Efficiency of Financial Integration, Foreign Direct Investment and Output Growth: Policy Options for Pollution Abatement in Africa

Ekundayo Peter Mesagan[1]

ABSTRACT

This paper evaluates the impact of financial integration on environmental pollution through foreign direct investment and output growth channels between 1980 and 2017. The study employs panel cointegration techniques using the fully modified ordinary least squares to estimate the country-specific and panel data from the five largest African nations. The findings show that financial integration positively impacts pollution in Nigeria, Algeria, Egypt, Angola, and in the panel, while it reduces pollution in South Africa. Also, financial integration lowers pollution through the foreign investment channel in the panel, Nigeria, Egypt, Angola and Algeria, but not in South Africa. Lastly, financial integration increases pollution through the output growth channel in the panel, Algeria, South Africa, Nigeria and Angola, but not in Egypt. Pollution-reduction policies are then recommended for the African region.

JEL Classification: F21; F36; F64; O10; O44
Keywords: Africa; Economic Growth; Financial Integration; Foreign Direct Investment

1. INTRODUCTION

In recent times, the discourse of environmental sustainability has moved to the top of the agenda in every economy. Most global treaties now factor the issue of environmental sustainability into their templates to curb the rampaging global warming. This is hinged on the fact that global warming has continued to alter the socio-economic space and has restricted the freedom that nature brings to the global economy. Also, climate change is strongly driven by global warming and therefore requires adequate attention from policy experts.

A key ingredient fuelling global warming, as identified in the environmental economics literature, is carbon dioxide emissions (CO_2). Scholars including Dasgupta *et al* (2002), Bhattacharyya (2011), and Mesagan and Olunkwa (2020), posit that the rise in CO_2 emissions intensify global warming. As

identified by, for example, Bhattacharyya (2011) and Mesagan *et al* (2021), CO_2 emissions contribute more than 80 per cent of total global warming and it is the most critical of all the greenhouse gas emissions (GHGs). To address the menace of global warming and lower greenhouse gas emissions, the Kyoto Protocol was signed by numerous countries.

However, since African nations only feature in the Annex 2 list of the Protocol, it is pertinent to focus attention on the region. This is because Annex 2 nations are without specific emissions-reduction targets. Furthermore, African nations are fast gaining prominence in the global community in terms of output growth and economic integration. Specifically, Africa's largest economies, Nigeria, South Africa, Algeria, Angola, and Egypt are among the fastest-growing emerging nations with increases in their economic size driven by growth in Gross Domestic Products (GDP) and their financial sectors, which are highly financially integrated and helping to drive the economy of the wider African region. Thus, the situation in these five countries is analysed to set the template for the African region.

As noted by You *et al* (2015), Rasoulinezhad and Saboori (2018), and Koengkan *et al* (2019), nations promote financial integration to sustain the increase in their GDP and enhance their overall economic activities. Also, when countries are financially integrated, this will impact also on their foreign investment inflows. Financial integration makes nations attractive to foreign investment inflows, which in turn promotes economic growth. Studies by Okada (2013), Tan *et al* (2019), Arif-Ur-Rahman and Inaba (2020), Koengkan *et al* (2020), and Park *et al* (2020) attribute increases in the number of foreign investments across the world to the efforts by national governments to promote financial integration.

As posited in the theoretical literature, environmental pollution is strongly linked with an increase in economic output[2] (see Andreoni and Levinson, 2001; Dasgupta *et al,* 2002; Yandle *et al,* 2002). This implies that the effect of financial integration on pollution can be analysed via two critical channels, of output growth and foreign direct investment. Also, pollution haven theory intuitively states that with increases in financial openness across the world, investment flows to these countries to boost growth will affect pollution levels (see Eskeland and Harrison, 2003; Greaker, 2007; Dong *et al,* 2012; Mesagan *et al,* 2018).

As affirmed by Ertugrul *et al* (2016), one prominent means of investing in a foreign economy is by setting up production plants. Such expansion in production technology raises incomes, local production and wealth. An increase in wealth further boosts the techniques of production and alters the status of environmental pollution generated. This implies that through the production technique created, environmental pollution can be reduced. This is the first channel through which financial integration can affect environmental pollution. Again, as financial integration expands, economic growth is enhanced through increases in production activities (Levine, 2001; Edison *et al,* 2002). For Copeland and Taylor (2004), Ertugrul *et al* (2016), and Mesagan and Nwachukwu

(2018), production activities are associated with an increase in the composition effect of emissions caused by the rise in the production of dirty goods.[3] Once there is a rise in the share of dirty goods in total output composition, environmental degradation increases and vice-versa. Hence, via the composition effect created by foreign direct investment, environmental pollution can be compounded. This is the second channel through which financial integration can affect environmental pollution.

