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FOREIGN DIRECT INVESTMENT, HUMAN CAPITAL AND ECONOMIC GROWTH IN AFRICA: A PANEL THRESHOLD REGRESSION APPROACH

Marvellous Ngundu
Corresponding Author: University of Johannesburg (RSA), South Africa
E-mail: marvengundu@gmail.com

Nicholas Ngepah
University of Johannesburg (RSA), South Africa
E-mail: nngepah@uj.ac.za

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Abstract

This paper examines how FDI from China, US, EU and the rest of Asia can transmit to sub-Sahara Africa's growth through human capital development for the period (2003-2012). We utilize the education index developed by the UNDP to proxy for the quality of human capital. Using the PTR model, our results show that the human capital threshold level required to absorb knowledge embodied in all FDI sources is 0.51 years in terms of educational attainment. Nevertheless, only FDI from the EU can enhance sub-Sahara Africa's growth through the development of less-skilled stock of human capital (less than 0.51 years). The impact of the latter turns negative and insignificant as the quality of human capital required to absorb knowledge spillovers increases beyond 0.51 years. For other FDI sources, 0.51 years demonstrates a sign-change threshold due to the regime shift from positive to negative. While our findings reveal that Africa is short of quality human capital stock required to absorb advanced knowledge embodied in FDI from both its traditional and emerging investors, it can be argued that the knowledge spillover effects depend on the technicalities and capital intensity of the economic sectors targeted by FDI sources. Based on the EU's result, it could be possible that the knowledge spillover effects in Africa can be effective in less industrialized sectors.

Keywords: Economic Growth, Foreign Direct Investment, Human Capital, Panel Threshold Regression, Knowledge Spillovers

JEL Classifications: J24, F21, F62, P52

1. Introduction

The contribution of Foreign Direct Investment (FDI) to physical capital accumulation alone can hardly present the entire picture of how FDI affects economic growth in the host country. Literature provides substantial evidence in that the participation of foreign investors in the FDI-receiving firms and the role of multinational enterprises (MNEs) in creating employment are accompanied by the transfer of expertise and production know-how to the host country's stock

of human capital (Demena and Murshed, 2018). Likewise, the emphasis on human capital development as a vital economic growth engine can be traced from the pioneering work of Romer (1986). This implies that FDI can indirectly transmit to the economic growth of the host country through human capital development.

Empirical literature regarding the indirect transmission channel of FDI on growth in Africa based on disaggregated FDI data is still very scanty. Even those studies which looked on China's FDI in Africa (Donou-Adonsou and Lim, 2018; Doku *et al.* 2017; Chen *et al.* 2015; Busse *et al.* 2014; and Zhang *et al.* 2014) seem to have focused more on the direct transmission channel. We recognize the empirical contribution of Borensztein *et al.* (1998), Xu, (2000) and Unisa Yusufu, (2013) however without disregarding other potential literature. Unisa Yusufu (2013) focuses on sub-Sahara Africa but uses aggregate FDI data while Borensztein *et al*. (1998) and Xu (2000) respectively looked on FDI from OECD countries and US firms to developing countries in general.

Irrespective of the differences in sample and the nature of FDI data used, all these studies concur in that the contribution of FDI on growth through human capital development can only be realized in countries where the quality of human capital stock is above a certain threshold level. Demena and Murshed (2018) also assert that effective and efficient absorption of knowledge from foreign investors is hypothesized to depend on the existing capacity of human capital stock in the host country. In line with these views, this study is attempted based on two major aspects. First, the growth effects of FDI through knowledge spillovers depend on the absorption capacity of the human capital stock in the host country. Second, the potential knowledge spillovers of FDI on the growth of the host country depend on the economic sectors targeted by the FDI source in the host country.

The threshold levels found by Borensztein *et al*. (1998), Xu (2000), and Unisa Yusufu (2013) were estimated using group-specific dummies or series of exogenously selected thresholds. Respectively, a threshold point estimate is confirmed when the test statistic *t* of the dummy variable reaches maximum value or when the spillover efficient sign-change is statistically significant. This study estimates the human capital threshold levels endogenously using panel threshold regression (PTR) of Hansen (1999). With PTR, all the inferences are given based on statistical data as opposed to an arbitrary choice of thresholds.

In terms of human capital indicator, various studies including Borensztein *et al*. (1998) and Unisa Yasufu (2013) use Barro and Lee (2010) dataset on educational attainment while others utilize Penny World Tables (Xu, 2000). Penny World Tables is, however, another version of Barro and Lee (2010) dataset where education attainment data is available on an annual basis. Although they have been a wide-spread recognition of education index (developed by UNDP) as a proxy and perhaps a more appropriate measure of human capital indicator (Barro and Lee, 2010), we could hardly find a study which utilized it. To this end, three different aspects add to the originality of our study. First, the study provides a comparative analysis on how FDI from Africa's traditional investors (US and EU) versus FDI from emerging investors (China and the rest of Asia) transmit to growth in Africa through human capital development. Second, the determination of the human capital threshold level required to absorb FDI knowledge spillovers using the PTR model. Last but not least, the use of education index developed by UNDP in 2010 to proxy for the the quality of human capital.

The rest of this paper is organized as follows; Section 2 provides a literature review on how FDI transmit to growth through human capital development. Section 3 describes the methodology, specifies the model and the estimation technique. Section 4 reports estimated results and finally, Section 5 gives conclusion and recommendations based on main findings.

2. FDI knowledge spillover effects on growth

The contribution of human capital on economic growth can be traced from the endogenous growth theories, pioneered by Romer (1986), Lucas (1988) and the augmented Solow growth model of Mankiw *et al.* (1992). Romer (1986) modeled increasing returns as a function of knowledge spillovers and concluded that the variable impels productivity coming about to increase economic growth both in the short and long-run. Furthermore, knowledge spillovers

prompt the invention of totally new varieties of capital goods (Romer, 1990). The technology gaps between developed and developing countries can be minimized through knowledge transfer (Romer, 1993). Lucas (1988) suggests that technological progress in endogenous growth theories can be modeled as a function of human capital accumulation through education and learning-by-doing. Mankiw *et al*. (1992) modeled human capital accumulation as part of the physical capital input in the exogenous growth models and concluded that the variable serves as a vital growth factor. These studies and more provide ample evidence about the role of human capital on economic growth.

