reason why financial depth reduces environmental risk. A similar finding is reported by [Shahbaz et al. \(2018\)](#), [Tamazian et al. \(2009\)](#) and [Riti et al. \(2017\)](#) who used a subcomponent of financial depth – domestic credit to the private sector – to measure the effect of financial development on carbon emission.

Additionally, financial access increases environmental risk as reported in Column (2) of [Table 3](#). This is not surprising because access to financial services increases the number of households in the mainstream financial system which enables them to have access to funds. This study is not advocating that financial access should be curtailed but rather given the African case where an increase in financial access finds its way to destroying the environment, appropriate financial depth and efficiency should be instituted to direct the funds into climate-resilient sectors. Column (3) of [Table 3](#), shows that financial efficiency is a good catalyst for environmental quality. This is affirmed by [Acheampong \(2019\)](#) that the low cost of funds enables climate-resilient and energy-efficient sectors which hitherto were less profitable to investors will start receiving appropriate investment attention. One major cause of the lack of investment in climate-resilient sectors such as clean energy is the high cost of finance; hence, an increase in financial efficiency to reduce the cost of funding can reduce environmentally degrading activities.

Columns (4), (5) and (6) of [Table 3](#) present the results of the quadratic relationship between financial development and environmental risk and their turning points as well. The squared term of financial depth and efficiency failed to enter into the models at conventional levels. However, financial access recorded a negative coefficient of 4.101% at a 5% level of significance, implying that if the level of financial access is doubled, environmental risk is likely to be reduced.

Furthermore, the findings on the financial access index both in the linear form and the quadratic form reveal an inverted “U” shape between access and environmental risk. This means that whereas lower levels of financial access aggravate environmental risk, higher

levels of access can reduce it. There are two reasons accounting for this finding. First, at low levels of financial access, investors concentrate their investment in a few profitable sectors. Low levels of financial access also imply that the cost of funding is high due to the competing needs for the funds. Given the investment landscape in Africa, profit-seeking investors are more likely to invest in the extractive sectors which worsen the environmental risk. Second, high levels of financial access reduce environmental risk due to the widening of the financial nets to capture a variety of previously neglected sectors. An increase in financial access also means that research and development into environmentally resilient technologies can be undertaken. One of the major hindrances to the adoption of clean production technology is cost, and financial access empowers entrepreneurs to scale over the cost barrier (United Nations, 2021).

Also, the linear and non-linear coefficients of the financial efficiency presented in Column (5) of Table 3 mimic a classical financial development EKC as reported by Ntow-Gyamfi *et al.* (2020), Dasgupta *et al.* (2002) and Grossman and Krueger (1991).

Furthermore, FDI continues to exert a positive effect on environmental risk in all the baseline models except for Columns (2) and (8) where it fails to enter into the empirical models at conventional levels. These findings are not new to the literature (Boachie-Yiadom and Mensah, 2021; Singhania and Saini, 2021; Shahbaz *et al.*, 2018; Bokpin, 2017; Zheng and Sheng, 2017; Omri *et al.*, 2014). Boachie-Yiadom and Mensah (2021) observed with concern that FDI moves into jurisdictions with lax environmental laws to take advantage to reap high returns. This finding should guide policy formulation to regulate inward FDI.

Beyond the negative environmental effects of FDI, it contributes to economic growth. This makes FDI a delicate issue for policymakers. This study offers policy options in using financial depth, access and efficiency to regulate the effect of FDI on the environment. FDI is a necessary evil in Africa's development story, hence, there is a need to find innovative means to overturn if possible its negative effect on the environment. In line with institutional economics, we suspect the decomposed financial development indicators could.

In Columns (7), (8) and (9) of Table 3, we test whether financial depth, access and efficiency make the FDI – environmental risk nexus better by introducing the interaction terms into the models.