Therefore, since carbon dioxide emissions are often associated with increases in economic growth and foreign investment that could be triggered by the level of financial integration, this study focusing on fast-growing African economies becomes particularly relevant. Measured with the level of the capital account openness of the five largest African economies, the channels through which financial integration affects environmental pollution in Africa are analysed. The empirical literature includes many studies relating to the drivers of CO_2 emissions, but the issue of financial integration remains largely untouched. This study not only fills this literature gap by controlling for financial integration in the pollution-abatement model, but it also expands the frontiers of knowledge by examining the channels (i.e. output growth and foreign investment inflow) through which financial integration alter environmental pollution.

Research by Okada (2013), Tan *et al* (2019), Arif-Ur-Rahman and Inaba (2020), and Koengkan *et al* (2020) has illuminated the relationship between financial integration and foreign inflow of investment, with mixed results. While Okada (2013) found that financial integration did not impact foreign inflows of investment significantly, Tan *et al* (2019), Arif-Ur-Rahman and Inaba (2020), and Koengkan *et al* (2020) all found that financial integration significantly influenced investors' decisions to invest in a host country. Bussiere and Fratzscher (2008), Kose *et al* (2009), Bekaert *et al* (2011), Harnphattananusorn (2018), Fasanya and Olayemi (2020), and Gaies *et al* (2020), focused on financial openness and growth, but also produced mixed results. Bussiere and Fratzscher (2008), Bekaert *et al* (2011), Harnphattananusorn (2018), and Gaies *et al* (2020) found that financial integration increased growth. However, Kose *et al* (2009) and Fasanya and Olayemi (2020) found no such causal relationship.

Diao *et al* (2009), Shahbaz *et al* (2015), Hakimi and Hamdi (2016), Saibu and Mesagan (2016), Charfeddine *et al* (2018), and Mesagan *et al* (2018) examined the nexus between foreign direct investment, output growth and pollution, also with mixed findings. Diao *et al* (2009) found that growth reduced pollution, Shahbaz *et al* (2015) found that foreign investment lowered pollution, while Saibu and Mesagan (2016) observed that growth and foreign investment both reduced pollution. Meanwhile, Hakimi and Hamdi (2016) found bidirectional causality between pollution and foreign investment, while both Charfeddine *et al* (2018) and Mesagan *et al* (2018) confirmed that growth increased pollution.

Shahbaz *et al* (2013), Omri *et al* (2015), Shahbaz *et al.* (2016) Nasreen *et al* (2017), and Mesagan and Nwachukwu (2018) examined pollution abatement via the channel of financial sector development. Shahbaz *et al* (2013) and

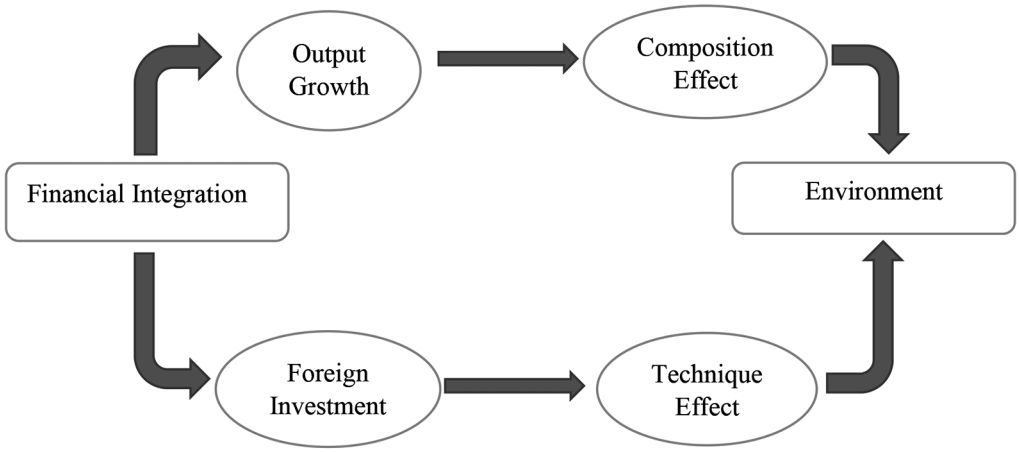
Shahbaz *et al* (2016) found that financial sector development increased pollution, while Nasreen *et al* (2017) found that financial sector development lowered pollution. For Omri *et al* (2015), a neutral effect was confirmed for financial development and pollution, Mesagan and Nwachukwu (2018) observed that financial performance strongly influenced environmental pollution.

