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The non-linear effect of foreign direct investment on the informal economy in sub-Saharan African countries: An approach using the Method of Moments Quantile Regression

Cephas Melchior Kuipou Mfo Talom
University of Dschang, Cameroon

Luc Nembot Ndeffo
University of Dschang, Cameroon

Abstract

A number of studies have empirically analysed the effect of foreign direct investment on the informal economy. However, these studies have been limited to a regression framework in which the analysis focuses on the average effects of foreign direct investment, omitting that the relationship may be non-linear. In this study, we use quantile-moment regression to examine the non-linear effect of foreign direct investment on the informal economy in African countries. The results show that inward foreign direct investment has an inverted U-shaped relationship with the informal economy, and that the amount of foreign direct investment flows to reach the threshold is more considerable for countries with a small informal economy. Hence it is advantageous for African countries to set up policies to control the informal economy that take into account the quantity of inward foreign direct investment flows, by putting in place mechanisms that allow the acceleration of financial development that encourages inward foreign direct investment flows.

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Contact: Cephas Melchior Kuipou Mfo Talom - cephaskuipoumfo@gmail.com, Luc Nembot Ndeffo - ndefluc@yahoo.fr.
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1. Introduction

The informal economy remains omnipresent in Sub-Saharan Africa as in other regions of the world, but with a more considerable weight, and attracts the attention of researchers and political decision-makers (Medina and Schneider, 2019). The persistence of the informal economy may be thought to be the result of a glaring lack of financing for the economy, both internally and externally. However, when it comes to the external financing of the economy, the UNCTAD report (2022) shows that FDI flows are on a general upward trend in Africa. FDI flows to Africa reached a record level of $83 billion in 2021, or 5.2% of global FDI flows, compared with $39 billion in 2020. The UNCTAD report (2019) also shows that FDI flows to Africa rose by 11% in 2018, reaching a total of 46 billion dollars, but representing less than 2% of global FDI flows. Given that FDI inflows to Africa are on an upward trend, it becomes important to examine their effect on the informal economy.

From an empirical point of view, several studies have looked at the effect of FDI on the informal economy and vice versa. Nikopour et al (2009), using a sample of 145 countries, prove that foreign direct investment leads to a reduction in the underground economy, and conversely the informal economy leads to an increase in FDI, between 1999 and 2005. Subsequently, Davidescu and Strat (2015) show a short-term unidirectional causality between FDI and the underground economy, as well as a short-term negative relationship between FDI and the underground economy in the case of Romania. Ali and Bohara (2017), using a gravity model to explore the effects of the informal economy on FDI inflows in 34 OECD countries over the period 1999 to 2007, find that there is a positive relationship between the informal economy and FDI inflows, implying that multinationals are motivated to take advantage of the informal economy. However, Huynh et al (2020) analyse the tripartite links between FDI, the informal economy and institutional quality by applying the dynamic simultaneous equation modelling approach to a sample of 19 developing Asian countries over the period 2002 to 2015. Then the empirical results of the two-stage GMM system show that FDI inflows have the effect of reducing the informal economy through institutional improvement and that reducing the informal economy increases institutional quality which encourages FDI inflows. In the same vein, Bayar et al (2020) assess the impact of the informal economy and human development on FDI in eleven post-transition EU member states over the period 1995 to 2015. They use second-generation panel causality and cointegration analysis for both cross-sectional dependence and heterogeneity. The empirical analysis revealed a two-way causality between FDI flows and the informal economy only for Bulgaria, Croatia and Romania and a one-way causality between the informal economy and FDI in the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Slovakia and Slovenia. The long-term analysis revealed that the informal economy has a negative impact on FDI flows. Although these studies do not distinguish the type of FDI in relation to the informal economy, the study by Cuong et al (2021) which examines the impact of the informal economy on FDI for a panel of 158 countries shows that the informal economy has no clear impact on FDI inflows. But by examining FDI by type of entry, they conclude that the informal economy has a positive impact on greenfield investments and a negative impact on cross-border mergers and acquisitions. The recent study by Zander (2023) takes into account the effect of the informal economy on both the target country and the country of origin of the FDI, and proves that the informal economy has a positive effect on FDI target countries and a negative effect on FDI countries of origin.

These studies reveal several limitations, in fact these studies are mainly based on econometric methods that estimate the average effect of FDI on the informal economy, implicitly assuming that the effect is the same all along the distribution of the informal economy, i.e. not taking into account the way in which FDI affects the economy at different points in the distribution of the

informal economy. They also analysed the direct, simultaneous, as well as the short- and long-term link between FDI and the informal economy, thus overlooking the likely non-linear aspect in explaining the effect of FDI on the informal economy. In addition, some of these studies have taken into account the channel of institutional quality and human capital in the study of the link between FDI flows and the informal economy, but none have looked at the channel of financial development, which is seen as a means of attracting more FDI flows when it performs better (Al Nasser and Gomez, 2009; Hajilee and Al Nasser, 2015).