Several factors contribute to human capital development and FDI has been widely acknowledged as one among the prime factors. The immediate effect of FDI on human capital in host countries is through employment created by multinational companies. The contracted workers are trained and educated to enhance their capabilities on new operations thus promoting labor productivity (Ozturk, 2007). Due to physical labor mobility, the expertise provided to contracted workers can spillover to other people across the host country (Demena and Murshed 2018) and this occurs in various ways. For instance, some workers may be contracted by local companies (Hanson, 2001), while some may choose to utilize new skills to establish their organizations and after that, they will transmit their insight to the employees of the new firm (Lim, 2001). The participation of foreign investors in the FDI-receiving companies is also accompanied by an indirect transfer of expertise and production know-how through brain drain (Demena and Murshed 2018).

It is not guaranteed however that FDI can prompt human capital development in host countries, it depends on whether the available stock of human capital meets the required quality threshold (Borensztein *et al*. 1998). This follows that host countries with the inadequate absorption capacity of human capital tend to suffer or at better the estimated coefficient of the interaction term between human capital and FDI tend to be insignificant. For instance, using secondary educational attainment of the population over 15 years of age as a proxy of human capital, Unisa Yusufu (2013) found that the impact of FDI on growth in sub-Sahara Africa turns negative above the human capital threshold level of 2.54 years. The latter concluded that on average sub-Sahara Africa is still below this threshold level as a result the region is far yet to reach the point where improved human capital levels may lead to negative growth.

In line with Fu and Li (2010); Ucal *et al.* (2010) and Demena and Murshed (2018), we argue that the result obtained from the study of Unisa Yusufu (2013) indicates the scarcity of human capital stock in sub-Sahara Africa beyond the threshold level of 2.54 years. Accordingly, due to the incapacity of the available stock of human capital to absorb knowledge and production know-how embodied in FDI, economic growth in the region is strained. Fu and Li (2010) assert that knowledge embodied in FDI is advanced such that high levels of educational attainment are required for effective absorption while Ucal *et al.* (2010, pp. 21) state that “higher productivity of FDI holds only when the host country has a minimum threshold stock of human capital”. Likewise, Demena and Murshed (2018) suggest that knowledge emanating from FDI can be effectively and efficiently absorbed in skilled labor.

In as much as the absorption of knowledge embodied in FDI is subjected to the existing capacity and quality of human capital stock in the host country, we equally urge that the economic sectors targeted by various foreign investors matter too. All sources of FDI in the host country can rarely target one economic sector as assumed in the analysis of FDI-growth nexus using aggregate FDI data (total FDI in the host country). This follows that the human capital threshold levels required for the absorption of knowledge spillovers might differ with FDI source subject to the targeted economic sectors. Hence, we employ a disaggregated FDI data approach to explicitly differentiate one source of FDI from the other in terms of their contribution to Africa’s economic growth through human capital development.

According to Borensztein *et al*. (1998), the impact of FDI from OECD countries was found to be positive on growth in developing countries conditional to the human capital threshold of (0.52-1.13) years. The threshold point estimate is based on male secondary school attainment of adults over 25 years of age. They argue that the stock of human capital in most developing countries is above this threshold. In contrast, Xu (2000) found a higher human capital threshold level of (1.4-2.4) years using FDI from US companies and suggests that most

developing countries are yet to reach this threshold. Fu and Li (2010) argue that the human capital threshold level obtained from the secondary school attainment (Borensztein *et al*. 1998; Xu, 2000; Unisa Yufusu, 2013) may mislead policymakers in developing nations to focus more on secondary education. Yet, the level of advancement associated with knowledge embodied in FDI seems to correspond to higher than secondary levels of education.

Furthermore, the latter argue that the threshold level estimated in terms of the population aged above 25 years of age (Borensztein *et al*. 1998; Xu, 2000) may underestimate the actual educational attainment level of developing countries. They cited that the education structure in developing countries is rapidly changing, as a result, there is now a significant difference between the older generation's education structure and the younger generation who seem to contribute a greater share of the active labor force. We equally urge the gender perspective constituting the human capital indicator used in the study of Borensztei *et al*. (1998) and Xu (2000). The education structure in developing countries has since changed with equal learning opportunities made available for both males and females. Meanwhile, a threshold estimate based on male population could be disputed.

3. Methodology

The model of this study is inferred from the neoclassical growth theories following the lead of Lucas (1988) and Neuhaus (2006). The latter pioneered FDI augmented version of Solow by replacing human capital in the augmented Solow model of Mankiw *et al*. (1992) with the inward stock of FDI. The former argued that technological progress in growth theories can be modeled as a function of human capital accumulation through education and learning-by-doing. FDI-growth nexus literature shows that FDI can transmit to the long-run economic growth of the host country through physical capital accumulation and human capital development, simultaneously. In this respect, this study incorporates FDI both as a physical capital input (s_f) and knowledge input ($s_f * hc$). The knowledge input subscript represents our variable of principal interest. The basic model can be summarized using the following econometric statement:

$$lny_{it} - ln_{yit-1} = \alpha + \beta lny_{it-1} + \gamma lns_{d,it} + \emptyset lns_{f,it} + \varphi\, ln(n_{it} + g + d) + \vartheta\left(s_f * hc\right)_{it} + \varphi' lnX_{it} + \lambda_t + \eta_i + \varepsilon_{it} \quad (1)$$