Given the scale of the literature with mixed findings, this study becomes crucial by examining the effect of financial integration on pollution control in Africa via the channels of foreign direct investment and output growth. Specifically, this research analyses the impact of financial integration on carbon emissions. It examines the effect of financial integration on pollution through the augmenting channel of output growth. It also determines its impact on carbon pollution through the foreign direct investment channel. Fully modified ordinary least squares (FMOLS) is used to analyse the country-specific results for the selected countries. Following the introduction section, the rest of the paper proceeds as follows. Section 2 presents the conceptual framework and background facts. Section 3 focuses on the empirical model, Section 4 presents the analysis, Section 5 discusses the findings, while Section 6 presents the conclusions.

2. Conceptual Framework and Background Facts

In this section, the study provides the linkage between the major variables that are used in the study. It also presents the trend of the key variables as a form of scenario analysis.

Figure 1: Conceptual Framework of the Study

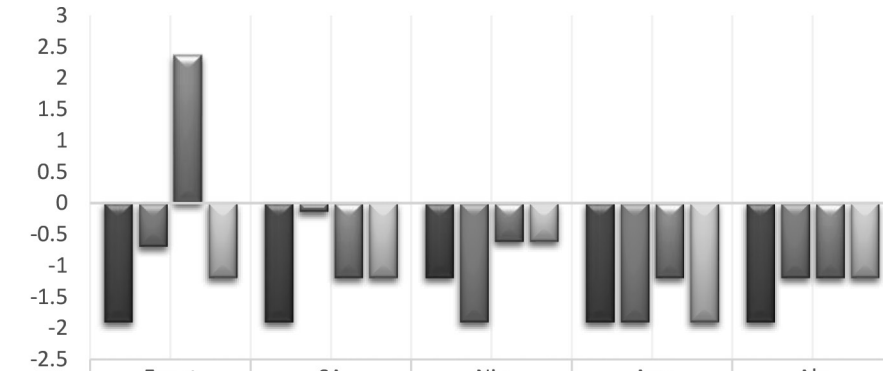


In Figure 1, the conceptual framework for analysing the link between financial integration and environmental quality is presented. As nations open

up their financial system to the international market, it creates two important channels of output growth and foreign investment that affect the environment. Regarding the output growth channel, financial integration increases domestic production and consequently improves economic growth. According to Edison *et al* (2002), financial integration can help to accentuate the pace of output growth given certain institutional and financial indicators. This is hinged on the fact that financial integration facilitates improved performance of the capital market and boosts overall output through an expansion in portfolio investment. Consequently, foreign direct investment expands as well. This is so because financial openness can enhance foreign investment inflows by acting as a catalyst to the domestic financial market (Levine, 2001).

Moreover, through the channel of output growth, financial openness can affect pollution by altering the output composition. As noted in Copeland and Taylor (2004) and Mesagan and Nwachukwu (2018), an increase in carbon pollution can boost the composition effect of emissions by raising the proportion of dirty goods in total output. Also, via the channel of foreign investment inflows, financial integration can impact the environment through the technique effect it generates. As argued by Ertugrul *et al* (2016), the inflow of foreign investment leads to the domestic expansion of production technology and consequently income. As income expands, wealth to control pollution increases, production techniques improve, and the environment becomes cleaner.

Figure 2: Financial Integration in the selected countries

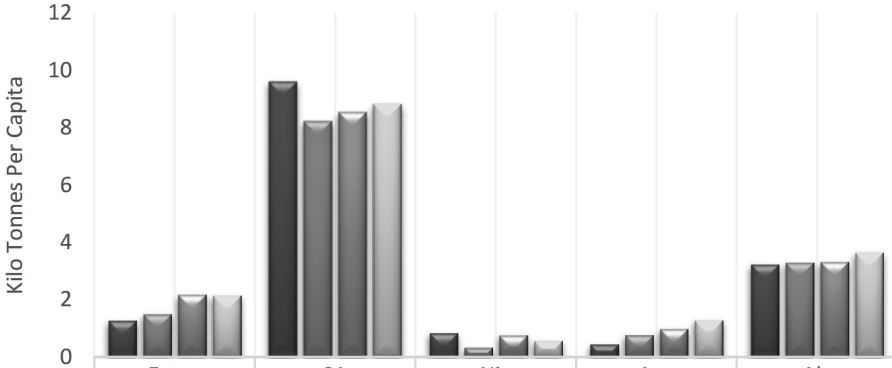


	Egypt	SA	Nig	Ang	Alg
1985	-1.9	-1.9	-1.19	-1.9	-1.9
1995	-0.69	-0.13	-1.9	-1.9	-1.19
2005	2.37	-1.19	-0.61	-1.19	-1.19
2015	-1.19	-1.19	-0.61	-1.9	-1.19

Source: Author's Computation from Chinn and Ito (2008, 2017)

Figure 2 presents data based on the Chinn-Ito Index (Chinn and Ito 2006, 2008, 2017). This measures a country's degree of capital account openness (KAOPEN). KAOPEN is derived from data in the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER) that model restrictions on cross-border financial transactions. This Index has a mean of zero, with higher values indicating greater openness to cross-border capital transactions. As can be seen in Figure 2, the sample countries are relatively closed but, to the extent that a pattern across time is visible, it is towards slightly greater openness.