Unlike previous studies, this paper examines the effect of FDI flows on the informal economy using the quantile regression methodology via the moments of Mechado and Silva (2019), so the main advantage comes from the fact that it studies the effect of FDI flows at many points of the conditional distribution of the informal economy, taking into account endogeneity problems, as well as the non-linear form of the model. We conclude that the existing relationship between FDI flows and the informal economy is inverted U-shaped, and that the amount of FDI flows needed for the transition threshold is more significant at the lower quantile level.

The remainder of the article is organised as follows. Section 2 presents the econometric methodology and describes the data, section 3 examines the empirical results, while section 4 concludes.

2. Methodology and Data

2.1 Methodology

This study uses the panel quantile regression model with fixed effect, namely the MMQR model Machado and Silva (2019), which allows to study the heterogeneous and distributional impacts between the quantile of the informal economy, FDI, GDP growth rate, inflation, resource rent, as well as financial development indicators.

While allowing for the individual fixed effect, the MMQR method absolutely examines the impact of conditional heterogeneous covariance of informal economy determinants to affect the overall distribution. Unlike Koenker (2004) and Canay (2011) who shift the means, this method captures the effect of covariance in the overall distribution. The advantage of using this method is that it takes into account the conceivable presence of endogenous properties in the explanatory variables. Similarly, this technique is appropriate in cases where individual effects overwhelm the panel data model.

In addition, the MMQR model also produces confident estimates in the case of a non-linear model, unlike the non-linear NARDL models. The advantage of using the MMQR model is that it defines the threshold through a process based on the data and not in an exogenous way (Shin and Greenwood-Nimmo, 2014). In addition, MMQR allows for location-based asymmetries. It is clear that fixed effects do not take heterogeneity into account, however the use of MMQR takes this difficulty into account due to its ability to give heterogeneous estimates of the whole distribution. It is clear that the heterogeneous values of the coefficients explicitly indicate that the MMQR addresses the issue of heterogeneity.

Other panel methods with instruments, which deal with the problems of correlation and endogeneity, do not allow estimates to be made based on the conditions of the data. Hence the MMQR method is preferred because it deals with heterogeneity and endogeneity by taking into account the asymmetric and non-linear association between the informal economy and its determinants. The conditional estimates of the quantile $Q_y(\tau / X)$ of the location scale variant model can be expressed by the following equation:

$$y_{it} = \alpha_i + x_{it}^{'}\beta + (\delta_i + z_{it}^{'}\gamma)u_{it} \qquad (1)$$

Or the probability $P = \left\{\delta_i + z_{it}^{'} > 0\right\} = 1$, $(\alpha, \beta', \delta, \gamma')$ are the parameters to be estimated. The fixed effects of individual i are denoted by (α_i, δ_i), $i = 1,.....n$ and k the vector of known elements of x is denoted by Z, which are differentiable conversions with the l component mentioned below:

$Z_l = Z_l(x)$, $l = 1,.....k$ (2)

Or x_{it} i is independently and identically distributed for any fixed t. u_{it} is also independently and identically distributed across individuals i over time t and are orthogonal to x_{it} and are standardised to satisfy the moment conditions. Equation (1) gives the following results:

$$Q_y(\tau / x) = (\alpha_i + \delta_i(\tau)) + x_{it}^{'}\beta + z_{it}^{'}\gamma q(\tau) \qquad (3)$$

Or x_{it} represents a vector of independent variables represented here by FDI, the square of FDI, the growth rate, inflation, CO2 emissions, natural resource rents, liquidity, and loans granted by banks and other financial institutions. $Q_y(\tau / x)$ Postulates that the structural quantiles are distributed to the dependent variable y_{it} (informal economy) as a function of the distribution (location) of the exogenous variables x_{it}.

The individual fixed effects i and the quantile τ are shown by the scalar coefficient designated $\alpha_i(\tau) = \alpha_i + \delta_i q(\tau)$. The shift in the intercept does not represent the individual effect, unlike the fixed effect typical of least squares. Such parameters are time invariant with heterogeneous effects likely to diverge along the conditional distribution quantile of the endogenous variable. The τ - quantile of the sample represented by $q(\tau)$ can be evaluated by tackling the resulting optimisation problem written in equation (4):

$$\min_q \sum_i \sum_t \rho_\tau (R_{it} - (\delta_i + Z_{it}^{'}\gamma)q) \qquad (4)$$

Or $\rho_\tau(A) = (\tau - 1)AI\{A \le 0\}TAI\{A > 0\}$ indicates the control function.