Since this study follows neoclassical growth theories, we utilize changes in the log of per capita GDP in real terms as our dependent variable ($lny_{it} - lny_{it-1}$). The specification of our regressors incorporates fundamental determinants of the steady-state, that is, lagged dependent variable (y_{it-1}), population growth rate (*n),* changes in technology (*g*), the rate of depreciation for capital stock (d) and domestic investment savings rate (s_d) (Mankiw *et al*. 1992). As highlighted above, the subscript (s_f) denotes FDI stock while ($s_f * hc$) is a proxy of the interaction term between FDI and education index. The subscript ($X_{i,t}$) represents other components of technical progress as suggested by Bassanini and Scarpetta (2001). These variables include rule of law, terms-of-trade growth, total natural resource rents and inflation. The subscripts $\lambda_t, \eta_i, \varepsilon_{it}$ proxy for period-specific effects that are assumed to affect all countries for example technology shocks, unobserved country-specific effects, and white noise error term respectively. In line with augmented Solow model of Mankiw *et al*. (1992), we assume the depreciation rate of the physical capital stock (*d*) and changes in technology (*g*) to be constant over time and equal to 0.05. Thus, Equation (1) can be presented as follows:

$$lny_{it} = \alpha + (\beta + 1) lny_{it-1} + \gamma lns_{d,it} + \emptyset lns_{f,it} + \varphi\, ln(n_{it} + 0.05) + \vartheta\left(s_f * hc\right)_{it} + \varphi' lnX_{it} + \lambda_t + \eta_i + \varepsilon_{it} \quad (2)$$

3.1. Data and variable description

This study measures per capita GDP in real terms for income levels, Gross Capital Formation as a percentage of GDP for domestic investment savings rate and the share of inward stock of FDI in GDP for the foreign investment savings rate. We use stock rather than flow data of FDI to capture for perpetual and some of the immeasurable effects of FDI on growth. Neuhaus (2006) argues that that the ratio of the inward stock of FDI to GDP is more accurate than flows in capturing for perpetual and some immeasurable effects of FDI on economic growth. FDI is differentiated between FDI from a particular source and FDI from the rest of the world (ROW) to sub-Saharan African countries. FDI from ROW is controlled by subtracting source's FDI from the total inward stock of FDI to Africa. For population growth, we add 0.05 before generating logs.

The components of X_{it} include total natural resource rents as a percentage of GDP to capture the value of extraction[1], changes in terms-of-trade to account for trade openness, rule of law to proxy for institutional quality and the GDP deflator, annual change in percentage to control for inflation. The subscript ($s_f * hc$) is the interaction term between FDI and education index to capture for the FDI knowledge spillovers. The latter term is our variable of interest. All these control variables are in logarithms except for changes in terms-of-trade, as the variable exhibits a large number of negative values. We use education index as the human capital indicator. The index measure was updated in 2010 and since then, it measures educational attainment by calculating the mean of the average years of schooling for adults and children's expected years of schooling (Barro and Lee, 2010). The summary of all the variable descriptions and data sources is provided in Table 1.

Table 1. Variable descriptions and data sources

VARIABLE	DESCRIPTION	SOURCE
GDP per capita	Gross Domestic Product (GDP) per capita, constant 2010 US$	World Bank (2019)
Domestic Investment	Gross Capital Formation,% of GDP	World Bank (2019)
Population Growth	Population growth rate in %	World Bank (2019)
Terms-of-Trade Growth	Changes in terms of trade in %, based on an index 2000=100	World Bank (2019)
Inflation	GDP deflator, annual change in %	World Bank (2019)
Institutional Quality	Rule of Law: The estimates range from approximately -2,5 to 2.5 indicating weak and strong governance performance respectively	World Bank (2019)
FDI ROW	Total inward stock of FDI from the rest of the world (Total inward stock of FDI less inward stock of FDI from China/USA/EU/Asia), % GDP	UNCTAD (2019)
FDI (CHINA/USA/EU/ROA)	Inward stock of FDI from China, USA, European Union and the Rest of Asia respectively,% of GDP	UNCTAD (2019)
Total Natural Resource Rent (% of GDP)	Total natural resources rents are the sum of oil rents, natural gas rents, coal rents (hard and soft), mineral rents, and forest rents.	World Bank (2019)
Human Capital Indicator	Education Index: Measures education attainment by calculating the mean of the average years of schooling for adults and expected years of schooling for children. The scale ranges from 0-1, where 1 indicates perfect education attainment.	UNDP (2019)

Source: Authors' compilation

[1] Chen *et al*. (2015) argue that FDI from both China and the Western investors is earmarked for natural resources in Africa.

The sample of this study is restricted by the availability of reliable FDI bilateral data between African countries and the FDI sources considered in this study. The choice of the FDI sources is guided by the analytical framework of Sy (2014) which analyzes the surge of FDI in Africa for the period (2001-2012)[2]. The list of sub-Sahara Africa countries utilized is given in Table 2.

Table 2. Sample

Angola	Benini*	Botswana	Burkina Faso	Burundi	Cameroon	Cape Verde	Central Africa Republic
Chad	Comoros	Congo	Cote D'Ivoire	DRC	Equatorial Guinea	Eritrea	Ethiopia
Gabon	The Gambia	Ghana	Guinea	Guinea-Bissau*	Kenya	Lesotho	Liberia
Madagascar	Malawi	Mali*	Mozambique	Niger	Nigeria	Rwanda*	Sao Tome & Principe*
Senegal*	Seychelles	Sierra Leone	South Africa	Swaziland	Togo*	Uganda	Tanzania
Zambia	Zimbabwe						

Notes: *countries with less than three observations of FDI from all the FDI sources for the period (2001-2012). The estimation of PTR using STATA is very sensitive to missing values hence; these countries were removed to obtain a strongly balanced panel data. We hardly could ipolate and epolate for the missing FDI values of the removed countries. For 2SLS analysis, we prefer to use the whole sample although the difference between the estimated coefficients obtained using the whole sample and those obtained using the reduced sample is marginal.