Figure 3: Carbon Emissions in the selected countries



	Egypt	SA	Nig	Ang	Alg
1985	1.27	9.61	0.84	0.44	3.23
1995	1.5	8.23	0.33	0.77	3.3
2005	2.18	8.54	0.76	0.98	3.32
2015	2.15	8.83	0.57	1.29	3.65

Source: WDI (2019)

Figure 3 presents data for CO_2 emissions per capita. There are clear and significant differences across countries. It is interesting to note that the countries with the lowest per capita emissions levels, Nigeria and Angola, are two oil producers, although Angola's per capita emissions show a clear rising trend. Algeria, also a member of the Organisation of Petroleum Exporting Countries (OPEC), has significantly higher per capita emissions, despite having the lowest level of oil production of the three. As discussed later, South Africa relies on coal for much of its energy needs, contributing to its much high per capita emissions.

3. The Empirical Model

This study derives from the proposition of the Environmental Kuznets Curve (EKC), which specifies environmental pollution as a function of income per capita. As posited in Yandle *et al* (2002) and Dasgupta *et al* (2002), carbon emission exhibits an inverted U-shaped relationship with income per capita as it rises with early increases in income and then falls over the long term as wealth expands further. Therefore, the functional relationship becomes:

$$CO_2 = \beta_0 + \chi_1 Y + \chi_2 Y^2 + \mu \quad (1)$$

Where CO_2 stands for carbon emissions, β_0 represents the intercept term, Y and Y^2 represent the EKC proposition, captured by income per capita, χ_1 and χ_2 are the coefficients of income while μ is the residual. To achieve the specific objectives, the study conducts a stepwise regression by modifying Equation (1) to account for the regressors. Firstly, to determine the effect of financial integration on carbon emissions, Equation (2) is presented as:

$$CO_2 = \beta_0 + \chi_1 Y + \chi_2 Y^2 + \chi_3 FINT + \chi_4 EXC + \mu \quad (2)$$

Where *FINT* represents financial integration, *EXC* represents the exchange rate, while χ_3 and χ_4 are the coefficients of financial integration and exchange rate in the model. The other variables remain as explained in equation (1). The official exchange rate is used in the model as a control variable to reduce omitted variable bias. Again, the study modifies Equation (2) by controlling for the effect of output growth and foreign direct investment as follows:

$$CO_2 = \beta_0 + \chi_1 Y + \chi_2 Y^2 + \chi_3 FINT + \chi_4 FDI + \chi_5 OTG + \chi_6 EXC + \mu \quad (3)$$

In Equation (3), *FDI* stands for foreign direct investment, *OTG* stands for output growth, χ_4 and χ_5 are the coefficients of these variables while other variables remain the same. To determine the output growth and foreign investment channels of reducing the emissions caused by financial integration, Equation (3) is then augmented to control for the interaction terms as follows:

$$CO_2 = \beta_0 + \chi_1 Y + \chi_2 Y^2 + \chi_3 KFDI + \chi_4 KOTG + \chi_5 EXC + \mu \quad (4)$$

In Equation (4), *KFDI* is the interaction between financial integration and foreign direct investment, while *KOTG* is the interaction between financial integration and output growth. Their respective elasticities are captured with χ_3 and χ_4.

The data used are carbon emission per capita measured in thousand tonnes, income per capita, foreign direct investment measured as net inflows, the growth rate of real gross domestic product, the official exchange rate, and a measure of financial integration. As employed in Chinn and Ito (2006), financial integration is captured by the capital account openness of the selected countries. The official exchange rate is used as a control variable in the model because of its relationship with the current account balances in these countries.

Hence, it has some influence on the relationship between financial openness and pollution.

To obtain a comprehensive result for the selected sample, country-specific and panel estimates are reported using the panel cointegration approach via the FMOLS. This approach is appropriate because it makes it possible to compare the situation in every country, given that they have unique policies and structural differences. Also, Pedroni (1999, 2000) noted that the FMOLS is superior to the classic OLS framework in that it overcomes endogeneity and corrects serial correlation in the model. Lastly, the financial integration data are sourced from Chinn and Ito (2008, 2017) while all the other indicators are sourced from the World Development Indicators database (WDI, 2019).

4. Results and Discussion

In this section, the findings of the empirical study are presented. We start with the panel descriptive summary, correlation, followed by the panel unit root. Also, the country-specific and panel estimates of the FMOLS are presented, before presenting the causality results. The section ends with the discussion of and intuitions emanating from the various findings.