2.2 Data and descriptive statistics

This empirical analysis uses panel data for 41 SSA countries over the period 1995 to 2020 depending on data availability. The study variables include the informal economy (IE), which measures the volume of informal production as a percentage of GDP, FDI inflows into the reporting economy, expressed in current US dollars to which the natural logarithm (LnFDI) is applied, GDP growth rate (RGDP), Inflation, consumer prices (IF) as an annual percentage, Carbon dioxide emissions (CO2) in kilo tonnes, Total natural resource rents (RTRS) as a percentage of GDP, Financial development is represented by two main components, namely : Liquid assets (Liq) which are as a percentage of GDP, they are also known as broad money, or M3, finally Private credit (CP) from deposit banks and other financial institutions as a percentage of GDP. The informal economy data is from WB and calculated by Elgin et al (2021), the financial development indicators are from the World Bank Financial Development Database. The rest of the data comes from WDI.

Table 1 presents the descriptive statistics and the Shapiro-Wilk normality test. As shown in Table 1, the null hypothesis is rejected at a significance level of 1%, proving that the study data are non-normal. Not all variables are normally distributed, and these results support the idea of using non-linear models that can capture the heterogeneous relationship between the factors of the dependent variable.

Table 1: Descriptive statistics and the Shapiro-Wilk normality test

	descriptive statistics					Normality test			
Variable	**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**W**	**V**	**z**	**Prob>z**
IE	1 066	38.838	8.288	19.34	64.44	0.982	11.777	6.123	0.000
LnFDI	1 000	18.756	2.142	9.903	23.029	0.961	24.293	7.900	0.000
RGDP	1 060	4.426	7.438	-36.392	149.973	0.581	278.786	13.976	0.000
IF	979	18.495	162.334	-16.86	4 145.106	0.062	580.471	15.746	0.000
CO2	1 066	15 285.358	59 817.304	78	448 298.09	0.236	511.007	15.484	0.000
RTRS	1 057	12.336	11.56	0.002	88.592	0.816	121.770	11.919	0.000
Liq	998	28.363	24.043	0.336	224.775	0.645	223.505	13.395	0.000
CP	1 001	19.696	26.175	0.25	187.784	0.583	263.512	13.804	0.000

3. **Results and discussion**

Before proceeding with the empirical analysis, we test for cross-sectional dependence to check the adequacy of the unit root and cointegration tests. Table 2 presents the results of the dependence tests of Pesaran (2015, 2021), the weighted test of Juodis and Reese (2021), and the test of Pesaran and Xie (2021). The null hypothesis of low cross-sectional dependence is rejected at a significance level of 1% for all these tests. This result calls for the adoption of second-generation unit root and cointegration tests.

Table 2: Cross-section dependency test

	CD	**CDw**	**CDw+**	**CD***
Residual	6.690	3.460	1147.070	19.580
	(0.000)	(0.001)	(0.000)	(0.000)

Note: P-values in brackets. (P<0.01 significant at the 1% level)

Notes: CD, CDw, CD* represent the test of Pesaran (2015, 2021), Juodis, Reese (2021) and Pesaran, Xie (2021) respectively.

We therefore adopt the unit root test of Im, Pesaran and Shin (IPS, 2003) and the Fisher type test of Choi (2001). The null hypothesis is that all panels contain a unit root. The results for the level and first difference variables are presented in Table 3. It appears that for the Im, Pesaran and Shin (IPS, 2003) test, FDI, the GDP growth rate, inflation and the total rent from natural resources are stationary at level, while all the other variables are stationary at first difference. According to Choi's (2001) CADF test, other than the informal economy, which becomes stationary at level, the stationarity results remain unchanged for the other variables. On the basis of these results, we can proceed with the cointegration test.

Tableau 3: **Unit root test.**

Variables		**IE**	**LnFDI**	**RGDP**	**IF**	**CO2**	**RTRS**	**Liq**	**CP**
Unit root test.	Test IPS	-10.947[b],*	-8.264[a],*	-12.555[a],*	-13.166[a],*	-15.182[b],*	-5.245[a],*	-13.566[b],*	-14.777[b],*
	Test CADF	6.391[a],*	11.596[a],*	33.558[a],*	53.131[a],*	52.957[b],*	7.217[a],*	40.7854[b],*	53.892[b],*

Note: significance at the 1% critical level is represented by *. Stationarity in level and first difference are represented by « a » and « b » respectively.

As cross-sectional dependency exists, we use the Pedroni (1999, 2004) and Westerlund (2005) cointegration tests to verify its presence. The null hypothesis of these tests is the absence of cointegration and the alternative hypothesis is that the variables are cointegrated in all the panels. According to table 4, integration for the entire panel is confirmed at a significance level of 1% for the Pedroni test and at a significance level of 5% for the Westerlund test

Tableau 4: **Pedroni and Westerlund cointegration test**

Test de Pedroni	**Modified Phillips-Perron t**	**Phillips-Perron t**	**Augmented Dickey-Fuller t**
statistic	6.1704	-6.1035	-4.6467
p-value	0.0000	0.0000	0.0000
Test Westerlund	Variance ratio		
statistic	2.2971		
p-value	0.0108		

Note: P-values in brackets. (P<0.01 significant at the 1% level).

