How Does Foreign Direct Investment Affect Growth in Sub-Saharan Africa? New Evidence from Non-threshold and Threshold Analysis

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Abstract

We draw on the threshold analysis to examine the effect of foreign direct investment on growth in Sub-Saharan Africa. The growth literature is awash with divergent evidence on the role of foreign direct investment (FDI) on economic growth. Although the FDI-growth nexus has been studied in diverse ways, very few studies have examined the problem within the framework of threshold regression analysis. Furthermore, even where this framework has been adopted, none of the previous studies has comprehensively examined the FDI-growth nexus in the broader Sub-Saharan Africa (SSA). In this paper, we revisit, within the standard panel and threshold regression framework, the problem of determining the growth impact of FDI. We use as thresholds six variables – inflation, initial income, population growth, trade openness, financial market development and human capital, and we base the analysis on a large panel-data set that comprises 45 SSA countries for the years 1985-2013. Our results show that the direct impact of FDI on growth is largely ambiguous and inconsistent. However, under the threshold analysis, we find evidence that FDI accelerates economic growth when SSA countries have achieved certain threshold levels of inflation, population growth and financial markets development. This evidence is largely invariant qualitatively and robust to different specifications. FDI enhances growth in SSA when inflation and private sector credit are below their threshold levels while population growth is above its threshold level.

Keywords

Foreign Direct Investment (FDI), Economic Growth, and Threshold Analysis

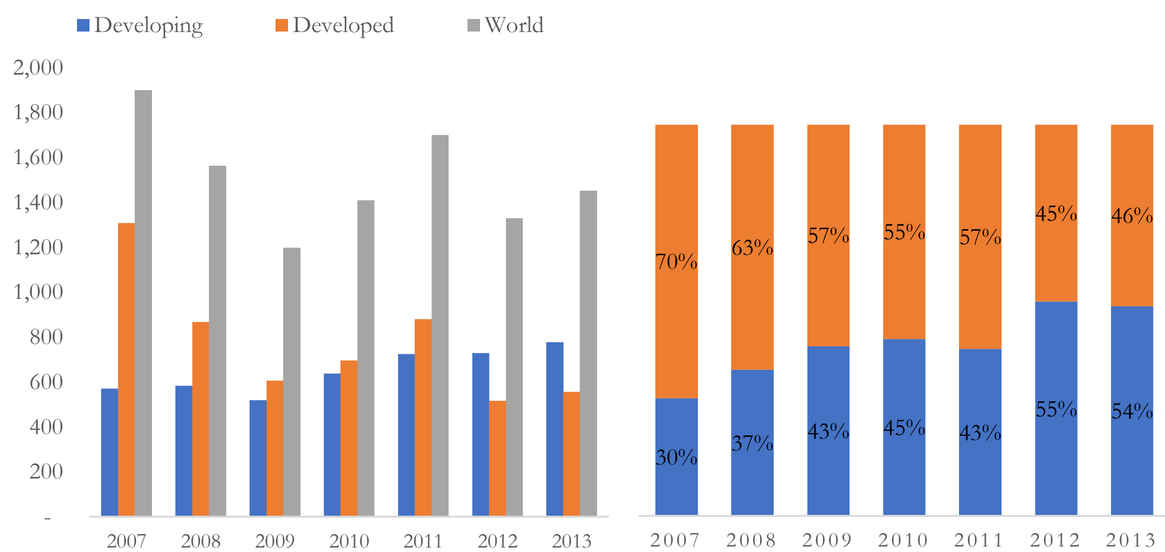
JEL

C33, E22, F21, F43, N77, O16, O55

1.1 Introduction and Literature Review

In the current era of increased globalization and economic openness, foreign direct investment (FDI) is a major factor responsible for the interdependence of economies. Over the last two decades, FDI flows across countries have recorded a significant growth in magnitude. The United Nations Conference on Trade and Development (UNCTAD, 2014) reports that from $0.21 billion in 1990, global FDI rose unprecedentedly to $1.45 trillion in 2013, despite falling from an all-time-high of $1.90 trillion in 2007 due to the financial crisis that began in 2008 and led to persistent global disinvestment. Of the global FDI flows in 2013, developing economies took up more than 53%.

Fig. 1.0: FDI inflows ('billion US$) and proportion of world FDI inflows to developed & developing countries



Source: UNCTAD World Investment Report, 2014, 2013, 2012 and 2011

Progressively, FDI is becoming an important unifying global factor among countries. Policies in developing economies are increasingly being designed to support significant FDI inflows even as decision makers consistently implement strategies to attract FDI in the belief that FDI creates positive productivity effects for host economies. According to the Organization for Economic Cooperation and Development (OECD), FDI is a key element in international economic integration and creates direct, stable and long-lasting links among economies while encouraging transfers of technology and know-how among countries. In addition, FDI provides an alternative source of funding for investment and, under the right policy environment, can be an important vehicle for development, allowing host countries to promote their products more widely in international markets.

Many developing countries, particularly in Asia and Africa, are pro FDI and believe it brings important benefits advantageous to a host country's growth and developmental efforts as well as provides a buffer against sharp reversals in portfolio inflows during periods of crisis such as, for example, the ASEAN financial crisis of 1997-1998, given its relative stability compared to portfolio inflows that are more liquid and reputed for being very volatile and unstable. On the whole, a number of countries believe attracting FDI is synonymous to potentially increasing growth. For instance, Indonesia, after the ASEAN financial crisis, has become much more open-minded in its economic policies to attract more FDI (see Diaconu (2014)) to increase its economic growth, compared to attracting more liquid foreign portfolio investment whose outflow partly triggered the ASEAN financial crisis (see Bordo et.al (2010) and Poulsen and Hufbauer (2011)). In fact, FDI is now seen as a composite of not only capital stock but also knowledge and technology which impacts growth via capital accumulation that facilitates utilization of more advanced technologies in the production and knowledge transmission processes. Meanwhile, the acquisition of skills by labour enhances existing knowledge stock, in addition to promoting improved management practices and structural arrangements in economies.

In an ideal scenario, besides providing long lasting direct capital to finance real businesses and investments in productive capital and to accumulate equity ownerships in businesses resident in foreign countries, FDI also provides valuable advanced technology and intellectual know-how and exposes local businesses to processes adopted in more advanced climes. As these exposure and adoption of advanced technology and intellectual know-how can help channel an economy towards a positive growth path, a number of countries have opened and continue to open their doors wide to foreign investors in a bid to maximize inflows of FDI. Furthermore, developing countries in Asia, Africa and America have come to see FDI as a source of economic growth and development, among other things, as reflected in their pro-FDI economic policies.