The results show that financial depth and efficiency are significant and negative at conventional levels. This is because the coefficient of the interaction between depth and FDI recorded a negative coefficient of 37.11 at a 10% significant level, while the interaction term for efficiency and FDI reported a negative coefficient of 20.42 at a 1% significant level. This means that depth and efficiency are two good channels that can overturn the negative impact of FDI on the environment. This finding is possible and consistent throughout this study. This is because the study has justified the bivariate relationship between financial development (depth and efficiency) and environmental risk as well as FDI in Figure 2(a) and (b) and the correlation matrix in Table 2. If financial development (depth and efficiency) correlates negatively with environmental risk and also reduces the environmental risk [Columns (1) and (3) in Table 3] then it can influence the FDI–environment nexus.

However, the interaction terms of depth and efficiency could be deceptive when explaining them, hence, we compute their marginal effects following Alfaro *et al.* (2004) approach and present the results in Columns (7) and (9) of Table 3. The marginal effect coefficient of -1.192 and -1.49 is reported for depth and efficiency respectively. This means that depth and efficiency consistently improve the FDI and environmental risk nexus. Although this finding is still under-researched in the literature, it finds support from the larger institutional economics studies which suggest that institutional quality overturns the negative effect of FDI on the environment (Bokpin, 2017). On the other hand, the interaction

term between access and FDI failed to record a negative coefficient of 0.837 but failed to enter into the model at conventional levels. The more likely reason for this finding is that the interactions were done in the linear form of the data and financial access in the linear form does not improve the quality of the environment. Hence, it is no surprise that the financial access index interaction term could be significant. Perhaps, the quadratic or better still a higher level of financial access is required to improve the impact of FDI on the environment.

4.3 Robustness checks, control variables and validity of the results

To check the robustness of the findings of the study, we split the dataset into high and low-financially developed countries and presented the results in [Tables 4](#) and [5](#), respectively. The data splitting was done using a simple quartile analysis to locate the median financial development indicator and countries above the median were separated and classified as highly financially developed countries. We followed the same approach to classify the low financially developed countries.

The results presented from Column (10), through Column (18) of [Table 4](#) replicate the baseline regression results in [Table 3](#) in terms of the expected signs and the level of significance of the variables of interest. For instance, the interaction term between financial depth and FDI recorded a coefficient of -18.44% at a 5% significant level. This finding confirms the baseline results that financial depth indeed overturns the negative impact of FDI on the quality of the environment, especially among highly financially developed countries. Column (18) of [Table 4](#) presents a similar result for financial efficiency and FDI. Notwithstanding, Column (19), through to (27) presents the results for the low financially developed countries. Our variables of interest: financial depth, access and efficiency together with their squared terms as well as interactions failed to enter into the empirical models at conventional levels, except for the squared of financial access in Column (23). The results imply that financial development indicators are ineffective in either improving environmental risk by themselves or correcting the negative effect of FDI on the environment. Thus, weak financial developments do not matter in explaining environmental risk even at the linear levels (Columns 19–21). Also, none of the financial development components is significant in explaining the effect of FDI on environmental risk (Columns 25–27).

Taking the regression results in [Tables 4](#) and [5](#) together gives further evidence that financial depth, access and efficiency are key determinants in accounting for the effect of FDI on environmental risk. Weak or low financial development fails to protect the environment from being deteriorated by FDI.

Additionally, the results of the control variables presented in the baseline regression in [Table 3](#) maintain their expected signs which are consistent in the literature ([Boachie-Yiadom and Mensah, 2021](#); [Singhania and Saini, 2021](#); [Dasgupta et al., 2002](#); [Grossman and Krueger, 1991](#)). For instance, economic growth (gdp) and urbanization (urban) recorded a positive and significant coefficient in Columns (1) through to (9) implying that the two variables worsen environmental quality. Domestic investment (dinv) reduces environmental risk (see Columns 1, 4 and 7). This means that local investors are more environmentally considerate than foreign investors. Financial regulation (fr) was significant in Columns (8) and (9) and reveals that the current states of financial regulations in Africa are environmentally depressive.