Table 5: basic result and control with the growth rate

VARIABLES	IE					
	IV	Q (10)	Q (25)	Q (50)	Q (75)	Q (90)
LnFDI	16.76*	3.468*	3.631*	3.857*	4.071*	4.227*
	(2.033)	(1.046)	(0.757)	(0.574)	(0.786)	(1.070)
$LnFDI^2$	-0.491*	-0.120*	-0.126*	-0.134*	-0.143*	-0.148*
	(0.0562)	(0.0296)	(0.0214)	(0.0162)	(0.0222)	(0.0302)
IF	-0.00848**	-0.00108	-0.00123*	-0.00144*	-0.00164**	-0.00178**
	(0.00376)	(0.000879)	(0.000636)	(0.000482)	(0.000660)	(0.000899)
CO2	4.76e-06	-2.01e-05*	-1.83e-05**	-1.58e-05**	-1.34e-05	-1.17e-05
	(1.20e-05)	(1.13e-05)	(8.20e-06)	(6.22e-06)	(8.51e-06)	(1.16e-05)
RTRS	0.147*	0.149*	0.155*	0.164*	0.172*	0.178*
	(0.0198)	(0.0522)	(0.0378)	(0.0287)	(0.0392)	(0.0534)
Control with growth rate						
LnFDI	16.32*	3.727*	3.836*	3.971*	4.111*	4.207*
	(1.949)	(1.021)	(0.721)	(0.575)	(0.821)	(1.104)
$LnFDI^2$	-0.480*	-0.127*	-0.132*	-0.138*	-0.145*	-0.149*
	(0.0538)	(0.0286)	(0.0202)	(0.0161)	(0.0230)	(0.0309)
IF	-0.00536	-0.00118	-0.00133**	-0.00151*	-0.00170*	-0.00183**
	(0.00363)	(0.000752)	(0.000531)	(0.000424)	(0.000604)	(0.000813)
CO2	6.19e-06	-1.81e-05	-1.59e-05**	-1.31e-05**	-1.03e-05	-8.39e-06
	(1.15e-05)	(1.11e-05)	(7.82e-06)	(6.24e-06)	(8.91e-06)	(1.20e-05)
RTRS	0.106*	0.112*	0.112*	0.112*	0.112*	0.112*
	(0.0199)	(0.0394)	(0.0278)	(0.0222)	(0.0317)	(0.0426)
RGDP	0.118*	0.117**	0.125*	0.136*	0.146*	0.153*
	(0.0162)	(0.0532)	(0.0376)	(0.0300)	(0.0428)	(0.0575)

Note: The values in the parentheses are the standard error. * p<0.01, ** p<0.05, *** p<0.1.

In this analysis we use the panel fixed effect model with instrument, in basic regression, so the aim is to correct for endogeneity. Table 5 presents the basic quantile regression results for the 10-th, 25-th, 50-th, 75-th, 90-th quantiles, for an overall understanding of the effects of FDI flows and other decisive factors on the informal economy. Quantile regression allows analysis at the extremes of the distribution, which is very necessary for proposing economic policy recommendations.

The results of the panel fixed effects survey with instrument indicate that there is an inverted U-shaped relationship between FDI inflows and the informal economy, i.e. FDI inflows first lead to an increase in informal production up to a certain threshold or after this threshold FDI inflows lead to a reduction in the size of the informal economy. Inflation is found to reduce the share of informal production. Carbon dioxide emissions have no significant effect. Total resource rents increase the share of informal production. By controlling our results by the GDP growth rate, the results remain identical and the GDP growth rate increases the share of informal production.

The quantile regression results show significant differences between different points in the conditional distribution of the informal economy. There is an inverted U-shaped relationship between FDI inflows and the informal economy, and this result is also supported by the graphical representation in Figure A1. Moreover, the thresholds[1] for the 10th, 50th and 90th quantiles are 14.45, 14.39 and 14.28 respectively, proving that the quantity of FDI flows needed to reach the threshold is greater for countries in the lower quantiles. In fact, this inverted U-shaped relationship can be explained by the fact that the economies of SSA are heavily dominated by informal activity, which is well justified by the desire of economic agents to evade taxes. Similarly, the predominance of informal activity can be justified by the poor quality of institutions in the area. So, to begin with, foreign investors will want to take advantage of this loophole in the economy, either by under-declaring taxes or by paying bribes. This should contribute to an increase in the share of informal income in GDP (Okada and Samreth, 2010; Davidescu and Strat, 2015, Jones and Temouri, 2016).

Subsequently, despite the tax losses generated by under-declaration of taxes, the company's activities should grow until it reaches a very considerable size. In this case, even if the phenomenon of under-declaration continues, because of the size of the company the proportion of under-declared income will be smaller and smaller, which should lead to a gradual reduction in the proportion of informal income and consequently a reduction in the informal economy.