To accelerate FDI inflows, these countries offer attractive incentives such as tax breaks, favourable import and export tariffs, enhanced property protection, benign foreign policies and reduced administrative bottlenecks. These lead foreign investors to believe their interests in the host countries are well-protected to attract lasting benefits. In Sub-Saharan Africa, for instance, countries such as Nigeria have for many years provided a 5-year tax exemption and export grants to domestic firms (see Rapu et. al (2013)), which also include FDI-related firms, that have expanded capacities and/or engaged in Greenfield projects, on the assumption that the expanded capacities and Greenfield projects would provide opportunities supportive of the growth and well-being of the domestic economy, in the medium to long term. In all these, while some economies have enjoyed improved economic growth rates on the back of FDI upsurge, many continue to struggle. Furthermore, despite documented evidence supportive of FDI, especially in developed countries, excessive FDI inflows could themselves be a curse in disguise. For this reason, a distinction must be made between 1) merely attracting FDI in order to make countries appear globally renowned, as choice investment destinations, but without any accompanying growth benefits – and 2) proactively attracting FDI in order to particularly enhance growth. The Vietnamese economy exemplifies how too much reliance on FDI can be suboptimal for growth. Over the years, significant reliance on FDI has left the Vietnamese economy with weaker domestic firms, negative and less benign impact on economic growth, Thuy (2007). As a result, the Vietnamese government in 2014 and more recently in 2017 noted the need to focus on selected domestic firms and priority sectors rather than continually attracting increasing quantities of FDI which has over time come at huge sacrifices and costs to the country, with little or no boost to growth in all sectors of the economy. Given this, Vietnam now implements policies that aim to make domestic enterprises the major drivers of the country's growth and development in the years ahead, focusing on priority sectors and quality of investments, rather than quantity Shira et. al (2017). This implies a scale-back of incentives granted to attract FDI for some sectors.

In recent times, the opportunity costs of high FDI inflows, which include, amongst others, substantial loss of tax revenues, have attracted the interest of researchers and brought differing opinions on the merits of FDI. These differing opinions are further supported by the growth literature which shows that the positive effects of FDI on the growth of host countries is ambiguous. Hanson (2001), for instance, argues that evidence that FDI generates positive spill overs for host countries, is weak. A lot of studies have been done to unravel this FDI-growth conundrum. Rather than proffer definitive answers, these studies have called for more studies, which conclude that FDI alone might not be growth inducing and certain conditions are required for FDI to impact growth positively. Although Lipsey (2002) argues for the existence of some positive effects of FDI on host economies, Gorg and Greenaway (2002) find that the effects are mostly negative. Meanwhile, Carkovic and Levine (2002) show that FDI by itself does not directly influence growth. They show that the exogenous component of FDI has no robust positive effect on growth and the benefits of FDI are conditional on other growth determinants within a country.

Further studies such as Borensztein et al. (1998), Xu (2001) and Alfaro et al. (2004), which analyse the conditions required for FDI to be growth-inducing, propose additional explanations. One such explanation is that a country's absorptive capacity, i.e. benign domestic conditions, plays a significant role in unlocking the positive effects of FDI on growth. This explanation is based on the notion that FDI not only provides investible capital, but also provides a conduit through which countries gain access to advanced technologies that help increase their total factor productivity which boosts growth. Following this line of reasoning, if favourable domestic factors are unavailable to maximize the absorption of advanced technologies, there will be no significant improvement in productivity and, as a result, a noticeable economic growth is unlikely to occur. Based on this, the discrepancy in domestic absorptive capacities across countries might provide some explanation on why the impact of FDI on growth varies widely.

Borensztein et al. (1998), Xu (2001) and Alfaro et al. (2004) are all proponents of absorptive capacities. They suggest that country-specific circumstances such as the level of educational attainment, development of domestic financial markets and other domestic conditions, play important roles in promoting a positive FDI-growth nexus. Alfaro et al. (2004) emphasize the role of financial institutions and argue that lack of development of local financial markets can limit the ability of an economy to take advantage of potential FDI spillovers, concluding that countries with well-developed financial markets record more gains from FDI. Blomstrom and Kokko (2003) conclude that positive spillovers are not automatic and that local conditions influence the adoption of foreign technologies and skills. This means that high FDI inflows do not guarantee positive spillovers into host countries unless domestic conditions are right and supportive and the FDI flows come from entities with much higher levels of efficiency and possess truly more superior skills and advanced technologies.

To buttress this, Krugman (2000) argues that in a financial crisis, the presence of increased foreign-owned businesses in host countries is not a recipe for positive spillovers into the host countries because the increased foreign participation, via acquisition of substantial portions of domestic businesses, could have been driven by foreigners' quest to take advantage of liquidity-constrained domestic investors' asset sales. In this context, Krugman argues that foreigners are less efficient than domestic investors, since foreigners acquire businesses in host countries not because they possess special technological advantage or know-how which they bring to the host countries, but because they have a superior cash position. This supports the idea that positive spillovers do not automatically come from increased FDI. The FDI should flow from more efficient entities and destinations and, more importantly, the recipient countries should have attained certain levels of domestic development for the FDI to induce growth spillovers.

It is important to note that the domestic absorptive capacities do not all react with FDI in a congruent manner in all scenarios; different absorptive capacities react differently with FDI to release positive spillover effects that enhance growth. For instance, Blomstrom, Lipsey, and Zejan (1994) find that FDI has a significant impact on growth, and positive spillovers from FDI depend on current income levels of host countries. On the other hand, they conclude that these spillovers are not driven by countries' levels of education and human capital development. Meanwhile, Balasubramanyam, Salisu, and Sapsford (1999) find that a country's trade openness is a favourable absorptive capacity that increases the benefits that economic growth accrues from the contribution of FDI.

There are also evidences in the literature showing that the positive spillovers from FDI depend on some minimum threshold levels of domestic absorptive capacities - human capital, well developed financial markets, trade openness, levels of income and technological gap. Borensztein, De Gregorio and Lee (1998) show that the existence of high human capital, via well-educated labour force, is required to spread the benefits of new technologies from FDI across industries. In other words, FDI catalyses growth when the host countries have attained certain threshold levels of human capital. Their findings indicate that gains from FDI come through diffusion of technology rather than through capital accumulation alone. Alfaro et.al (2004) conclude that economies with well-developed domestic financial markets are the major beneficiaries of FDI. But, how well-developed would countries' financial markets be in order to benefit optimally from the growth-inducing merits of FDI? Also, what level of financial markets is considered too underdeveloped and hinders economies from unlocking the growth benefits of FDI? Azman-Saini et.al (2010) provide answers to these questions through their empirical studies which show that the positive impact of FDI on growth kicks in only after financial market development, represented by private sector credit, exceeds a threshold level of 49.70% of GDP, until which the benefits of FDI on growth are non-existent.

Broadly speaking, the abovementioned empirical research, which has analysed the FDI-growth nexus, argues that positive spillover effects of FDI stem from a set of favourable domestic factors. These factors include human capital, development of domestic financial markets, trade openness, initial income levels, macroeconomic stability, and population growth. In this paper, we draw on these absorptive capacities to determine the extent to which they alter the FDI-growth nexus in SSA. This implies that we evaluate how high or low these factors can attain for them to alter the impact of FDI on growth in SSA. In this sense, threshold regression models, where the threshold variables and values are the domestic absorptive capacities and levels, respectively, provide an appropriate empirical framework for such analysis as they are models that split data samples into regimes of high and low absorptive capacities, depending on whether the threshold variables exceed their estimated threshold values. The threshold values are assumed unknown and estimated from available data. To the best of our knowledge, no previous study has addressed the problem of determining the growth impact of FDI in SSA via the lenses of the aforementioned absorptive capacities under the panel threshold analysis framework. More often than not, studies that have investigated the growth benefits of FDI employed empirical techniques that implicitly rely on the linearity between FDI and growth and in the process neglected the possible nonlinearities that could exist between FDI and growth and the channels through which they operate. These are the deficiencies of most previous studies which our paper attempts to address in SSA.