Source*:* Authors' compilation

3.2. Model specification

This study uses fixed effects PTR model of Hansen (1999) to determine the human capital threshold levels required for the absorption of FDI knowledge spillovers from various FDI sources in sub-Sahara Africa. Allowing for fixed individual effects (μ_i) and given a human capital indicator ($hc_{i,t}$) as a threshold variable, the PTR divides the observations into two or more regimes, depending on whether each observation is above or below a threshold level. The econometric equation of PTR model with two extreme regimes can be defined as follows;

$$y_{it} = \mu_i + \beta'_{it} s_{f,it} g(hc_{it}; c) + \varphi' X_{it} + \varepsilon_{it} \quad (3)$$

where X_{it} proxies for fundamental Solow growth variables and other control variables discussed above excluding human capital indicator. Excluding human capital from other explanatory variables defines its role as a threshold variable. Furthermore, it controls for reverse causality and collinearity between the variable and other economic growth variables. The subscript $s_{f,it}$ represents the inward stock of FDI while ε_{it} is the error term. The binary transition function $g(hc_{it}; c)$ divides the single threshold equation (3) into two regimes with coefficients β_1 and β_2, where *c* is the threshold parameter. This translates equation (3) into the following equation:

$$y_{it} = \begin{cases} \mu_i + \beta'_1 s_{f,it} + \varphi' X_{it} + \varepsilon_{it} & if\ hc_{it} \leq c \\ \mu_i + \beta'_2 s_{f,it} + \varphi' X_{it} + \varepsilon_{it} & if\ hc_{it} > c \end{cases}, \quad (4)$$

[2]An analytical framework of Sy (2014) shows that there has been a surge of inward stock of FDI in Africa from $27.2 billion to approximately $132.8 billion between the periods (2001-2012). This surge was mainly fuelled by China, whose FDI grew at an annual rate of 53%, compared with, 16% for the EU and 14% for the U.S. In addition to China, other new emerging investors from Asia were increasingly investing in the continent.

Equation (4) can be thought of as linear heterogeneous panel model with coefficients that vary across cross-section units and over time. Where the slope parameters satisfy;

$$\frac{\partial y_{it}}{\partial s_{f,it}} = \beta_{it} = \begin{cases} \beta_1 \; if \; hc_{it} \leq c \\ \beta_2 \; if \; hc_{it} > c \end{cases}, \tag{5}$$

Notwithstanding uncertainty about the endogeneity bias and potential reverse causality, this study uses lagged inward stock of FDI from a specific source and lagged values of the human capital indicator. This translates our equation of interest (equations (3)) into the following equation:

$$y_{it} = \mu_i + \beta'_{it} s_{f,it-1} g(hc_{it-1}; c) + \varphi' X_{it} + \varepsilon_{it} \tag{6}$$

3.3. Estimation procedures

The first test is conducted to determine the significance of the threshold effect in equation (6) (Hansen, 1999). The threshold effect hypothesis in the equation (6) can be presented as follows;

$$H_0 : \beta_1 = \beta_2$$

Accepting H_0 is an indication that normal panel regression with fixed effects should be utilized, otherwise panel threshold regression is appropriate. Due to the presence of the nuisance parameter in H_0, the asymptotic distribution of F_1 statistic is rendered non-standard (Davies, 1987). Hansen (1996) proposed the use of bootstrap simulation and demonstrated how it produces first-order asymptotic distributions and therefore test statistic F_1 and the corresponding *p*-value that is asymptotically valid. The null hypothesis is rejected if the test statistic $F_1 >$ its critical value.

The second step is conducted to discriminate between single and double threshold regression. In this context, H_0: Single threshold regression. The hypothesis of the double threshold is rejected in favor of the single threshold if $F_2 <$ its critical value. Otherwise, a sequential procedure based on $F_2, \ldots F_j$ (until the corresponding H_0 is accepted) allows the determination of the number of thresholds or regimes hence the appropriate regression. The corresponding asymptotic *p*-value for $F_2, \ldots F_j$ can again be estimated using bootstrap analogue (Hansen, 1999).

4. Estimated results

This study uses the education index to proxy for human capital. The index is given on a scale ranging between 0 and 1 where 1 is the highest possible theoretical score indicating perfect educational attainment. Table 3 gives a summary of the human capital variable in both logs (row (1)) and raw data (row (2)).

Table 3. Summary statistics of the threshold variable

Variable		Minimum value	25% quantile	50% quantile	75% quantile	Maximum value
ln lagged Education Index	(1)	-2.087	-1.165	-0.901	-0.726	-0.365
Lagged Education Index	(2)	0.124	0.312	0.406	0.484	0.694

Source*:* Authors' scale of educational attainment in sub-Sahara Africa based on UNDP (2019)

The result above shows that on average, educational attainment in sub-Sahara Africa does not exceed 0.69 years while the minimum educational attainment is 0.12 years. The 50% quantile demarcates between low and high educational attainment in the context of sub-Sahara Africa. Thus, the quantile demarcates skilled from the less-skilled stock of human capital in the

context of sub-Sahara Africa. Table 4 presents the results obtained in testing the null hypothesis of no threshold effects across all sources of FDI considered in this study.

Table 4. Hypothesis of no threshold and the number of regimes

	Chinese FDI	US FDI	EU FDI	ROA FDI
Test for Single threshold (two regimes)				
F_1	17.92	19.59	22.67	20.37
P-Value	0.020**	0.040**	0.020**	0.020**
1% critical values	18.41	22.98	22.89	21.02
5% critical values	17.00	16.03	17.77	17.66
10% critical values	15.66	15.66	12.55	15.15
Test for Double threshold (three regimes)				
F_2	3.50	4.33	5.71	3.77
P-Value	0.980	0.800	0.680	0.940
1% critical values	30.50	31.75	23.27	17.32
5% critical values	16.11	23.40	21.43	15.38
10% critical values	13.33	15.05	13.15	15.07

Notes: *P*-values and critical values are computed from 50 bootstrap simulations. F_1 represents the Fisher type statistic associated with the test of H_0 of no threshold against a single threshold. F_2 corresponds to the test of a single threshold against a double threshold. *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

Source: Authors' estimations using STATA 14

The results confirm the existence of human capital thresholds across all the FDI sources. For FDI from China, EU and the rest of Asia, the estimated bootstrapped *p*-value is 0.02 with corresponding test statistics F_1 of 17.92, 22.67 and 20.37 respectively. The estimated bootstrapped *p*-value of FDI from the US is 0.04 with corresponding test statistic F_1 of 19.59.

To determine the number of human capital thresholds available for each source of FDI, the results show that the test statistics F_2 and corresponding bootstrapped *p*-values are statistically insignificant across all sources of FDI. This result conveys information that there are two regimes for each source of FDI demarcated by the respective human capital threshold point estimate. The first regime is associated with low values of education index indicating low education attainment (less-skilled stock of human capital) while the second regime corresponds to high values of education index indicating high education attainment (skilled stock of human capital).