Table 1: Summary statistic for the key panel variables

Regressors	*Description*	*Min*	*Max*	*SD*	*Mean*
OTG	Output growth (Per cent)	–24.7	33.74	5.148	3.515
CO_2	Carbon emissions (Kilotonnes of Oil)	0.281	9.871	3.062	3.019
EXC	Exchange rate (LCU per US $)	0.029	305.3	53.31	36.20
FINT	Financial integration	–1.90	2.374	1.014	–1.11
Y	Income per person (US $)	1102	7583	1834	3400
FDI	Foreign investment (net inflow % GDP)	–275	333.2	60.38	29.40

Note: Number of Observation is 190; Min. – minimum; Max. – maximum; SD – standard deviation; LCU – local currency unit.

Table 1 shows summary statistics of the major panel regressors. These data indicate wide variations around the mean values.

The panel correlation result presented in Table 2 indicates that all the regressors used in the study are in order. This is consequent on the fact that none of the variables are strongly related, except for the interaction terms which are inevitably linked with their root variables. For instance, the correlation coefficient between foreign direct investment (FDI) and its interaction with financial integration (KFDI) is -0.735, while the one between output growth (OTG) and its interaction with financial integration (KOTG) is -0.749. However, this is not a problem because the study introduces the interaction terms only

Table 2: Panel Correlation Analysis

	CO_2	FDI	INT	KFDI	KOTG	OTG	Y	EXC
CO_2	1.000							
FDI	0.140	1.000						
FINT	–0.043	0.167	1.000					
KFDI	–0.114	–0.735	0.307	1.000				
KOTG	0.062	0.161	0.475	0.120	1.000			
OTG	–0.124	–0.035	0.099	0.108	–0.749	1.000		
Y	0.491	0.155	–0.157	–0.164	–0.029	–0.091	1.000	
EXC	–0.286	0.028	0.024	–0.069	–0.151	0.210	–0.115	1.000

in models which omit their root variables. Therefore, multicollinearity is not a problem in the estimated models.

Table 3: Panel Unit Root Results

Variables	Level		First Difference	
	LLC	Breit	LLC	Breit
CO_2	–0.1539	–1.6013	–6.1780***	–5.1888***
FDI	0.6131	–0.0397	–3.5292***	–3.8349***
FINT	0.0662	–0.4886	–5.7127***	–6.2610***
KFDI	–0.1146	–1.1316	–6.0844***	–4.6232***
KOTG	–1.1513	–0.9122	–4.9394***	–5.8144***
OTG	–1.9970**	–4.6974***	–5.9708***	–7.3468***
Y	–1.1452	0.1400	–7.7218***	–6.7520***
EXC	2.3371	–1.9569	–7.5213***	–5.7420**

Note: LLC represents Levin, Lin & Chu (2002), Breit represents Breitung (2001); ** means 5%; *** means 1% significance levels

The unit root test presented in Table 3 indicates that carbon emission, foreign direct investment, financial integration, income per capita, exchange rate, and the two interaction terms are not stationary in levels, only output growth. However, all the regressors become stationary after first differencing, at 1 per cent and 5 per cent levels of significance. Thus, no unit root exists among the regressors used in the study.

In Table 4, the cointegration results for models I-III are presented using the KAO residual-based test. Using the probability values, Table 3 shows that the study rejects the null hypotheses of no cointegration for the three models at the 5 per cent level of significance. It implies that model I, model II, and model III are all stationary at the 5 per cent level. Hence, the conclusion is that a long-run relationship exists among the regressors across all the models estimated in the study.

Table 4: KAO Residual Test for Cointegration

	t-Statistic	*Probability*
Model I		
ADF	–2.055370	0.0199**
Residual Variance	2830.612	
HAC Variance	6044.429	
Model II		
ADF	–1.723633	0.0424**
Residual Variance	2821.050	
HAC Variance	5650.617	
Model III		
ADF	–2.134090	0.0164**
Residual Variance	2846.067	
HAC Variance	5805.895	

Note: *** specifies 1% significance level.

Table 5: Country-Specific Empirical Results

Variables	*Dependent Variable: CO_2*		
	I	*II*	*III*
		Nigeria	
C	–15.9147 (10.4774)	–27.2193*** (9.4607)	–30.9923** (11.2966)
Y	–0.0014 (0.0008)	–0.0021*** (0.0008)	–0.0024** (0.0009)
Y^2	3.0078 (1.8531)	4.9884*** (1.6713)	5.5770*** (2.0017)
FINT	0.3712*** (0.0773)	0.3673*** (0.0619)	-
FDI	-	–0.0069*** (0.0021)	-
OTG	-	0.0022*** (0.0034)	-
KFDI	-	-	–0.0124*** (0.0032)
KOTG	-	-	0.0057** (0.0045)
EXC	–0.0018** (0.0007)	–0.0017*** (0.0006)	–0.0006 (0.0007)
		South Africa	
C	–23.9891 (18.5160)	–35.7119 (19.2458)	–30.7357 (18.0118)
Y	0.0042 (0.0037)	0.0065 (0.0038)	0.0066 (0.0042)
Y^2	–3.0078 (3.6329)	–5.3704** (2.8511)	–5.5078 (3.1366)
FINT	–0.1271 (0.2341)	–0.2340 (0.2506)	-
FDI	-	0.0016 (0.0019)	-
OTG	-	0.0779** (0.0424)	-
KFDI	-	-	0.0014 (0.0018)
KOTG	-	-	0.0645** (0.0339)
EXC	–0.0664** (0.0338)	–0.0764** (0.0335)	–0.0818** (0.0389)