Our starting point for the threshold analysis of FDI-growth nexus is the panel threshold model of Hansen (1999). The concept of threshold regression modelling has a wide variety of applications in economics and finance. In this thesis, the motivation to draw on the concept of thresholds stems from our primary objective – we wish to determine whether the empirical relationship between FDI and growth in SSA is invariant to sample splitting, where the sample split is based on a list of selected variables – which are important economic characteristics representing the threshold variables. If we find evidence that such a split yields dissimilar relationships between FDI and growth across the split samples, then this suggests that the threshold variable enabling the sample split does have an influence on the link between FDI and growth. That is, there exists a 'cut off' point for the threshold variable at which the link between FDI and growth is reversed. For instance, it could be that FDI decelerates growth when inflation is above $x\%$ but accelerates growth when inflation is below $x\%$. On the other hand, it could be that whether inflation is above or below x%, the link between FDI and growth is unchanged, i.e. FDI either accelerates or decelerates growth irrespective of the state of domestic inflation. Such an outcome would reveal the type of relationship existing between FDI and growth – whether the relationship is nonlinear, as in the first scenario, or linear, as in the second scenario. This in turn provides a fresh perspective that can create awareness among researchers and policymakers and propel them to monitor not just FDI and how it affects growth but also how other variables might influence the effect of FDI on growth. One important consequence of this awareness is its potential to inspire a tradition where policymakers target certain levels of these economic characteristics or threshold variables that increase the chances of FDI having a more benign influence on growth in the instances where the relationship between FDI and growth is nonlinear, i.e. there exists a threshold effect. We look at these issues within the context of SSA by investigating the nonlinearities in the FDI-growth nexus using six threshold variables. This motivates the concept of thresholds employed in the empirical analysis presented in this paper.

The threshold approach helps to appropriately answer questions such as what are the economic conditions or factors required to achieve a favourable FDI-growth nexus? Does high inflation crowd out the positive effects of FDI on growth, wherever they exist, and lead FDI to impact growth negatively? Is there any optimal level of trade openness or population growth for which the FDI-growth nexus is positive in SSA? These questions are better answered within the framework of threshold analysis. The sample split, which yields the subsamples on which the threshold regression analysis is performed, is obtained using the threshold value associated with each threshold variable. As stated in Hansen (2000), when subsamples are selected based on continuous threshold variables, some decision must be made concerning what is the appropriate threshold value or 'cutoff' point at which to split the main sample to generate the subsamples. Given this value is not known with certainty, some method must be employed in its selection. Formally, such a selection is achieved using the concept of thresholds as in Hansen (1999, 2000). Accordingly, in this paper, we employ Hansen (1999, 2000) method to empirically determine estimates of the threshold parameters, based on historical data, and subsequently split the samples based on these estimates. As estimated thresholds using historical data can change and thus vary over time when more data become available in the future, a caveat of the adopted method is that the estimated thresholds are data-specific and should not be construed as representing the sole threshold levels on which to always base a sample split. This is because they are not forward looking and do not account for the possibility of future changes in the threshold variables. As such, they need to be re-estimated as new data become available over time.

In the threshold model, the threshold value associated with each threshold variable is estimated rather than imposed. Each threshold variable is then compared to its estimated threshold value and the sample is split, depending on whether the threshold variable is above or below its estimated threshold value. Regression is then performed on each of the split samples. Applying Hansen (1999) model poses limitations, notable of which is the strong requirement that all explanatory variables be treated as exogenous, an assumption which can bias parameter estimates in instances where the focus explanatory variable, in this case FDI, is not exogenous. To address this problem, we apply the Caner and Hansen (2004) model which allows for endogenous explanatory variables. This model improves on Hansen (1999) and forms the basis of the second part of our threshold analysis of FDI-growth nexus presented in this paper.

In general, the use of threshold regression models in the study of FDI-growth nexus is not new. Azman-Saini et.al (2010), Raheem and Oyinlola (2013), Jyun-Yi and Chih-Chiang (2008) all adopted threshold regression models to analyse FDI-growth nexus. However, Azman-Saini et.al (2010) consider only one threshold variable, financial market development, and a panel of 91 broadly selected countries. Raheem and Oyinlola (2013) also consider financial market development as their sole threshold variable and perform a threshold regression time series analysis, rather than a panel analysis, on each of their 15 chosen SSA countries. Jyun-Yi and Chih-Chiang (2008), on the other hand, consider 3 threshold variables, namely human capital, income level and trade openness, and perform a threshold regression analysis on a panel of 62 broadly selected countries. In this paper, instead of selecting countries broadly, we specifically focus on SSA, select a panel of SSA countries from 1985 - 2013 and expand the set of threshold variables to include inflation and population growth – two new variables which hitherto had not been used as thresholds in the analysis of FDI-growth nexus. This increases the number of threshold variables in this paper to six, which makes for a more comprehensive empirical analysis. The six threshold variables are initial income, human capital, trade openness, financial market development, inflation, and population growth.

The contribution of this paper is twofold. First, the paper streamlines the threshold analysis of FDI-growth nexus to focus on countries in SSA – previous studies on FDI-growth nexus in SSA are country-specific and time series based (see Tshepo (2014), Raheem and Oyinlola (2013) and Bende-Nabende (2002)). This paper provides a panel analysis and considers a broader set of up to 45 SSA countries. Such a broad set of SSA countries had never been considered in the literature. Second, the paper expands on available threshold variables to include two new important macroeconomic variables, population growth and inflation which, though are important absorptive capacities but, until now, had not been used as thresholds in the FDI-growth literature. The rationale for including these variables as thresholds stems from the evidence of an empirical relationship between population growth and economic growth, see Darrat and Al-Yousif (1999), and inflation and economic growth, see Kremer et.al (2013).

Furthermore, the motivation for the two new threshold variables, population growth and Inflation, has both economic and historical perspectives. The last decades witnessed a surge in research on economic growth and its determinants. One of the frequent questions concerns examining the link between FDI and economic growth in SSA, to check whether FDI benefits growth in SSA. While it is well known that SSA is largely characterized by fragile economic conditions, infrastructure and institutions Alence (2004) relative to their developed counterparts, research so far has not comprehensively investigated whether these economic conditions are associated with a positive or negative FDI–growth relationship. Aseidu (2002) notes that since FDI influences growth, it is germane to know the economic conditions or factors that affect FDI flows to SSA because Africa is different and FDI might be driven by different factors such that policies that have been successful in other economies might be unsuccessful in SSA. Drawing from this intuition, in this paper, we examine how the FDI–growth relationship is influenced by a list of domestic and economic conditions. One such economic condition is the state of domestic inflation. The effect of inflation on growth has been extensively studied in the literature. Kremer (2013) provides argument in support of a negative relationship between inflation and growth in high inflation episodes. Temple (2000) discusses various arguments for the inflation–growth relationship and surveys the empirical literature. Earlier influential studies such Fischer (1993) and Barro (1996) provide an empirical basis for the widely supported negative relationship. Among these studies are Bruno and Easterly (1998) who show that the negative relationship between inflation and growth is due to high inflation episodes.