Table 5 presents the human capital threshold point estimates for each source of FDI in Africa and their asymptotic 95% and 99% confidence interval.

Table 5. Human capital threshold point estimates

		Estimate	95% Confidence Level	99% Confidence Level
Chinese FDI	Single threshold	-0.677	[-0.691;-0.668]	[-0.691;-0.668]
US FDI	Single threshold	-0.683	[-0.691;-0.675]	[-0.691;-0.675]
EU FDI	Single threshold	-0.683	[-0.691;-0.675]	[-0.691;-0.675]
ROA FDI	Single threshold	-0.683	[-0.691;-0.675]	[-0.691;-0.675]

Source: Authors' estimations using STATA 14

The results show that FDI from the US, EU and the rest of Asia share the same threshold level of -0.683. Although for China the threshold point estimate is -0.677, the difference with the threshold level of other FDI sources is marginal. The results also show that the asymptotic confidence intervals for the thresholds are equal at 95% and 99% across all the estimations, indicating certainty about the nature of this division.

The threshold point estimates of -0.677 and -0.683 correspond to education index values of 0.508 and 0.505, respectively. The difference between these values is still very

marginal implying that the human capital threshold level required to absorb knowledge embodied in all FDI sources is 0.51 years in terms of educational attainment. This threshold level is located above the 75 % quantile (Table 3), indicating high educational attainment in the context of sub-Sahara Africa. However, in terms of the UNDP scale, this value indicates average educational attainment.

The main results of this study are presented in Table 6. Column (1)-(4) presents the estimations relating to the FDI from China, US, EU and the rest of Asia, respectively. Based on the results attained in Table 4 and 5, all estimates are derived from a single threshold regression model.

Table 6. PTR estimates of FDI knowledge spillover effects on growth in sub-Sahara Africa

Dependent Variable: ln real GDP per Capita					
		(1)	(2)	(3)	(4)
Lagged Dep Var		0.755***	0.0755***	0.748***	0.743***
		(0.036)	(0.042)	(0.041)	(0.042)
ln Domestic Investment		0.010***	0.010***	0.009***	0.010***
		(0.002)	(0.002)	(0.002)	(0.002)
ln Population Growth		0.012	0.007	0.0004	0.002
		(0.008)	(0.005)	(0.005)	(0.005)
ln Natural Resource Rents		0.003	0.003	0.002	0.003
		(0.010)	(0.010)	(0.010)	(0.010)
In Inflation		-0.0003	-0.0003	-0.0003	-0.0003
		(0.000)	(0.000)	(0.000)	(0.000)
In Rule of Law		0.050**	0.050**	0.037	0.050**
		(0.023)	(0.025)	(0.023)	(0.023)
Terms to Trade growth		0.023***	0.022***	0.022***	0.022***
		(0.005)	(0.005)	(0.005)	(0.005)
ln FDI ROW		-0.105***	-0.130**	-0.080*	-0.122***
		(0.019)	(0.052)	(0.044)	(0.032)
ln FDI China		-0.015			
		(0.179)			
ln FDI US			-0.028		
			(0.066)		
In FDI EU				-0.169**	
				(0.077)	
In FDI ROA					-0.267*
					(0.136)
ln $FDI^j g(.)$	β_1	0.061	0.062	0.094**	0.069
		(0.046)	(0.043)	(0.045)	(0.046)
	β_2	-0.047	-0.022	-0.005	-0.018
		(0.077)	(0.057)	(0.060)	(0.063)
Observations		340	350	350	350
Countries		34	35	35	35
R-Squared (within)		0.867	0.869	0.872	0.870

Notes: The subscript j denotes FDI from a specific source while $g(.)$ represents the binary transition function. For FDI from US, EU and the rest of Asiaβ_1: $hc_{it} \leq -0.683$ and β_2:$hc_{it} > -0.683$ while for Chinese FDI,β_1: $hc_{it} \leq -0.677$ and β_2:$hc_{it} > -0.677$. Robust standard errors are in parentheses. *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level.

Source: Authors' estimations using STATA 14

4.1. Variables of interest

The results show that the estimated coefficients of β_1 are positive in all regressions albeit statistically insignificant in the regression relating to FDI from China, US and the rest of Asia. In

terms of FDI from the EU, the estimated coefficient of β_1 is positive and statistically significant at 5%. We also found negative and statistically insignificant estimated coefficients of β_2 across all the sources of FDI.

These results indicate that the impact of FDI from the US, China and the rest of Asia is insignificant in both the first and second regimes. However, the sign change of the estimated coefficients upon the switching of regimes affirms the existence of human capital threshold concerning the absorption of FDI knowledge spillovers (Fu and Li, 2010). Thus the human capital threshold estimate of -0.68 is referred to as the sign-change threshold. Moreover, our results convey information that only FDI from the EU can positively contribute to economic growth through human capital development in African countries falling within the first regime. The quality of human capital stock in these countries does not exceed 0.51 years in terms of educational attainment. However, the impact of the latter turns negative and insignificant as the threshold level of human capital surpasses -0.68 (educational attainment of 0.51 years) implying lack of capacity in terms of absorption of FDI knowledge spillovers.

These results are consistent to the findings of Xu (2000) and Unisa Yusufu (2013). Using secondary educational attainment of the population over 15 years of age as a proxy of human capital, the latter found that the impact of FDI on growth in sub-Sahara Africa turns negative above the human capital threshold level of 2.54 years. Xu (2000) argued that developing countries are yet to reach a minimum human capital threshold level where FDI knowledge spillovers can enhance growth in their economies. Likewise, our findings provide evidence that Africa is short of quality human capital stock required to absorb advanced knowledge embodied in FDI from both its traditional (US and EU) and emerging investors (China and the rest of Asia).