5. Conclusions and policy implications

The contribution of FDI to economic growth especially among financially cursed economies has been well researched. However, recent studies show that although FDI improves

Variables	(10) envtr	(11) envtr	(12) envtr	(13) envtr	(14) envtr
lenvtr	0.651*** (0.0653)	0.594*** (0.0494)	0.639*** (0.0705)	0.590*** (0.0689)	0.642*** (0.0664)
fr	-0.087*** (0.0262)	-0.056*** (0.0145)	-0.092*** (0.0272)	-0.093*** (0.0268)	-0.116*** (0.0275)
gdp	-0.0032 (0.0233)	0.0052 (0.0171)	0.0021 (0.0234)	-0.00052 (0.0238)	0.0112 (0.0235)
urban	0.115*** (0.0183)	0.00527 (0.0146)	0.120*** (0.0200)	0.126*** (0.0180)	0.109*** (0.0201)
divnt	0.0753*** (0.0142)	0.0102 (0.0117)	0.0838*** (0.0156)	0.0594*** (0.0112)	0.0936*** (0.0162)
fdi	1.018 (0.742)	0.587*** (0.196)	1.055 (0.758)	0.837 (0.761)	0.550 (0.760)
dep	-0.528** (0.213)			-2.244*** (0.618)	
acc		0.858** (0.339)			13.21*** (2.471)
eff			-1.303** (0.587)		
dep ²				0.127 (0.707)	
acc ²					-35.59*** (6.365)
eff ²					
dep × fdi					
acc × fdi					
eff × fdi					
Constant	-4.451*** (0.712)	0.0599 (0.637)	-4.344*** (0.721)	-4.491*** (0.630)	-4.818*** (0.788)
Year dummy	Yes	Yes	Yes	Yes	Yes
Observations	981	981	981	981	981
F Statistics	42.15	43.56	48.25	44.27	52.26
Groups/instruments	43/32	43/32	43/33	43/35	43/35
AR (2)	0.624	0.684	0.678	0.586	0.612
Hansen Statistics	0.324	0.342	0.368	0.425	0.428
Turning point (TP)	n/a	n/a	n/a	n/a	0.186
<i>Marginal effect</i>					
FD Comp.	n/a	n/a	n/a	n/a	n/a
FDI	n/a	n/a	n/a	n/a	n/a

Notes: Standard errors in parentheses. ***, **, * are statistical significance at the 1, 5 and 10% levels respectively
Source: Authors' computations

(continued)

Table 4.
 System GMM
 results – high FD
 nations

Table 4.

Variables	(15) envtr	(16) envtr	(17) envtr	(18) envtr
lenvtr	0.605*** (0.0786)	0.569*** (0.0715)	0.723*** (0.0593)	0.653*** (0.0717)
fr	-0.089*** (0.0289)	-0.109*** (0.0279)	-0.042* (0.0241)	-0.038** (0.0191)
gdp	0.0046 (0.0249)	0.0014 (0.0243)	-0.0183 (0.0206)	0.0171 (0.0229)
urban	0.131*** (0.0227)	0.127*** (0.0182)	0.0879*** (0.0141)	0.110*** (0.0180)
dinvtr	0.0963*** (0.0188)	0.0619*** (0.0111)	0.0678*** (0.0128)	0.0849*** (0.0156)
fdi	1.052 (0.805)	2.536** (1.262)	0.804 (1.466)	9.962*** (2.287)
dep		-1.614*** (0.491)		
acc			2.521*** (0.506)	0.195 (0.606)
eff	-14.02 (9.011)			
dep ²				
acc ²				
eff ²	16.84 (11.90)			
dep × fdi				
acc × fdi		-18.44** (8.876)		
eff × fdi				
Constant	-2.596* (1.453)	-4.585*** (0.647)	-3.681*** (0.611)	-31.29*** (7.025)
Year dummy	Yes	Yes	Yes	Yes
Observations	981	981	981	981
F Statistics	51.78	38.47	39.25	34.58
Groups/instruments	43/35	43/34	43/34	43/36
AR (2)	0.576	0.624	0.489	0.594
Hansen Statistics	0.412	0.452	0.467	0.489
Turning point (TP)	n/a	n/a	n/a	n/a
<i>Marginal effect</i>				
FD Comp.	n/a	-1.051***	n/a	-1.268***
FDI	n/a	1.494***	n/a	2.567***