The evidence that high inflation episodes are the primary source of the negative inflation–growth nexus is particularly interesting in our choice of inflation as a threshold variable because it can also have strong implications for the FDI–growth relationship. The reason for this is that FDI inflows become more difficult when inflation rates are high in SSA, Asiedu (2006), thus altering the FDI-growth nexus. By creating uncertain economic environment and curtailing adequate flow of information on investment projects, high inflation shrinks expected returns on investment; there is more uncertainty in an inflationary environment that leads to policy decisions which could distort the growth benefits of FDI. Thus, the effect of FDI on growth plausibly depends on certain levels of inflation which is the state of domestic inflation. Hence our choice of inflation as a possible threshold variable in the FDI-growth nexus.

The effect of population growth on economic growth is a well-known subject of debate among researchers and has birthed opposing views without an unequivocal empirical support. The Malthusian approach suggests that population growth stifles the economy as a rise in population progressively lessens the amount of resources available to each person, thus shrinking economic growth. However, McNicoll (1984) proposes that population growth is neural and can even influence economic development positively. More recently, Nagarajan (2007) argues compellingly that the classical Malthusian approach ignores a crucial factor, technological advancement, which can enhance the quality and productivity of production factors, and harness population to accelerate rather than stifle growth. Thus, while it is agreed that population growth influences economic growth, the type of influence it has on growth appears to depend on the countries and or periods considered (see Headey and Hodge, (2009) for a comprehensive survey of studies on population and economic growth). Meanwhile, Aziz and Makkawi (2012) study whether the expansive population of developing countries positively influences FDI inflows. They find a positive relationship between FDI and population. The literature however remains unclear on the link between FDI and growth, with some providing evidence that FDI on its own might even decelerate growth Alfaro et. Al (2004). Meanwhile, Bloomstrom, Lipsey, and Zejan (1994) have argued that positive effects of FDI on the host economy are not a given and might depend on a variety of factors. Population growth may well be one of such factors because if population growth influences FDI, it could also influence, indirectly, the relationship between FDI and economic growth. On this basis, it is interesting to empirically investigate whether there exists a level of population growth that reveals the type of relations which FDI bears with growth. That is, how high or low must population growth reach for FDI to be growth enhancing? This motivates the choice of population growth as a potential threshold variable. To the best of our knowledge, the analysis of FDI-growth nexus in SSA, as presented in this paper, is new. Therefore, it serves as a contribution to the growth literature.

Our focus on SSA stems from the many peculiarities of the region. For instance, Asiedu (2002) finds that in the context of FDI drivers, SSA is different from its more developed counterparts. More importantly, empirical studies reveal that SSA is characterized by a growing population, and a high average inflation rate that is driven by largely dissimilar monetary policy regimes and macroeconomic policies (see Ndoricimpa (2017)) relative to their more developed counterparts. Thus, it is pertinent to investigate whether these characteristics sabotage the sole aim of attracting FDI which is to boost inclusive growth and catalyse economic development and prosperity in SSA. The findings of our study would be useful to African policymakers as they decide on policies to adopt in order to maximize the growth benefits of FDI in a yet-to-be developed macroeconomic environment that hallmarks SSA economies.

We perform both a threshold and a non-threshold analysis. Our empirical results for the non-threshold analysis suggest that the direct effects of FDI on growth are largely conflicting, mixed, ambiguous and inconsistent. Nevertheless, FDI affects growth indirectly when it interacts with human capital to generate a positive effect on growth, and this is among the few more robust results in the non-threshold analysis section. Moreover, the effects are statistically significant. The sometimes-conflicting results and the need to determine whether there are certain levels/thresholds of domestic macroeconomic variables or absorptive capacities that suggest the type of relationship that FDI would bear with growth in SSA motivate us to perform a threshold regression analysis using the threshold models of Hansen (1999) and Carner and Hansen (2004). Accordingly, turning to results of the main analysis, which is the threshold regression analysis of FDI-growth nexus in

SSA, we find that FDI accelerates economic growth when SSA countries have achieved certain threshold levels of inflation, population growth and financial markets development, and this evidence is largely invariant and robust even after the consideration of endogeneity. In particular, FDI enhances growth in SSA when inflation and private sector credit are below their threshold levels, and population growth is above its threshold level. Until these are achieved, the benefits of FDI might either be non-existent or not fully harnessed. For the rest threshold variables, the results are not robust as findings are quite sensitive to assumptions on FDI. Our evidence of a threshold effect of population growth in the FDI-growth nexus is a revealing highlight because the role of population growth in the FDI-growth relation has hardly ever been investigated in the literature. In all, this paper proposes that FDI, on its own, has mixed effects and might not necessarily spur growth; however, it can be growth-enhancing when domestic macroeconomic indicators are at benign levels. Thus, FDI does not enhance SSA economic growth in isolation, it does so in the presence of important domestic catalysts and the absence of these benign domestic factors, collectively known as domestic absorptive capacities, could limit the potential benefits of FDI. This perspective surpasses the traditional view that exclusively promotes foreign capital as a major recipe for growth without considering the state of the domestic economy. The rest of the paper is structured as follows. The second section briefly presents the threshold models for the empirical analysis. The next section presents a description of the data and methodology and discusses empirical results while the last section concludes.

1.2 The Threshold Model

The exposition of the model provided in the next sections and subsections is largely in the spirit of Ibhagui and Olokoyo (2018). The model comprises dependent, threshold and control variables as well as a focus regressor – FDI. In general, different forms of threshold regression models are possible. However, in this analysis, we consider 2 specific forms: A) focus regressor, threshold and control variables are all exogenous and B) focus regressor is endogenous while threshold and control variables are exogenous. These forms of threshold regression models are due to Hansen (1999) and Caner and Hansen (2004). A brief general presentation is detailed in the subsections below.

1.2.1 A) Exogenous Threshold Variable, Focus Regressor and Control Variables

As in Hansen (1999), we consider a scenario where the focus regressor, control and threshold variables are exogenous components of the threshold model. This implies they affect the model, but are unaffected by the model and do not bear relationships with the error term. In growth regressions, such threshold models exclude regressors, control and threshold variables that correlate with the error term or are affected by growth. To this end, consider the structural threshold regression model

$$y_{it} = \beta_1' x_{it} I(q_{it} \leq \gamma) + \beta_2' x_{it} I(q_{it} > \gamma) + v_{it}, \tag{1.1}$$

where $v_{it} = \mu_i + e_{it}$

The observed data samples are drawn from a panel $\{y_{it}, q_{it}, x_{it}: 1 \leq i \leq n, 1 \leq t \leq T\}$, where i and t represent country and time indexes respectively, x_{it} is a set of regressors containing the focus regressor and control variables while q_{it} is the threshold variable which is assumed to follow a continuous distribution.