Demena and Murshed (2018) and Glass and Saggi (2002) assert that knowledge spillover effects emanating from FDI can hold if there is physical mobility of host country's human capital stock from MNEs to domestic companies. This movement catalyzes the contagion effects of knowledge and also encourages brain drain. In the context of sub-Sahara African countries, physical mobility of human capital stock seems to be discouraged by wage differentials between MNEs and domestic firms. MNEs offer high wages relative to domestic companies and the wage differentials are high in developing countries due to lack of competition between the MNCs and the domestic firms (Aitken *et al.* 1996).

Demena and Murshed (2018) also suggest that significant development of human capital stock can be realized if domestic companies can imitate advanced technologies exposed to them by foreign investors. The imitation of advanced technologies from foreign investors is constrained due to the lack of competition between MNEs and domestics firms in sub-Sahara Africa. This might be, to the larger extent, attributed by technicality and capital requirements of the sectors which the FDI sources are targeting. For instance, Chen *et al*. (2013) argue that FDI from both China and Western countries are earmarked for natural resources in Africa. This gives an impression to assume that a high share of FDI from the US, EU and Asia is found in mining projects. These are capital intensive and highly technical projects which domestic companies in Africa cannot afford to operate and compete with MNEs due to capital constraints.

Be that as it may, the positive impact of FDI from EU on growth in African countries with the less-skilled stock of human capital (educational attainment of at most 0.51 years) is an indication that the EU's investments in the region are diversified relative to other sources. Precisely, EU's investments in Africa seem to be found also in less technical and less capital intensive sectors which offer opportunities for imitation and physical mobility of human capital stock in the host country. It is, therefore, logical to argue that African countries that receive significantly less technical and less capital intensive FDI are likely to benefit positive growth through human capital development. Supposedly, in developing countries like sub-Sahara Africa, the absorption of knowledge embodied in FDI is effective in less technical and less capital intensive economic sectors.

Amendolagine *et al.* (2017) assert that FDI spillovers are likely to host countries that encourage foreign investors to source for production inputs locally. However, these countries should be in the position of quality human capital stock. Since our findings indicate that the stock of human capital stock in sub-Sahara Africa does not meet a minimum threshold (0.51

years) required for the absorption of advanced knowledge embodied in FDI from all sources considered in this study, these foreign investors might be outsourcing for production inputs and also exporting raw minerals to other countries outside the region for further processing. This implies that employment creation in MNEs is limited to a certain level so is the amount of knowledge transmitted to the stock of human capital in the region. This adds to the reasons why we obtained statistically insignificant estimated coefficients of β_2 across all the sources of FDI.

4.2. Control variables

The estimated coefficients of the lagged per capita GDP, domestic investment, and terms-of-trade growth are standard relative to literature and highly significant across all regressions. The estimated coefficient of rule of law enters all the regressions as expected however significant at 5% only in regressions relating to FDI from China, US and the rest of Asia. Contrary to theory, the estimated coefficient of population growth is positive albeit statistically insignificant and small. The estimated coefficients of inflation and natural resource rents are very small and statistically insignificant. The estimated coefficients of FDI from the rest of the world separately controlling for the respective sources of FDI are all negative and significant. The estimated coefficients of FDI from the US and China are statistically insignificant while those of FDI from the EU and the rest of Asia are negative and statistically significant at 5% and 10%, respectively.

4.3. Robustness checks

Endogeneity is a central econometric problem which is associated with economic growth models. In a single regression framework, the workhorse of dealing with endogeneity is using instrumental variables estimator and the popular form of that estimator, often utilized is known as two-stage least squares (2SLS). Hence, we use fixed effects 2SLS estimator to check the robustness of the PTR results. In principle, instrumental variable techniques account for the probable endogeneity arising from FDI variables. The regressions are conducted with interaction terms between each source of FDI and human capital indicator in sub-Sahara Africa.

However, one of the drawbacks associated with classical fixed-effects estimation techniques in as much as the interaction term is concerned ($s_f * hc$) is the inability to capture for varying slopes. Rather, they reflect the heterogeneity of different countries in the intercepts. While we acknowledge that PTR model does not fully account for endogeneity, the model is effective in capturing different links in terms of statistical significance, magnitude and signs of FDI from a specific source in distinct regimes of human capital stock in sub-Sahara Africa. In this respect, it is important to note that the former and the latter estimation techniques complement each other. For this study, 2SLS is used to confirm robustness of the estimated coefficients of FDI as a physical capital input (s_f) as well as other control variables (X) while reinforcing the effectiveness of PTR in capturing the heterogeneity of sub-Sahara Africa's human capital stock in terms of quality. The estimated results are presented in Table 7. Column (1)-(4) presents the estimated results for FDI from China, US, EU and the rest of Asia, respectively.

The results show that only the estimated coefficient of Chinese FDI is negative and significant at 5% while those of other FDI sources are statistically insignificant. In terms of FDI from the rest of the world, the estimated coefficients are negative and significant at 10% and 5% only in the regression relating to FDI from EU and the rest of Asia, respectively. Terms-of-trade growth estimated coefficient enter the model as expected albeit insignificant across all specifications. The estimated coefficient of rule of law enters all regression with expected sign however significant only in the regression relating to Chinese FDI. The estimated coefficients of all other variables are robust.

Table 7. Fixed effects 2SLS estimations

Dependent Variable: ln real GDP per Capita				
	(1)	(2)	(3)	(4)
Lagged Dep Var	0.723***	0.718***	0.721***	0.734***
	(0.060)	(0.069)	(0.061)	(0.060)
ln Domestic Investment	0.013**	0.012***	0.013***	0.012***
	(0.005)	(0.004)	(0.005)	(0.005)
ln Population Growth	-0.007	0.005	0.008	0.001
	(0.016)	(0.023)	(0.018)	(0.017)
ln Natural Resource Rents	0.003	0.002	-0.004	0.002
	(0.016)	(0.018)	(0.017)	(0.017)
In inflation	0.003	0.003	0.004	0.003
	(0.007)	(0.007)	(0.007)	(0.007)
Terms to Trade growth	0.013	0.013	0.014	0.014*
	(0.008)	(0.008)	(0.008)	(0.008)
ln Rule of Law	0.043*	0.042	0.031	0.034
	(0.025)	(0.040)	(0.026)	(0.029)
ln FDI ROW	-0.059	-0.103	-0.069*	-0.072**
	(0.038)	(0.071)	(0.041)	(0.034)
ln FDI China	-0.176**			
	(0.077)			
In FDI US		-0.021		
		(0.101)		
ln FDI EU			-0.016	
			(0.052)	
ln FDI ROA				0.036
				(0.143)
ln FDI^{j}*hc	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)
Observations	251	227	239	243
Countries	42	42	42	42
R-Squared (within)	0.804	0.795	0.802	0.802
Hausman/C test (p-value)	0.000	0.000	0.000	0.001
Hansen test (p-value)	0.861	0.227	0.276	0.400