Variables	(19) envtr	(20) envtr	(21) envtr	(22) envtr	(23) envtr
lenvtr	1.094*** (0.0278)	0.844*** (0.0511)	1.093*** (0.0277)	1.093*** (0.0277)	1.025*** (0.0351)
fr	-0.113** (0.0573)	-0.0061 (0.0226)	-0.103* (0.0604)	-0.120** (0.0577)	-0.230*** (0.0685)
gdp	-0.0200 (0.0244)	-0.0508** (0.0244)	-0.0212 (0.0246)	-0.0184 (0.0242)	-0.0406 (0.0260)
urban	0.0228 (0.0141)	-0.0113 (0.0155)	0.0257* (0.0147)	0.0226 (0.0141)	0.0223 (0.0142)
dlnvtr	-0.0175 (0.0179)	0.0195 (0.0169)	-0.0199 (0.0172)	-0.0189 (0.0177)	0.0114 (0.0180)
fdi	11.27** (4.944)	-0.532 (1.470)	11.03** (4.976)	11.73** (4.881)	3.490 (5.598)
dep	-0.746 (2.813)			-1.874 (2.389)	
acc		-0.625 (1.888)			45.16*** (13.92)
eff			-0.274 (0.454)		
dep ²				-18.26 (19.40)	
acc ²					-1.764*** (513.9)
eff ²					
dep × fdi					
acc × fdi					
eff × fdi					
Constant	-0.899* (0.469)	0.687 (0.553)	-0.953** (0.480)	-0.864* (0.467)	-0.841* (0.492)
Year dummy	Yes	Yes	Yes	Yes	Yes
Observations	653	653	653	653	653
F Statistics	72.56	67.28	59.53	58.24	62.86
Groups/instruments	43/29	43/29	43/28	43/30	43/30
AR (2)	0.392	0.352	0.386	0.625	0.685
Hansen Statistics	0.286	0.276	0.261	0.326	0.313
Turning point (TP)	n/a	n/a	n/a	n/a	12.800
<i>Marginal effect</i>					
FD Comp.	n/a	n/a	n/a	n/a	n/a
FDI	n/a	n/a	n/a	n/a	n/a

Notes: Standard errors in parentheses. ***, **, * are statistical significance at the 1, 5 and 10% levels, respectively

Source: Authors' computations

(continued)

Table 5.
System GMM
results – low FD
nations

Table 5.

Variables	(24) envtr	(25) envtr	(26) envtr	(27) envtr
lenvtr	1.088*** (0.0292)	1.105*** (0.0298)	1.084*** (0.0302)	1.096*** (0.0275)
fr	-0.1103* (0.0629)	-0.0508 (0.0403)	0.0003 (0.0402)	-0.0100 (0.0250)
gdp	-0.0264 (0.0259)	-0.0200 (0.0243)	-0.0237 (0.0244)	-0.0227 (0.0242)
turban	0.0297* (0.0157)	0.0243* (0.0140)	0.0299** (0.0141)	0.0262* (0.0146)
dinvtr	-0.0163 (0.0181)	-0.0339** (0.0163)	-0.0303** (0.0148)	-0.0288* (0.0162)
fdi	11.33** (5.183)	9.561 (6.624)	-0.634 (7.125)	1.752 (1.903)
dep		0.902 (5.083)		
acc			-3.240 (7.155)	
eff	10.59 (8.882)			-0.555 (0.497)
dep ²				
acc ²				
eff ²				
dep × fdi				
acc × fdi				
eff × fdi	-41.08 (33.53)	-191.9 (180.9)		
Constant				
Year dummy	-1.429** (0.632)	-0.783* (0.466)		
Observations	Yes 653	Yes 653	Yes 653	Yes 653
F Statistics	64.86	62.15	68.02	63.15
Groups/instruments	43/31	43/29	43/28	43/28
AR (2)	0.615	0.365	0.464	0.382
Hansen Statistics	0.356	0.286	0.276	0.257
Turning point (TP)	n/a	n/a	n/a	n/a
<i>Marginal effect</i>				
FD Comp.	n/a	n/a	n/a	n/a
FDI	n/a	n/a	n/a	n/a
				5.503 (8.420)
				-0.714 (0.462)