If the panel is balanced, then data samples are observed for the same years across all countries. In addition, total sample size equals $N = nT$, where n represents the number of countries in the sample and T is the number of years with available observations in each country i. However, if the panel is unbalanced, then each country's data samples are not necessarily observed in the same years and ∃ a pair of countries (i, j) such that $T_i \neq T_j$. In such instance, total sample size is given as $N = \sum_{i=1}^{n} \mathrm{T_i}$, where T_i is the number of years with observable or available sample points in country i. In our application of a threshold analysis, the panel estimated is balanced.

The above structural equation can be written as

$$y_{it} = \mu_i + \beta_1' x_{it} I(q_{it} \leq \gamma) + \beta_2' x_{it} I(q_{it} > \gamma) + e_{it} \tag{1.2}$$

where y_{it} is a real-valued scalar variable, x_{it} is an $m \times 1$ vector of regressors, q_{it} is a scalar threshold variable, with $Dim(y_{it}) = Dim(q_{it})$, γ is the unobserved threshold value which needs to be estimated, β_1' and β_2' are vectors of slope parameters associated with the two different regimes $A = \{q_{it} \mid (q_{it} \leq \gamma)\}$ and $B = \{q_{it} \mid (q_{it} > \gamma)\}$ and $I(.)$ is the indicator function defined for an arbitrary element d in a set $A \cup B$ as

$$I(d) = \begin{cases} 1 & d \in A \cup B \\ 0 & otherwise \end{cases} \tag{1.3}$$

where $A = \{q_{it} \mid (q_{it} \leq \gamma)\}$, $B = \{q_{it} \mid (q_{it} > \gamma)\}$ and $A \cap B = \emptyset$ since A and B are disjoint. The vector of regressors x_{it} contains both the focus regressor and control variables, both of which are assumed exogenous.

From above, two scenarios are possible, depending on whether $d \in \{q_{it} \mid (q_{it} \leq \gamma)\}$ or $d \in \{q_{it} \mid (q_{it} > \gamma)\}$. This yields the two different regimes as given below

$$y_{it} = \begin{cases} \mu_i + \beta_1' x_{it} + e_{it} & q_{it} \leq \gamma \\ \\ \mu_i + \beta_2' x_{it} + e_{it} & q_{it} > \gamma \end{cases}. \tag{1.4}$$

An alternative representation of the structural equation is obtained when both regimes are written compactly, so that the slope parameters are set in a row vector, while the regressors and thresholds are represented in a column vector, i.e.

$$y_{it} = \mu_i + (\beta_1' \ , \ \beta_2') \begin{pmatrix} x_{it} I(q_{it} \leq \gamma) \\ \\ x_{it} I(q_{it} > \gamma) \end{pmatrix} + e_{it} \tag{1.5}$$

$$y_{it} = \mu_i + \beta' x_{it}(\gamma) + e_{it}, \tag{1.6}$$

where $\beta = (\beta_1' \ , \ \beta_2')'$ and $x_{it}(\gamma) = \begin{pmatrix} x_{it}I(q_{it} \leq \gamma) \\ x_{it}I(q_{it} > \gamma) \end{pmatrix}$.

The observations from the data samples are divided into two regimes – 1) when the threshold variable is at most its threshold value, i.e. $q_{it} \leq \gamma$, and 2) when the threshold variable is above its threshold value, i.e. $q_{it} > \gamma$. The slopes β_1 and β_2 associated with regimes 1 and 2 are then estimated. For identification of β_1 and β_2, it is required that both x_{it} and q_{it} are time variant, otherwise β_1 and β_2 would largely be indistinguishable.

Notice that the error component v_{it} has been split into two parts $v_{it} = \mu_i + e_{it}$, where e_{it} is assumed to be an independent and identically distributed (iid) zero mean idiosyncratic random disturbance with constant and finite variance σ^2 (homoscedasticity) i.e. $e_{it} \sim iid\ N(0, \sigma^2)$. The iid assumption requires that the regressors x_{it} and threshold variable q_{it} exclude endogenous variables, which can correlate with the error term. Thus, e_{it} is is a martingale difference sequence $\{e_{it}, \mathcal{F}_t\}$ on the probability space $(\Omega, \mathcal{F}, \mathbb{P})$ for each i since $\mathbb{E}\,(e_{it}) = 0 < \infty$ and $\mathbb{E}\,(e_{it} |\, \mathcal{F}_{t-1}) = 0$, where $\mathcal{F}_t$ is a natural filtration at time t. Similarly, $\mathbb{E}\,(e_{it}|q_{it}) = \mathbb{E}\,(e_{it}|x_{it}) = 0$ and (x_{it}, q_{it}) are measurable with respect to $\mathcal{F}_{t-1}$, i.e. $(x_{it}, q_{it}) \in \mathcal{F}_{t-1}$, where $\mathcal{F}_{t-1}$ is the sigma field generated by $\aleph = \{x_{(i-j)t}, q_{(i-j)t}, e_{(i-1-j)t}: j \geq 0\}$.

These assumptions imply that results obtained cannot be extended to models with endogenous regressors and/or heteroscedastic and serially correlated errors. Meanwhile, μ_i constitutes countries' unobserved time invariant fixed effects that should be eliminated due to a likely correlation with the regressors.

1.2.2 Method of Estimation

The first step is to eliminate the country specific effect, μ_i. Several methods have been proposed in the literature, notable among them are the forward and backward orthogonal deviations of Arellano and Bover (1995) and fixed effects transformations. Thus, it is sufficient to eliminate μ_i using the fixed effects (within) transformation, for instance, wherein contemporaneous observations are subtracted from the within group average for each variable. The backward and forward orthogonal transformations also work well, especially in instances where there is a need to minimize gaps in unbalanced panels and ensure assumptions on the original structural model are preserved. There is also the first difference transformation, but it is not popular in the context of threshold analysis as it magnifies gaps in unbalanced panels, causes a negative serial correlation of the transformed error term and consequently violates the distributional assumptions of Hansen (1999) because, unlike the fixed effects transformation, the matrix resulting from its transformed error terms is not idempotent, making serial correlation an issue. Idempotency weakens the negative effects of serial correlation on estimated coefficients, Hansen (1999).

In contrast to the first difference transformation that subtracts immediate previous observations from contemporaneous observations, and the within transformation that subtracts the mean of observations from contemporaneous observations, forward orthogonal transformation subtracts the average of all available future observations from contemporaneous observations. We very briefly describe how the forward orthogonal transformation works in this section and in the next section we present the fixed effects transformation, all within a threshold model.