In addition, countries with a low level of informal economy are generally more developed than countries with a high level of informal economy (La porta and Shleifer, 2014). As a result, businesses in these countries are often larger and more formal. So, for an informal business to be noticed in these countries, it has to reach a considerable size, as it operates in an environment where formal businesses are already well established. On the other hand, in countries with a high rate of informal economy, businesses are often smaller and less formal (La porta and Shleifer, 2014). What makes them more visible and more remarkable is their smaller size than in countries with a low rate of informal economy. This suggests that countries with a low rate of informal economy have a higher threshold of entry of FDI flows, for informal enterprises to be noticed, while countries with a high rate of informal economy have a lower threshold of entry of FDI flows.

[1] To determine the threshold, solve the equation: $\beta_1(\tau, \ln IDE) - 2\beta_2(\tau, \ln IDE) \ln IDE = 0$ which represents the marginal effect of the variable $\ln IDE$ on the τ -th quantile of the informal economy.

The effect of inflation leads to a reduction in the size of the informal economy, and this effect is significant from the 25th to the 90th quantile, with a greater magnitude for the higher quantiles. Similarly, the effect of carbon dioxide leads to a reduction in the size of the informal economy only from the 10th to the 50th quantile. However, the total rent from natural resources leads to an increase in the size of the informal economy at all quantiles, with a greater effect at the lower quantiles than at the higher quantiles. Figure A2 also plots the coefficients for various factors at different quantile levels.

Controlling for the GDP growth rate we find that the link between FDI flows and the informal economy is inverted U-shaped, and that the effect of the GDP growth rate leads to an increase in the size of the informal economy across all quantiles with a more pronounced effect from the lower quantile to the higher quantile, this is explained by the (Elgin et al, 2021) which shows that the formal and informal sectors are procyclical, i.e. productivity increases in the formal sector can lead to productivity increases in the informal sector, as informal firms provide services, as well as final and intermediate goods to the formal sector. In addition, income from the informal economy can support demand in the formal economy.

Table 6: Liquidity effect and private credit effect

	IE					
VARIABLES	IV	Q (10)	Q (25)	Q (50)	Q (75)	Q (90)
LnFDI	14.24*	3.067**	3.201*	3.402*	3.604*	3.747**
	(2.062)	(1.223)	(0.904)	(0.751)	(1.113)	(1.511)
$LnFDI^2$	-0.416*	-0.0994*	-0.106*	-0.115*	-0.125*	-0.131*
	(0.0574)	(0.0346)	(0.0256)	(0.0213)	(0.0315)	(0.0427)
IF	-0.00867**	6.33^{e}-05	-0.000312	-0.000876**	-0.00144**	-0.00185**
	(0.00351)	(0.000663)	(0.000490)	(0.000410)	(0.000604)	(0.000820)
CO2	-2.07^{e}-06	-2.42^{e}-05**	-2.16^{e}-05*	-1.76^{e}-05*	-1.37^{e}-05	-1.08^{e}-05
	(1.12^{e}-05)	(9.55^{e}-06)	(7.06^{e}-06)	(5.88^{e}-06)	(8.70^{e}-06)	(1.18^{e}-05)
RTRS	0.143*	0.132**	0.140*	0.153*	0.165*	0.174**
	(0.0201)	(0.0626)	(0.0463)	(0.0385)	(0.0570)	(0.0774)
Liq	-0.163*	-0.211*	-0.189*	-0.155*	-0.120*	-0.0962*
	(0.0257)	(0.0403)	(0.0299)	(0.0250)	(0.0368)	(0.0499)
Liq2	0.000633*	0.000842*	0.000743*	0.000594*	0.000444**	0.000338
	(0.000129)	(0.000190)	(0.000140)	(0.000117)	(0.000173)	(0.000235)
private credit effect						
LnFDI	11.06*	2.340**	2.503*	2.768*	3.041*	3.213**
	(1.789)	(1.121)	(0.849)	(0.669)	(0.966)	(1.281)
$LnFDI^2$	-0.320*	-0.0724**	-0.0790*	-0.0896*	-0.100*	-0.107*
	(0.0499)	(0.0320)	(0.0242)	(0.0191)	(0.0276)	(0.0365)
IF	-0.0104*	-0.000726	-0.000991	-0.00142*	-0.00186**	-0.00214**
	(0.00304)	(0.000868)	(0.000657)	(0.000520)	(0.000748)	(0.000991)
CO2	-9.16e-06	-2.60e-05*	-2.41e-05*	-2.10e-05*	-1.78e-05*	-1.58e-05*
	(9.75e-06)	(7.59e-06)	(5.74e-06)	(4.53e-06)	(6.54e-06)	(8.67e-06)
RTRS	0.108*	0.0870	0.0969**	0.113*	0.130**	0.140*
	(0.0177)	(0.0630)	(0.0477)	(0.0376)	(0.0543)	(0.0720)
CP	-0.379*	-0.429*	-0.408*	-0.374*	-0.338*	-0.316*
	(0.0283)	(0.0483)	(0.0366)	(0.0290)	(0.0416)	(0.0551)
CP2	0.00191*	0.00214*	0.00205*	0.00190*	0.00174*	0.00165*
	(0.000162)	(0.000279)	(0.000211)	(0.000167)	(0.000240)	(0.000318)

Note: The values in the parentheses are the standard error. * p<0.01, ** p<0.05, *** p<0.1.