		Egypt	
C	7.1594** (3.9299)	4.6869 (3.1085)	8.5043** (3.9497)
Y	0.0014*** (0.0003)	0.0012*** (0.0002)	0.0015*** (0.0003)
Y^2	–1.2305 (0.6866)	–0.7816 (2.5411)	–1.4697** (0.6889)
FINT	0.0559*** (0.0116)	0.0534*** (0.0092)	-
FDI	-	–0.0063*** (0.0004)	-
OTG	-	–0.0063 (0.0070)	-
KFDI	-	-	–0.0004** (0.0002)
KOTG	-	-	–0.0093*** (0.0033)
EXC	–0.0175** (0.0076)	–0.0198*** (0.0056)	–0.0182** (0.0068)
		Angola	
C	29.7340*** (5.2401)	27.5605*** (4.4230)	23.4800*** (4.5541)
Y	0.0019*** (0.0003)	0.0017*** (0.0003)	0.0014*** (0.0003)
Y^2	–4.9424*** (0.8754)	–4.5724*** (0.7406)	–3.8886*** (0.0003)
FINT	0.2503*** (0.0686)	0.1659** (0.0625)	-
FDI	-	–0.0002 (0.0001)	-
OTG	-	0.0059*** (0.0020)	-
KFDI	-	-	–0.0001 (0.0008)
KOTG	-	-	0.0048*** (0.0012)
EXC	0.0033*** (0.0006)	0.0037*** (0.0005)	0.0046*** (0.0005)
		Algeria	
C	18.4401** (7.5416)	15.2561** (7.8684)	13.3884** (6.4186)
Y	0.0068** (0.0026)	0.0057** (0.0027)	0.0051** (0.0022)
Y^2	–2.8876** (1.1957)	–2.3858** (1.2454)	–2.0875** (1.0153)
FINT	0.4370 (0.3302)	0.3113 (0.3052)	-
FDI	-	–0.0009 (0.0033)	-
OTG	-	0.0388 (0.0295)	-
KFDI	-	-	–0.0008 (0.0022)
KOTG	-	-	0.0459*** (0.0153)
EXC	–0.0029 (0.0034)	–0.0013 (0.0043)	–0.0004 (0.0021)

Note: (***) Specifies 1% level of significance, (**) Specifies 5% level of significance, ( ) specifies standard error.

The individual country results presented in Table 5 show the estimates in a step-wise regression. Model I isolates the impact of financial integration on pollution, Model II introduces both foreign direct investment and output growth, while Model III accounts for the interaction effects on environmental pollution. For Nigeria, financial integration exerts a positive and significant impact on CO_2 in models I and II. In model II, foreign direct investment negatively and significantly affects pollution, while output growth positively and significantly impacts pollution. In Model III, financial integration interacts with foreign direct investment to reduce pollution significantly, while it interacts with the growth of output to increase the country's pollution significantly.

The situation is different in South Africa, where financial integration negatively but insignificantly affects pollution in Models I and II. In Model II, both foreign direct investment and output growth positively influence pollution with the latter being significant at the 5 per cent level. Also, in Model III, financial integration interacts with both channels to exert positive impacts on pollution. In Egypt, financial integration has a positive and significant impact on pollution in Models I and II. In Model II, both output growth and foreign direct investment negatively impact pollution with the former being significant at the 1 per cent level. In Model III, financial integration interacts with both foreign investment and growth to reduce pollution significantly.

In Angola, financial integration positively and significantly impacts pollution in Models I and II. In Model II, foreign direct investment negatively and insignificantly affects pollution, while output growth is significant in influencing pollution. Model III also indicates that financial integration interacts with foreign investment to reduce pollution, while it interacts with growth to significantly increase pollution. Lastly, in Algeria financial integration exerts a positive but insignificant effect on pollution in Models I and II. In Model II, foreign investment reduces pollution, while output growth intensifies pollution.