The forward orthogonal transformation of the structural equation in (1.1) yields

$$y_{it}^{\perp} = \beta' x_{it}^{\perp}(\gamma) + e_{it}^{\perp}, \tag{1.7}$$

where

$$y_{it}^{\perp} = c_{it}\left(y_{it} - \frac{1}{T-t}\sum_{\tilde{t}=t+1}^{T} y_{i\tilde{t}}\right), e_{it}^{\perp} = c_{it}\left(e_{it} - \frac{1}{T-t}\sum_{\tilde{t}=t+1}^{T} e_{i\tilde{t}}\right) \text{ and } \beta' = (\beta_1', \beta_2') \tag{1.8}$$

and

$$\mathrm{x}_{\mathrm{it}}^{\perp}(\gamma) = \mathrm{c}_{\mathrm{it}}\begin{pmatrix} \mathrm{x}_{\mathrm{it}}\mathrm{I}(\mathrm{q}_{\mathrm{it}} \leq \gamma) - \dfrac{1}{\mathrm{T}-\mathrm{t}}\displaystyle\sum_{\tilde{\mathrm{t}}=\mathrm{t}+1}^{\mathrm{T}} \mathrm{x}_{\mathrm{i}\tilde{\mathrm{t}}}\mathrm{I}(\mathrm{q}_{\mathrm{it}} \leq \gamma) \\ \mathrm{x}_{\mathrm{it}}\mathrm{I}(\mathrm{q}_{\mathrm{it}} > \gamma) - \dfrac{1}{\mathrm{T}-\mathrm{t}}\displaystyle\sum_{\tilde{\mathrm{t}}=\mathrm{t}+1}^{\mathrm{T}} \mathrm{x}_{\mathrm{i}\tilde{\mathrm{t}}}\mathrm{I}(\mathrm{q}_{\mathrm{it}} > \gamma) \end{pmatrix} \tag{1.9}$$

The scale factor, the term given by $c_{it} = \sqrt{\frac{T-t}{T-t+1}}$, adjusts the differences between the variables and their average future values and helps to preserve homoscedasticity of the error terms.

Let

$$y_i^{\perp} = \begin{pmatrix} y_{i2}^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ y_{iT}^{\perp} \end{pmatrix}, \quad x_i^{\perp}(\gamma) = \begin{pmatrix} x_{i2}^{\perp}(\gamma)' \\ \cdot \\ \cdot \\ \cdot \\ x_{iT}^{\perp}(\gamma)' \end{pmatrix}, \quad e_i^{\perp} = \begin{pmatrix} e_{i2}^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ e_{iT}^{\perp} \end{pmatrix} \tag{1.10}$$

denote the stacked data and errors associated with country i, with one time period deleted as in Hansen (1999).

Furthermore, let $Y^{\perp}, X^{\perp}$ and $\varepsilon^{\perp}$ denote the data stacked over all countries in the usual way of panel estimation,

$$Y^{\perp} = \begin{pmatrix} y_1^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ y_i^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ y_n^{\perp} \end{pmatrix}, \quad X^{\perp}(\gamma) = \begin{pmatrix} x_1^{\perp}(\gamma) \\ \cdot \\ \cdot \\ \cdot \\ x_i^{\perp}(\gamma) \\ \cdot \\ \cdot \\ \cdot \\ x_n^{\perp}(\gamma) \end{pmatrix}, \quad e^{\perp} = \begin{pmatrix} e_1^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ e_i^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ e_n^{\perp} \end{pmatrix}, \tag{1.11}$$

then the threshold regression model in terms of the stacked data is equivalent to

$$Y^{\perp} = X^{\perp}(\gamma)\beta + e^{\perp}. \tag{1.12}$$

The transformed equation preserves all assumptions made in the original structural equation. Thus, for any γ, the slope parameter β can be estimated by least squares, giving

$$\hat{\beta}(\gamma) = \left(X^{\perp}(\gamma)'X^{\perp}(\gamma)\right)^{-1}X^{\perp}(\gamma)'Y^{\perp} \tag{1.13}$$

Once estimated, the vector of regression residuals is obtained from the threshold dependent slope parameter as

$$\hat{e}^{\perp}(\gamma) = Y^{\perp} - X^{\perp}(\gamma)\hat{\beta}(\gamma) = Y^{\perp} - X^{\perp}(\gamma)\left(X^{\perp}(\gamma)'X^{\perp}(\gamma)\right)^{-1}X^{\perp}(\gamma)'Y^{\perp}). \tag{1.14}$$

The regression residual is then used to compute the sum of squared errors as $S_1(\gamma) = \widehat{e^{\perp}}(\gamma)'\widehat{e^{\perp}}(\gamma)$ where

$S_1(\gamma) = Y^{\perp}\left(I - X^{\perp}(\gamma)'\left(X^{\perp}(\gamma)'X^{\perp}(\gamma)\right)^{-1}X^{\perp}(\gamma)'\right)Y^{\perp}$. Since the threshold variables are each exogenous, the threshold value γ, which determines the sample split, can be estimated by least squares in line with Chan (1993) and Hansen (1999). This implies finding γ that minimizes the concentrated sum of squared errors, so that the least squares estimator of γ is $\hat{\gamma} = \underset{\gamma}{\operatorname{argmin}}\ S_1(\gamma)$ [1].

After $\hat{\gamma}$ is obtained, the slope parameter estimate is $\hat{\beta} = \hat{\beta}(\hat{\gamma})$. It is important to note that $\hat{\beta}(\hat{\gamma})$ represents the slope parameters computed at the two different regimes partitioned by $\hat{\gamma}$. Thus, the vector of slopes associated with the regimes $I(q_{it} \le \hat{\gamma})$ and $I(q_{it} > \hat{\gamma})$ are given by $\widehat{\beta_1}$ and $\widehat{\beta_2}$. In this instance, β is consistently estimated using least squares as all variables on the right-hand side of the regression are exogenous and the error term satisfies the usual assumptions.

[1] See Hansen (1999) and Hansen (2000) for details on computing $\hat{\gamma}$

1.2.3 B) Exogenous Threshold and Control Variables, Endogenous Focus Regressor

In this subsection, we present the Caner and Hansen (2004) derivation of a consistent estimate of β in the case where the threshold variable q_{it} and control variables are exogenous, but focus regressor x_{it} is endogenous. In this scenario, there is a need for an estimation technique that allows for endogenous regressors as this helps avoid asymptotic biasedness and inconsistency which usually occur when endogeneity is fully ignored.