Table 6 also presents the control of our results by the financial development, we notice that the inverted U-shaped relation between the FDI inflows and the informal economy, remains and remains statistically significant, however there is a U-shaped relation between the financial development and the informal economy. Indeed, when financial development is captured by liquidity, the inverse U-shaped relationship is statically significant on all quantiles except the 90th quantile, but when financial development is captured by private credit, it is statistically significant on all quantiles. This can be explained by the fact that financial development must first lead to a reduction in the size of the informal economy up to a certain threshold, from this threshold onwards the development of the financial system leads to an increase in the size of the informal economy.

Table 7: The liquidity and private credit channel

	IE					
VARIABLES	IV	Q (10)	Q (25)	Q (50)	Q (75)	Q (90)
LnFDI	16.33*	3.297*	3.413*	3.588*	3.755*	3.869*
	(2.175)	(1.098)	(0.809)	(0.636)	(0.901)	(1.207)
$LnFDI^2$	-0.477*	-0.110*	-0.115*	-0.123*	-0.131*	-0.136*
	(0.0605)	(0.0311)	(0.0229)	(0.0180)	(0.0255)	(0.0342)
IF	-0.00852**	-0.000370	-0.000675	-0.00114*	-0.00157*	-0.00187*
	(0.00376)	(0.000609)	(0.000449)	(0.000355)	(0.000500)	(0.000670)
CO2	3.49e-06	-1.96e-05**	-1.79e-05**	-1.54e-05*	-1.29e-05	-1.13e-05
	(1.19e-05)	(9.92e-06)	(7.31e-06)	(5.75e-06)	(8.14e-06)	(1.09e-05)
RTRS	0.158*	0.164*	0.165*	0.168*	0.171*	0.173*
	(0.0212)	(0.0572)	(0.0422)	(0.0331)	(0.0470)	(0.0629)
LnFDI*Liq	-0.00200*	-0.00244*	-0.00232*	-0.00214*	-0.00196*	-0.00184*
	(0.000459)	(0.000628)	(0.000463)	(0.000364)	(0.000515)	(0.000690)
Private credit channel						
LnFDI	16.41*	3.133*	3.263*	3.459*	3.642*	3.773*
	(2.173)	(1.075)	(0.793)	(0.620)	(0.869)	(1.174)
$LnFDI^2$	-0.480*	-0.106*	-0.111*	-0.119*	-0.127*	-0.132*
	(0.0604)	(0.0306)	(0.0226)	(0.0177)	(0.0247)	(0.0334)
IF	-0.00875**	-0.000629	-0.000884*	-0.00127*	-0.00163*	-0.00189**
	(0.00375)	(0.000700)	(0.000516)	(0.000405)	(0.000566)	(0.000764)
CO2	1.20e-05	-5.92e-06	-5.60e-06	-5.10e-06	-4.64e-06	-4.31e-06
	(1.19e-05)	(1.16e-05)	(8.54e-06)	(6.67e-06)	(9.36e-06)	(1.26e-05)
RTRS	0.160*	0.170*	0.170*	0.170*	0.171*	0.171*
	(0.0212)	(0.0567)	(0.0418)	(0.0327)	(0.0458)	(0.0619)
LnFDI*CP	-0.00246*	-0.00357*	-0.00334*	-0.00299*	-0.00266*	-0.00242**
	(0.000533)	(0.000900)	(0.000664)	(0.000520)	(0.000728)	(0.000983)

Note: The values in the parentheses are the standard error. * p<0.01, ** p<0.05, *** p<0.1.

Table 7 considers the financial development channel in explaining the link between FDI inflows and the informal economy. The results show that the coefficient of the interaction variable between FDI and financial development is negative and statistically significant. This means that improvements in financial development amplify the negative effect of FDI inflows on the informal economy. Note that the size of the coefficients of the interaction variable increases progressively from the lower quantiles to the upper quantiles. For countries with a lower level of informality, the negative effect of the interaction variable is greater. Indeed, a reliable, vital, trustworthy and open financial sector is evidence of a developed financial sector, moreover if

it has an efficient allocation of financial resources to promising sectors (Hajilee and Al Nasser, 2015), fast financial mediators and supply chain. It must then attract foreign investors, who will set up in a formal manner, which should lead to a reduction in the share of informal income in GDP.