Table 6: Post estimation test of the country-specific estimations

Countries	*Models*	*Cumulative Sum Test [P-Value]*	*Serial correlation [P-Value]*	*Normality [P-Value]*	*ARCH LM [P-Value]*
NIG	I	9.214 [0.000]	5.434 [0.031]	1.34 [0.312]	2.98 [0.421]
	II	8.021 [0.000]	5.871 [0.030]	1.42 [0.136]	1.43 [0.320]
	III	10.521 [0.000]	6.073 [0.028]	1.59 [0.298]	3.09 [0.762]
SA	I	9.032 [0.000]	5.765 [0.035]	2.91 [0.420]	2.65 [0.162]
	II	7.232 [0.001]	5.864 [0.031]	1.34 [0.154]	3.23 [0.197]
	III	12.621 [0.000]	6.085 [0.034]	1.21 [0.274]	2.09 [0.092]
ANG	I	9.346 [0.000]	5.786 [0.027]	1.67 [0.129]	2.76 [0.012]
	II	6.005 [0.001]	6.454 [0.024]	2.92 [0.190]	3.08 [0.176]
	III	11.656 [0.000]	7.053 [0.041]	3.17 [0.210]	1.54 [0.061]
EGY	I	6.554 [0.001]	6.043 [0.031]	1.65 [0.165]	2.76 [0.069]
	II	8.008 [0.000]	6.778 [0.038]	1.98 [0.184]	2.87 [0.283]
	III	11.684 [0.000]	6.665 [0.043]	3.09 [0.099]	3.90 [0.187]
ALG	I	8.831 [0.000]	5.969 [0.032]	3.04 [0.541]	1.09 [0.614]
	II	8.494 [0.000]	5.005 [0.021]	1.67 [0.175]	2.49 [0.091]
	III	6.777 [0.001]	6.965 [0.032]	2.62 [0.391]	2.04 [0.125]

Note: I, II, and III are used to present the diagnostic tests of models I to III. Also, the probability values are presented in the parentheses next to each test statistic.

In Model III, financial integration interacts with foreign direct investment to reduce pollution insignificantly while it interacts with growth to positively and significantly impact pollution.

To determine the appropriateness of the model specifications, especially the individual country estimations, Table 6 is presented. Results are presented for models I, II and III for all five African countries. The results of both the cumulative sum and serial correlation tests show that the models are dynamically stable and are also free from serial correlations, as they fall below the 5 per cent significance levels. Moreover, Table 6 indicates that both the normality and the *Arch-LM* tests are insignificant at the 5 per cent level. Hence, all the models are multivariate normal and are homoscedastic. The implication is that all the country-specific models are appropriate and are well specified.

Table 7: Panel Results

Variables	*Dependent Variable: CO_2*		
	I	*II*	*III*
Y	0.0004*** (0.0002)	0.0005*** (0.0002)	0.0051** (0.0002)
Y^2	–0.0347 (0.5944)	–0.0752 (0.6006)	–0.3489 (0.6018)
FINT	0.1091** (0.0488)	0.1102** (0.0497)	-
FDI	-	–0.0003 (0.0077)	-
OTG	-	0.0002*** (0.0086)	-
KFDI	-	-	–0.0004 (0.0003)
KOTG	-	-	0.0061** (0.0050)
EXC	–0.0011 (0.0010)	–0.0011 (0.0010)	–0.0019 (0.0011)

Note: (***) Specifies 1% level of significance, (**) Specifies 5% level of significance, ( ) specifies standard error.

The panel results presented in Table 7 show that financial integration positively and significantly impacts carbon emissions in Africa in both Models I and II. However, in Model II, foreign direct investment inflow to the region negatively but insignificantly impacts on carbon emissions, while the growth of output positively and significantly impacts the region's environmental pollution. In Model III, financial integration interacts with foreign direct investment to reduce carbon pollution insignificantly, while it interacts with output growth to exert a positive and significant effect on carbon dioxide emissions in the region. The implications and economic intuitions of these findings are presented in Section 5.

In Table 8, *F*-statistics are used to report the panel causality results of the main regressors. Table 8 indicates that there is a unidirectional causal nexus running from financial integration to output growth. Also, there is a bidirectional causal relationship between financial integration and foreign direct investment,

Table 8: Panel Causality of the Main Regressors

F-Statistics	*FINT*	*OTG*	*FDI*	CO_2
FINT	-	2.1067**	2.5769**	0.6609
OTG	1.2883	-	2.8917**	2.3684**
FDI	2.6792**	6.4133***	-	3.5873**
CO_2	0.5589	1.4638	0.8634	-

Note: **, *** represent rejection of no causality at 5%, 1% levels of significance, respectively.

but no causal relationship was found between financial integration and carbon emissions. Moreover, output growth and foreign direct investment are bidirectionally causal, while there is unidirectional causality from foreign direct investment to carbon emissions. Lastly, foreign direct investment and output growth are mutually causal. This result implies that in the selected African nations, financial integration does not directly affect environmental pollution. Instead, financial integration impacts both output growth and foreign direct investment, which in turn affects carbon emissions. Therefore, the level of financial openness in Africa influences environmental pollution through both the foreign investment and output growth channels.