Here, the observed sample is $\{y_{it}, Z_{it}, x_{it}: 1 \leq i \leq n, 1 \leq t \leq T\}$, where y_{it} is real valued. Recall that unlike the previous case (A) where x_{it} is used to represent both the control variables and regressor(s) of interest, here we distinguish between Z_{it}, an m-vector of control variables, and x_{it}, a k-vector of regressors, with $m \geq k$, in order to emphasize that x_{it} represents the endogenous regressor of interest or contains at least one endogenous regressor. The threshold variable q_{it} is an element or function of the vector of control variables Z_{it} and has a continuous distribution. The threshold regression model is

$$y_{it} = \mu_i + \beta_1' x_{it} I(q_{it} \leq \gamma) + \beta_2' x_{it} I(q_{it} > \gamma) + e_{it,} \tag{1.15}$$

where all variables are as defined, but x_{it} now contains at least one variable that is endogenous in the model. As before, the threshold parameter γ is assumed unknown and needs to be estimated. Estimate of the threshold parameter γ is obtained from the data samples of the threshold variable q_{it}, so that $\gamma \in \Gamma$ where Γ is a strict subset of the support of q_{it}. By definition, the support of q_{it}, denoted by $R_{q_{it}}$, is the set of all values that q_{it} can take. As $\gamma \in \Gamma$, where $\Gamma \subset R_{q_{it}}$, it follows that $\gamma \in R_{q_{it}}$, where $R_{q_{it}} = [min\, q_{it}, max\, q_{it}]$. Thus, $\gamma \in [min\, q_{it}, max\, q_{it}]$. In other words, the threshold parameter takes values between the least and greatest values of the threshold variable. Depending on the value of q_{it}, the model allows the regime-dependent slope parameters β_1 and β_2 to be different. This difference, denoted by $\delta_n = \beta_2 - \beta_{1,}$ is the magnitude of the threshold effect. The magnitude of threshold effect is taken as asymptotically small, so that $\delta_n \rightarrow 0$ as n$\rightarrow \infty$.

As before, e_{it} is a martingale difference sequence and $\mathbb{E}\,(e_{it} |\, \mathcal{F}_{t-1}) = 0$. Moreover, q_{it} remains exogenous and measurable with respect to $\mathcal{F}_{t-1}$, the sigma field generated by $\aleph = \{Z_{(i-j)t}, q_{(i-j)t}, e_{(i-1-j)t}: j \geq 0\}$, where $q_{it} \in \aleph$, so that $\mathbb{E}\,(e_{it} |\, q_{it}) = 0$. However, x_{it} is now endogenous, which means its measurability with respect to $\mathcal{F}_{t-1}$ is no more assumed and $\mathbb{E}\,(e_{it} | x_{it}) \neq 0 \;\exists\; x_{it}$. This means employing previous estimation method, where regressors, control variables and threshold variable are exogenous, would no more yield consistent estimates, suggesting a new method of estimation is required.

1.2.4 Method of Estimation

To address endogeneity of x_{it}, the first step is to estimate a reduced form model which is a function of instrumental variables. Suppose the instruments are denoted by the notation z_{it}. For each country i across time t, the reduced form model is the conditional expectation of x_{it} given z_{it}, i.e.

$$x_{it} = \varphi(z_{it}, \theta) + \pi_{it}, \tag{1.16}$$

in which $\mathbb{E}(\pi_{it} \mid z_{it}) = 0$. The function $\varphi(z_{it}, \theta)$ is presumed known; however, the vector θ must be estimated in order to determine the predicted value of x_{it}, the endogenous variable. We take $\varphi(z_{it}, \theta)$ to be linear, defined as $\varphi(z_{it}, \theta) = \theta' z_{it}$. Thus, the reduced form model can be written as

$$x_{it} = \theta' z_{it} + \pi_{it}, \tag{1.17}$$

which is a linear regression with regressors being the instruments which can be internal or external.

The model parameters are estimated in stages. First, least squares technique is used to estimate the parameter θ of the reduced form model. The estimated parameter $\widehat{\theta}$ of the reduced form model is then used to determine the predicted values $\widehat{x_{it}}$ of the endogenous regressor, x_{it}. Second, the threshold parameter γ is estimated. To do this, the endogenous regressor x_{it} is replaced with its predicted values, $\widehat{x_{it}}$. Following this, country specific fixed effects μ_i are eliminated and least squares method is used to determine $\widehat{\gamma}$, the estimate of threshold value γ. Finally, the estimated threshold value is used to split the data samples into 2 regimes — one in which the threshold variable q_{it} exceeds the estimated threshold value $\widehat{\gamma}$ and another in which the threshold variable q_{it} equals or falls below the estimated threshold value $\widehat{\gamma}$. Once split, the slope parameters associated with each regime are estimated. This is the fixed effects two stage least squares (FE2SLS). Without loss of generality, it can also be the forward orthogonal two stage least squares (FOD2SLS) if the forward orthogonal, rather than the fixed effects, transformation is used. The process of the FE2SLS is detailed below.

a. Reduced Form Estimation

The parameters θ of the reduced form equation $x_{it} = \theta' z_{it} + \pi_{it}$, are estimated by least squares. Once $\widehat{\theta}$ is determined, the predicted values of x_{it} are determined as $\widehat{x_{it}} = \varphi\left(z_{it}, \widehat{\theta}\right) = \widehat{\theta}' z_{it}$.

b. Threshold Value Estimation

After successful estimation of the parameters and predicted values associated with the reduced form equation, the next step is estimation of the threshold value γ in the structural equation. To do this, we estimate γ from the transformed threshold regression model. Before beginning the estimation, we apply fixed effects transformation to the threshold regression model and replace $x_{it}^{+}(\gamma)$ in the transformed equation with its estimated value $\hat{x}_{it}^{+}(\gamma)$. This yields

$$y_{it}^{+} = \beta' \hat{x}_{it}^{+}(\gamma) + e_{it}^{+}, \tag{1.18}$$

where

$$\hat{x}_{it}^{+}(\gamma) = \begin{pmatrix} \hat{x}_{it} I(q_{it} \leq \gamma) - \dfrac{1}{T} \displaystyle\sum_{t=1}^{T} \hat{x}_{i\tilde{t}} I(q_{it} \leq \gamma) \\ \hat{x}_{it} I(q_{it} > \gamma) - \dfrac{1}{T} \displaystyle\sum_{t=1}^{T} \hat{x}_{i\tilde{t}} I(q_{it} > \gamma) \end{pmatrix}. \tag{1.19}$$

For any γ, let Y^{+}, $\widehat{X_1^{+}}$ and $\widehat{X_2^{+}}$ denote the matrices of stacked vectors y_i^{+}, $x_i^{+} I(q_i \leq \gamma)$ and $x_i^{+} I(q_i > \gamma)$ respectively, where y_i^{+}, x_i^{+}, and e_i^{+} and Y^{+}, $\widehat{X_1^{+}}$ and $\widehat{X_2^{+}}$ are as defined as

$$y_i^{\perp} = \begin{pmatrix} y_{i2}^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ y_{iT}^{\perp} \end{pmatrix}, \quad x_i^{\perp}(\gamma) = \begin{pmatrix} x_{i2}^{\perp}(\gamma)' \\ \cdot \\ \cdot \\ \cdot \\ x_{iT}^{\perp}(\gamma)' \end{pmatrix}, \quad e_i^{\perp} = \begin{pmatrix} e_{i2}^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ e_{iT}^{\perp} \end{pmatrix} \tag{1.20}$$

and

$$Y^{\perp} = \begin{pmatrix} y_1^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ y_i^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ y_n^{\perp} \end{pmatrix}, \quad \widehat{X_1^{\perp}} = \begin{pmatrix} x_1^{\perp}\big(I(q_1 \le \gamma)\big)' \\ \cdot \\ \cdot \\ \cdot \\ x_i^{\perp}\big(I(q_i \le \gamma)\big)' \\ \cdot \\ \cdot \\ \cdot \\ x_n^{\perp}\big(I(q_n \le \gamma)\big)' \end{pmatrix}, \widehat{X_2^{\perp}} = \begin{pmatrix} x_1^{\perp}\big(I(q_1 > \gamma)\big)' \\ \cdot \\ \cdot \\ \cdot \\ x_i^{\perp}\big(I(q_i > \gamma)\big)' \\ \cdot \\ \cdot \\ \cdot \\ x_n^{\perp}\big(I(q_n > \gamma)\big)' \end{pmatrix} \quad e^{\perp} = \begin{pmatrix} e_1^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ e_i^{\perp} \\ \cdot \\ \cdot \\ \cdot \\ e_n^{\perp} \end{pmatrix}, \tag{1.21}$$