4. Conclusion

This study analysed the effect of FDI flows on the informal economy in SSA. Previous studies on this issue have focused on the average effect using mean regression approaches. In this study we use the quantile regression approach via the Machado and Silva moment method developed in 2019, to analyse the effect of FDI flows on the informal economy at different locations of the distribution of the informal economy.

The basic result of the fixed-effect panel regression with instrument shows that there is an inverted U-shaped relationship between FDI flows and the informal economy, and that the interaction between FDI flows and financial development contributes to the reduction in the size of the informal economy. However, the quantile regression via the method of moment shows that the transition threshold for FDI flows is more considerable for the lower quantile (or lower informal economy) and that the effect of the interaction of FDI and development leads to a more considerable reduction of the informal economy for the lower quantiles.

These results suggest that the relationship between FDI flows and the informal economy is non-linear for SSA countries and that financial development amplifies the negative effect of FDI flows on the informal economy. The implications of these findings are that SSA countries, in designing their policies to control the informal economy, need to take into account the quantity of FDI inflows, while putting in place mechanisms that encourage increased FDI flows while ensuring that these enterprises obey the regulations in force, and also implement policies that encourage the development of the financial system so that increased FDI flows lead to a reduction in the size of the informal economy.

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Appendix

List of acronyms and abbreviations

EU: European Union

FDI: Foreign direct investment

GDP: Gross Domestic Product

GMM: Generalized method of moments

MMQR: Methods of Moments Quantile Regression

OECD: Organisation for Economic Co-operation and Development

SSA: Sub-Saharan Africa

UNCTAD: United Nations Conference on Trade and Development

WDI: World Development Indicator

Table A1: List of countries in the sample and their code

Country	Country Code	Country	Country Code	Country	Country Code
Angola	1	Ghana	15	Namibia	29
Burundi	2	Guinea	16	Niger	30
Benin	3	Gambia. The	17	Nigeria	31
Burkina Faso	4	Guinea Bissau	18	Rwanda	32
Botswana	5	Equatorial Guinea	19	Senegal	33
Central African Republic	6	Kenya	20	Sierra Leone	34
Cote d'Ivoire	7	Liberia	21	Chad	35
Cameroon	8	Lesotho	22	Togo	36
Democratic Republic of Congo	9	Madagascar	23	Tanzania	37
Republic of Congo	10	Mali	24	Uganda	38
Comoros	11	Mozambique	25	South Africa	39
Cape Verde	12	Mauritania	26	Zambia	40
Ethiopia	13	Mauritius	27	Zimbabwe	41
Gabon	14	Malawi	28		