5. Discussion of Findings

The result of this scientific enquiry has interesting implications for the entire African region's pollution control efforts, as well as just the largest African nations. Except for South Africa, financial integration worsens environmental pollution in Nigeria, Algeria, Egypt, Angola, and in the panel. For instance, having liberalised their exchange rates in the 1990s, growth in primary exports, especially crude oil, has continued to enhance capital account openness in Nigeria, Algeria, Egypt and Angola. This has led to the attraction of huge investments into their oil and gas sector. However, this also triggers pollution which arises from investment generated through financial openness.

On the other hand, the result shows that financial integration interacts with foreign direct investment to reduce pollution in the panel, in Nigeria, Egypt, Angola, and Algeria. In South Africa, however, the interaction of financial integration with foreign direct investments causes more environmental damage. This suggests that foreign investment inflows into Nigeria, Egypt, Angola, and Algeria can, through the technique effect, result in financial integration reducing environmental pollution.

Another possibility is that the foreign investors operating in these countries adapt their plants to the prevailing pollution measures, thereby directing financial resources to less pollution-creating investments. As noted in Africa's green finance featured in Lexology (2018), recent efforts by several African

nations, including Nigeria, Egypt, Angola, and Algeria to establish green bonds initiatives and direct investment into less carbon-emitting ventures, also provide support for this result. However, while South Africa is also playing an active role in setting up green finance, its position as the 14th largest emitter of GHGs globally (see Carbon Brief, 2018) can massively alter its pollution-reduction quest via the foreign investment channel.

Lastly, the fact that financial integration interacts with output growth to increase environmental pollution in the panel, in Nigeria, Angola, Algeria, and South Africa, albeit not for Egypt, means that growth considerations in these countries are harmful to the environment. The result is understandable because output growth in most of these nations is pollution driven. For instance, Algeria, Nigeria, and Angola are oil-producing nations with rates of gas flaring that are globally very high, which contributes most to carbon emission. Also, South Africa's heavy reliance on coal for power generation makes the country's carbon emissions very high, explaining why financial openness could not reduce its pollution through the growth channel. It implies that through the composition effect created by output growth, financial integration expands environmental pollution in the panel, as well as in Nigeria, Angola, Algeria, and South Africa.

6. Conclusions

The results of this research have added to the ongoing global discussion on how to mitigate the adverse impact of environmental pollution across the world. The study's focus is on the five largest African economies, following their recent strides in opening their financial systems to attract foreign investment to stimulate economic growth. Data covering the period 1980 to 2017 are analysed using the panel cointegration framework. The empirical results reveal that financial integration positively impacts on pollution in Nigeria, Algeria, Egypt, Angola, and in the panel, while it reduces pollution in South Africa. Financial integration reduces pollution through the foreign investment channel in the panel, Nigeria, Egypt, Angola and Algeria, but not in South Africa. Lastly, financial integration increases pollution through the output growth channel in the panel, Algeria, South Africa, Nigeria and Angola, but not in Egypt.

A key policy recommendation is that the financial institutions operating in Nigeria, Algeria, Egypt, Angola could be made to channel funds only to investments in green technology. This will help to improve the impact of financial integration on environmental pollution. Also, these African countries should make efforts to set specific emissions-reduction targets that foreign investors can leverage to design environmentally acceptable technology that would promote environmental sustainability. This would help South Africa to benefit from the technique effects created by such investment; and to assist countries like Nigeria, Algeria, Egypt, Angola to sustain the current gains reported in this study.

Nations like Algeria, Nigeria, and Angola can fast track the full implementation of ending their routine gas flaring that is contained in their various gas master plans, even before the proposed 2030, to to reduce GHG emissions. Meanwhile, South Africa is encouraged to seek urgent assistance from its foreign partners in reducing its heavy reliance on coal. These strategies can help to reduce the composition effect of emissions in their domain and sustain the environment. Lastly, African countries should strengthen their financial linkages to expand the space for investment in pollution-friendly production technologies among governments and investors within the region. This can be done by developing common instruments and standards that can facilitate the flow of financial resources within the region to guarantee environmental sustainability.

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Endnotes

1. School of Management and Social Sciences, Pan-Atlantic University, Lagos, Nigeria. E-mail: profdayoms@yahoo.com.

2. The exposition of the Environmental Kuznets Curve (EKC). In the EKC, higher environmental pollution is recorded during the early stages of growth, with pollution reaching its peak as economic growth progresses. Eventually, the increase in wealth is used to control environmental pollution, resulting to its fall. The EKC thus suggests an inverted U-shaped relationship between growth and pollution.

3. These are highly polluting goods like carbon dioxide and other greenhouse gases that adversely affect the environment.

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