Notes: The subscript *j* represents a specific source of FDI. FDI^{j}*hc* is the interaction term between an FDI from a specific source and human capital indicator in sub-Sahara Africa. Robust standard errors are in parentheses. *significant at the 10% level; **significant at the 5% level; ***significant at the 1% level. In all regressions from column 1-4, specific FDIs are instrumented using their first three lags and the p-values of the Hausman test are <10% implying that 2SLS estimates are preferred to standard OLS fixed-effects estimates. All p-values of the Hansen test are >10% implying that the instruments used are valid.

Source: Authors' estimations using STATA 14

We found very small and statistically insignificant estimated coefficients of all interaction terms. This result confirms the weakness of the 2SLS in capturing the heterogeneity of sub-Sahara Africa in terms of the quality of human capital stock. Despite the noted differences in other control variables and more importantly in the estimated coefficients of the FDI sources, both PTR and 2SLS estimates demonstrate a similar qualitative pattern in that the direct impact of FDI from the sources is either negative or at best insignificant. This qualitative pattern is consistent with the empirical literature (Borensztein *et al*. 1998; Xu, 2000; Unisa Yusufu, 2013) which argues that the positive impact of FDI on the economic growth of the host country is not automatic rather subject to the absorption capacity of the host country's specific factors like human capital. Although the latter studies emphasize that decisive outcome of FDI induced growth is often realized above a certain threshold level of human capital, we argue based on our results that it can also be realized below a certain human capital threshold level depending on the type of FDI emanating from the sources.

5. Conclusion and recommendations

An approach that only considers FDI as a physical capital input does not fully describe how FDI affects growth in the host country. Substantial evidence from the FDI-growth nexus literature shows that FDI is also accompanied by knowledge transfer to human capital in the host country. Likewise, there is ample evidence to substantiate human capital as a vital growth factor. This paper, therefore, analyzes how FDI from China, US, EU and the rest of Asia transmits to growth through human capital development in sub-Sahara Africa for the period (2003-2012). We use education index developed by the UNDP as a human capital indicator and adopt PTR model to show the human capital threshold levels required for the absorption of knowledge embodied in FDI from the afore-mentioned sources.

The findings of this study demonstrate a human capital threshold level of 0.51 years in terms of educational attainment across all FDI sources. Nevertheless, only FDI from the EU can enhance sub-Sahara Africa's growth through the development of less-skilled stock of human capital (less than 0.51 years). The impact of the latter turns negative and insignificant as the quality of human capital required to absorb knowledge spillovers increases beyond 0.51 years. For other FDI sources, 0.51 years demonstrates a sign-change. This means that the impact of FDI from the sources is insignificant on growth in Africa either below or above 0.51 years. However, the sign change due to the regime shift from positive to negative, respectively confirms the existence of the human capital threshold level required for the absorption of potential knowledge spillovers of FDI. Based on these empirical findings, we conclude that Africa is short of quality human capital stock required to absorb superior knowledge embodied in FDI from its traditional and emerging investors. On the other dimension, it can be argued that the knowledge spillover effects depend on the technicalities and capital intensity of the economic sectors targeted by FDI sources. For instance, looking at the EU's result, one can conclude that the knowledge spillover effects in Africa can be effective in less industrialized economic sectors.

The minimum threshold level obtained of 0.51 years is important for human capital development policies in sub-Sahara Africa because it provides direction for mitigation procedures corresponding to the specific source of FDI. Thus, 0.51 years serves as a primary threshold to cartel the absorption of advanced knowledge embodied in both traditional and emerging investors in Africa, a sign-change threshold to overcome the negative growth effects of FDI from the US, China and the rest of Asia and an additional threshold to enhance the positive growth effects of FDI from the EU. On the other dimension, the findings provide aspects necessary to enhance the transmission of knowledge embodied in FDI to the human capital stock in African countries. For instance, policies that encourage less technical and less capital intensive FDI like FDI directed towards the agricultural sector, policies that encourage brain drain from MNEs to the domestic firms and policies that promote production value addition particularly in the extraction projects.

Although the human capital threshold obtained in this study relates to the absorption of FDI knowledge spillovers from specific FDIs, it is generalized in terms of industry. There is a possibility that this threshold might differ from one industry to the other. For instance, the human capital threshold required for the absorption of knowledge embodied in mining FDI might differ from that of FDI meant for agriculture, manufacturing, retailing or construction. Given the availability of industry-specific FDI data from source countries, this can serve as an important field for further research. Moreover, future studies can also look at the possibility to combine the strengths of the PTR model and instrumental variables techniques. We assume that the results obtained from the estimation techniques that combine the former and the latter into one model might provide a more robust confirmation of our findings.