Figure A1: Quantile response curve

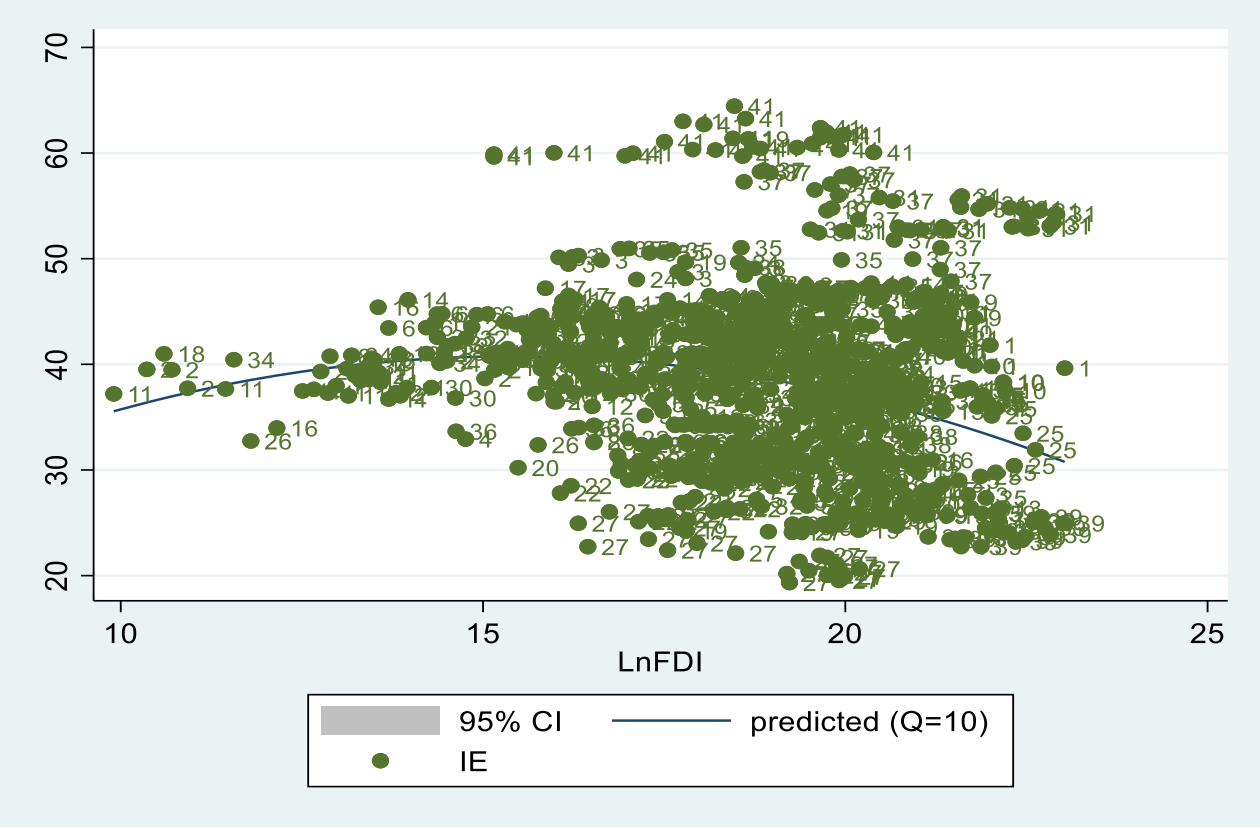
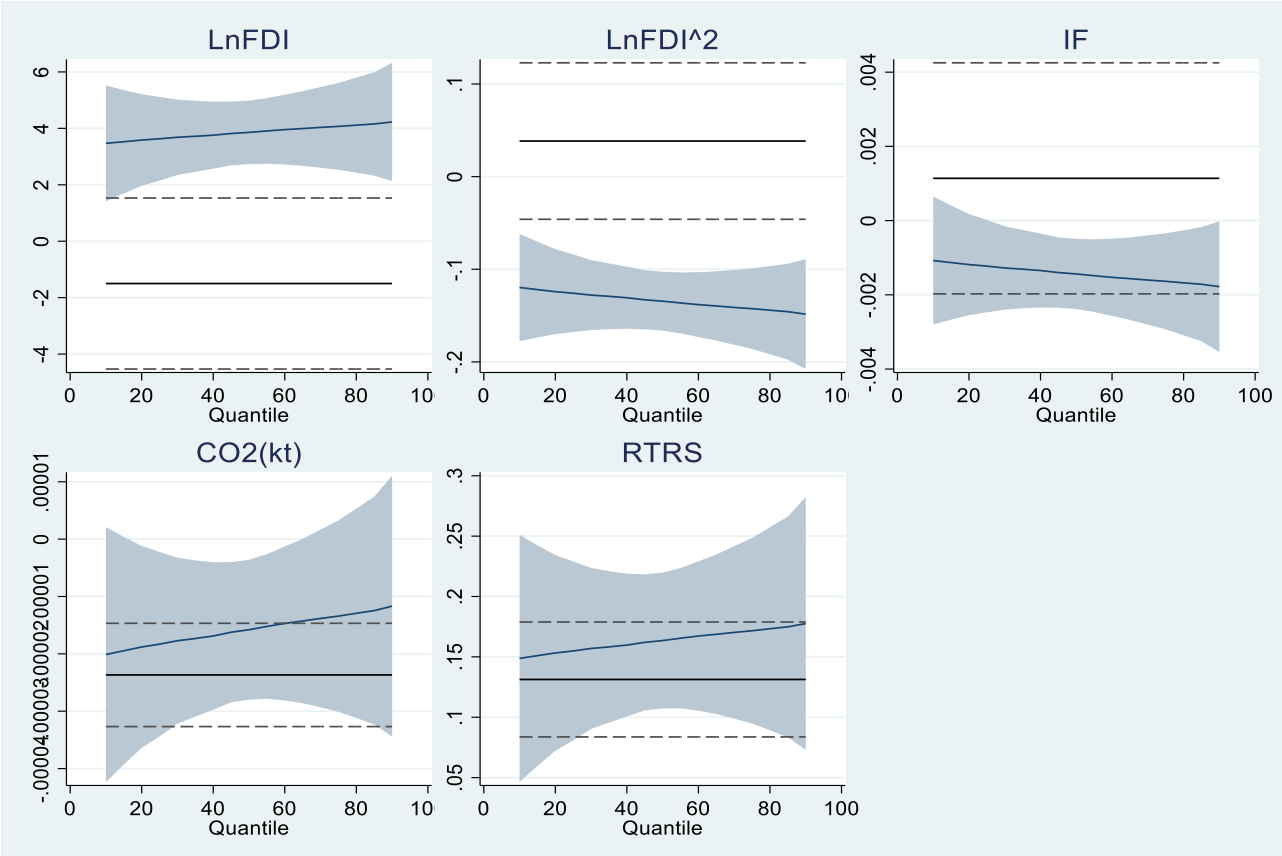
Figure A2: MMQREG and OLS coefficient at various quantile levels, blues lines show MMQR and solid black line show OLS based coefficients.