economic outcomes, it also worsens environmental risk (Acheampong *et al.*, 2020; Acheampong, 2019; Shahbaz *et al.*, 2018; Riti *et al.*, 2017; Bokpin, 2017; Shahbaz *et al.*, 2016). As FDI is almost a necessity for Africa's development, there is a need to explore channels that can overturn the negative effect of FDI on the environment. Many studies have advocated for strong institutions to correct the harmful effects of FDI on the environment (Boachie-Yiadom and Mensah, 2021; Bokpin, 2017). However, institutions are almost everything in the administration of a country and therefore the "institutional wholesale" recommendations leave policymakers still asking questions on which aspect of institutions can directly influence FDI–environment nexus. This study dissolves this doubt by exploring how financial development can play a good catalyst role in the FDI–environmental nexus. To this end little is known about the moderating effect of financial development in this all-important nexus. Therefore, we decomposed financial development into its three key components to investigate whether they can help reduce the negative impact of FDI on the environment.

The results from the various estimations conclude that financial deepening and efficiency reduce environmental risk and can overturn the negative impact of FDI on the environment. Additionally, we find that low levels of financial access worsen environmental risk, but doubling financial access is likely to reduce it which makes the relationship between access and environmental risk non-monotonic.

The practical implications of these findings can be put into three.

First, if inward FDI to Africa continues the business-as-usual investment, the environmental damage from carbon emissions in the region may continue to rise. The finding provides caution to policymakers to review regulations on FDI by strengthening the environmental conditionalities for FDI. Hence, this finding provides an investment guide and direction to both multinational companies and FDI host nations.

Second, the findings that financial depth and efficiency are effective at reducing environmental risk and overturning the negative impact of FDI on environmental risk reveal that these two financial development indicators need considerable attention. Financial depth indicators, for example private sector credits and public funding should be increased to aid in advancing credit to environmental resilient sectors. This can be achieved through deliberate government action of investing in environmental resilient sectors such as renewable energies. Indirectly, government can encourage private sector credits to green sectors of the economy by offering tax holidays and other incentives to attract investors. Improvement in financial efficiency guarantees high returns on savings and investment. A rise in savings and investment also increases financial depth. So, central government, may invest in financial technologies and infrastructure and formulate financial regulations through monetary and fiscal policies to enhance financial efficiency and depth.

Finally, our sample splitting approach reveals that countries with a low financial development indicator index suffer more environmental risk from FDI than countries with a well-developed financial system. Hence, financial development is key in accounting for the extent to which FDI influences the environment.

Therefore, the study recommends that central government policies which target increasing financial depth, access and efficiency should be encouraged. For example, the use of monetary policies such as reduction in policy rates and bank ratios, and fiscal policies such as tax cuts can improve the financial depth and access to combat environmental risk. Additionally, the study recommends that future studies construct or adopt environmental risk proxies that are complex or detailed to measure both financial and non-financial aspect of environmental damage other than carbon dioxide emissions.

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Further reading

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Depth	Access	Efficiency
1. Private-sector credit (% of GDP)	1. Branches (commercial banks) per 100,000 adults	1. Net interest margin
2. Pension fund assets (% of GDP)	2. ATMs per 100,000 adults	2. Lending deposits spread
3. Mutual fund assets (% of GDP)	3. Percent of market capitalization outside of the top 10 largest companies	3. Non-interest income to total income
4. Insurance premiums, life and non-life (% of GDP)	4. Total number of issuers of debt (domestic and external, nonfinancial corporations and financial corporations)	4. Overhead costs to total assets
5. Stock market capitalization to GDP		5. Return on assets
6. Stocks traded to GDP		6. Return on equity
7. International debt securities government (% of GDP)		7. Stock market turnover ratio (stocks traded/capitalization)
8. Total debt securities of nonfinancial corporations (% of GDP)		
9. Total debt securities of financial corporations (% of GDP)		

Note: The factors influencing the level of development in the financial depth, access and efficiency are the same as the variables used by [Sahay et al. \(2015\)](#) in computing them

Table A1.
Factors inducing
growth in financial
depth, access and
efficiency

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