References

Aitken, B. J., Harrison, A. E. and Lipsey, R. E., 1996. Wages and foreign ownership : A comparative study of Mexico, Venezuela, and the United States. *Journal of International*

Economics, 40, pp. 345–371. https://doi.org/10.1016/0022-1996(95)01410-1
Amendolagine, V. Presbitero, A. F., Sanfilippo, M. and Seric, A., 2017. *FDI, global value chains, and local sourcing in developing countries. International Monetary Fund*. WP/17. https://doi.org/10.5089/9781484335109.001
Barro, R. J. and Lee, J.-W., 2010. *A new data set of educational attainment in the world, 1950-2010*, *NBER Working Paper*. 15902. Cambridge. https://doi.org/10.3386/w15902
Bassanini, A. and Scarpetta, S., 2001 The driving forces of economic growth: panel data evidence for the OECD countries. *OECD Economic Studies*, 33(33), pp. 9–56. https://doi.org/10.1787/eco_studies-v2001-art10-en
Borensztein, E., De Gregorio, J. and Lee, J.-W., 1998. How does foreign direct investment affect economic 1 growth? We are grateful for comments from. *Journal of International Economics*, 45(45), pp. 115–135. https://doi.org/10.1016/S0022-1996(97)00033-0
Busse, M., Erdogan, C. and Muhlen, H., 2014. China's impact on Africa – The role of trade, FDI and aid. *KYKLOS*, 69(2), pp. 228-262. https://doi.org/10.1111/kykl.12110
Chen, W., Dollar, D. and Tang, H., 2015 Why is China investing in Africa? Evidence from the firm Level. *The World Bank Economic Review*, 32(3), pp. 610-632.
Davies, R. B., 1987. Hypothesis testing when a nuisance parameter is present only under the alternative. *Biometrika*, 74(1), pp. 33–43. https://doi.org/10.1093/biomet/74.1.33
Demena, B. A. and Murshed, S. M., 2018. Transmission channels matter: Identifying spillovers from FDI. *Journal of International Trade and Economic Development*, 27(7), pp. 701–728. https://doi.org/10.1080/09638199.2018.1439083
Doku, I., Akuma, J. and Owusu-afriyie, J., 2017. Effect of Chinese foreign direct investment on economic growth in Africa. *Journal of Chinese Economic and Foreign Trade Studies*, 10(2), pp. 162–172. https://doi.org/10.1108/JCEFTS-06-2017-0014
Donou-Adonsou, F. and Lim, S., 2018. On the importance of Chinese investment in Africa. *Review of Development Finance*, 8(1), pp. 63–73. https://doi.org/10.1016/j.rdf.2018.05.003
Fu, M. and Li, T., 2010. Human capital and technological spillovers from FDI in the chinese regions: A threshold approach. *The Rise of Technological Power in the South*, pp. 238–257. https://doi.org/10.1057/9780230276123_13
Glass, A. J. and Saggi, K., 2002. Multinational firms and technology transfer. *Scandinavian Journal of Economics*, 104(4), pp. 495–513. https://doi.org/10.1111/1467-9442.00298
Hansen, B. E., 1996. Inference when a nuisance parameter is not identified under the null hypothesis. *Econometrica*, 64(2), pp. 413–430. https://doi.org/10.2307/2171789
Hansen, B. E., 1999. Threshold effects in non-dynamic panels : Estimation, testing, and inference. *Journal of Econometrics*, 93, pp. 345–368. https://doi.org/10.1016/S0304-4076(99)00025-1
Hanson, G. H., 2001. Should countries promote foreign direct investment? *G-24 Discussion Paper Series, No. 9*.
Lim, E.-G., 2001. *Determinants of, and the relation between, foreign direct investment and growth: A summary of the recent literature.* IMF Working Paper, WP/01/175. https://doi.org/10.5089/9781451858754.001
Lucas, R., 1988. On the mechanics of economic development. *Journal of Monetary Economics*, 22, pp. 3–42. https://doi.org/10.1016/0304-3932(88)90168-7
Mankiw, N., Romer, D. and Weil, D., 1992. A contribution to the empirics of economic growth. *Quarterly Journal of Economics*, 107, pp. 407–438. https://doi.org/10.2307/2118477
Neuhaus, M., 2006. The impact of FDI on economic growth: An analysis for the transition countries of central and Eastern Europe. In: M. Miller, and W. A., Bihn, eds. 2006. *Contributions to economics*. London: Physica-Verlag A Springer Company.
Ozturk, I., 2007. Foreign direct investment - Growth nexus: A review of the recent literature. *International Journal of Applied Econometrics and Quantitative Studies*, 4(2), pp. 79–98.
Romer, P., 1986. Increasing returns and long-run growth. *Journal of Political Economy*, 94, pp. 1002–1037. https://doi.org/10.1086/261420
Romer, P., 1990. Endogenous technological change. *Journal of Political Economy*, 98, pp. S71-S102. https://doi.org/10.1086/261725

Romer, P., 1993. Idea gaps and object gaps in economic development. *Journal of Monetary Economics*, 32, pp. 543–573. https://doi.org/10.1016/0304-3932(93)90029-F

Sy, A., 2014. Is Africa at a historical crossroads to convergence? *Africa Growth Initiative, The Brookings Institute*, Washington, D.C.

Ucal, M., Ozcan, K. M., Bilgin, M. H. and Mungo, J., 2010. Relationship between financial crisis and foreign direct investment in developing countries using semiparametric regression approach. *Journal of Business Economics and Management*, 11(1), pp. 20–33. https://doi.org/10.3846/jbem.2010.02

Unisa Yusufu, K., 2013. *Foreign direct investment and growth in Sub-Saharan Africa what are the channels?* [pdf] Available at: <http://www2.ku.edu/~econ/people/documents/Kamara_2013_000.pdf> [Accessed on 12 February 2020].

United Nations Development Program (UNDP), 2019. *Education Index*. [online] Avaliable at: <http://hdr.undp.org/en/data> [Accessed on 20 November 2019].

United Nations Trade and Development (UNCTAD), 2019. *Bilateral FDI statistics*. [online] Available at: <https://unctad.org/en/Pages/DIAE/FDI%20Statistics/FDI-Statistics-Bilateral.aspx> [Accessed on 10 November 2019].

Word Bank, 2019. *World Bank development indicators: DataBank.* Available at: <https://databank.worldbank.org/source/world-development-indicators> [Accessed on 19 November 2019].

Xu, B., 2000. Multinational enterprises, technology diffusion, and host country productivity growth. *Journal of Development Economics*, 62(2), pp. 477–493. https://doi.org/10.1016/S0304-3878(00)00093-6

Zhang, J., Alon, I. and Chen, Y., 2014. Does Chinese investment affect Sub-Saharan African growth? *International Journal of Emerging Markets*, 9(2), pp. 257–275. https://doi.org/10.1108/IJoEM-10-2013-0171