The transformed equation can thus be written in matrix form as,

$$Y^{\perp} = \beta_1'\widehat{X_1^{\perp}} + \beta_2'\widehat{X_2^{\perp}} + e^{\perp} \tag{1.22}$$

The regression parameters are $(\beta_1, \beta_2, \gamma)$ and given the previous transformations, the natural estimators of these parameters are obtained by least squares. Let $S_n(\beta_1, \beta_2, \gamma) = \big(Y^{\perp} - \beta_1'\widehat{X_1^{\perp}} - \beta_2'\widehat{X_2^{\perp}}\big)'\big(Y^{\perp} - \beta_1'\widehat{X_1^{\perp}} - \beta_2'\widehat{X_2^{\perp}}\big)$ be the sum of squared errors function. By definition, the least squares estimators $\widehat{\beta_1}$, $\widehat{\beta_2}$ and $\hat{\gamma}$ together minimizes $S_n(\beta_1, \beta_2, \gamma)$, where γ is assumed restricted to the closed and bounded set $\left[\underline{\gamma},\ \overline{\gamma}\right] = \Gamma$ of threshold values. To estimate γ, it is computationally easiest and more convenient to obtain the least squares estimates through concentration. Concentration implies conditioning on γ in order to obtain estimates of the slope parameters at the given/conditional value which is concentrated on γ. Since the matrix equation is linear in β_1 and β_2 when conditioned on γ, it follows that the conditional least squares estimators of β_1 and β_2, i.e. $\widehat{\beta_1}(\gamma), \widehat{\beta_2}(\gamma)$ are obtained via regressing $Y^{\perp}$ on $\widehat{X^{\perp}} = \left[\widehat{X_1^{\perp}}, \widehat{X_2^{\perp}}\ \right]$. These conditional least squares estimators, which are a function of γ, are substituted into the sum of squared errors function to obtain a concentrated sum of squared errors function that is a function of γ, i.e.,

$$S_n\big(\widehat{\beta_1}(\gamma), \widehat{\beta_2}(\gamma), \gamma\big) = S_n(\gamma) = Y'Y - Y'X^{\perp}(X^{\perp\prime}X^{\perp})^{-1}X^{\perp\prime}Y \tag{1.23}$$

and $\widehat{\gamma}$, the estimate of the threshold value $\gamma \in \Gamma$, is the minimizer of $S_n(\gamma)$, i.e. $\hat{\gamma} = \underset{\gamma}{\operatorname{argmin}}\ S_n(\gamma)$.

c. Slope Estimation

Once the estimate $\hat{\gamma}$ of the threshold value γ is obtained, the data sample is partitioned into two regimes, based on whether the threshold variables are more or less than the corresponding estimates of their threshold values. The final slope parameters β_1 and

β_2 associated with the regimes $I(q_i \leq \hat{\gamma})$ and $I(q_i > \hat{\gamma})$ are then estimated, giving $\widehat{\beta_1} = \widehat{\beta_1}(\hat{\gamma})$ for $I(q_i \leq \hat{\gamma})$ and $\widehat{\beta_2}(\hat{\gamma})$ for $I(q_i > \hat{\gamma})$.

1.3 Data Samples and Empirical Methodology

This section describes data and methodology used in the empirical analysis. The data samples comprise FDI and economic growth as well as the threshold and control variables. In the empirical set up, there are 1) six threshold variables – initial income, human capital, trade openness, financial market development, inflation and population growth; 2) eight control variables which consist of government consumption, domestic investment, and the threshold variables and 3) one focus regressor (FDI) and one dependent variable (growth).

1.3.1 Data and Variables

Data samples used in the empirical analysis are obtained from secondary sources such as the World Bank, Penn World, and International Financial Statistics (IFS). The data samples are gathered for 45 Sub-Saharan African countries from 1985 – 2013. The overall mean economic growth rate across countries from 1985-2013 is 4.42% while for FDI it is 3.97%. Economic growth ranges from -51.03% to 149.97% while FDI ranges from -82.89% to 161.82%. Over these years across SSA, Equatorial Guinea recorded the highest net FDI inflows (as a % of GDP) of 161.82% in 1996 while Liberia has the least net FDI inflows (as a % of GDP) of -82.89% in 1996. In the same way, Equatorial Guinea recorded the fastest growth rate of 149.97% in 1997 while Liberia recorded the least growth rate of -51.03% in 1990. The summary statistics are presented below.

Table 1.0: Summary Statistics

	Mean	Std. Dev	Maximum	Minimum
Growth	4.42	9.47	149.97	-51.03
FDI	3.97	10.02	161.82	-82.89
Initial income[2]	2.78	0.46	4.37	1.81
Human capital[1]	0.86	0.05	0.95	0.00
Domestic investment[2]	1.29	1.32	47	-0.53
Government consumption[2]	1.14	0.21	1.84	0.31
Inflation[1]	0.76	0.60	4.38	-1.51
Trade openness[2]	1.81	0.23	2.73	1.03
Financial development[2]	1.07	0.37	2.03	-0.81

1. Included as Log (1+ variable)
2. Included as Log (variable)

Rather than gross FDI inflows, net FDI inflows (as a % of GDP) are used as a measure of FDI as is common in the literature while growth rate of real GDP per capita in constant dollars measures economic growth. This growth measure is more favourable because it considers output-driven economic growth that excludes changes in prices. Inflation, as measured by changes in consumer price index (CPI), represents macroeconomic stability while trade openness is the sum of visible exports and imports (as a % of GDP). We use domestic credit to private sector as a measure of financial market development because bank credits are the major source of financing for most SSA countries given that other sources of short or long term financing are either non-existent or largely inadequate. For instance, many SSA countries have underdeveloped or non-existent debt or bond capital markets and the insufficient number of available observations for equity market indicators reflects the unavailability of functional equity capital markets in most SSA countries and further proves the heavy reliance on bank credits in the region. Development of the credit market or financial market development is represented by private sector credit which equals domestic credit to the private sector (as a % of GDP). Other variables such as human capital, population growth, government expenditure and initial income level are measured by average secondary schooling years, yearly percentage change in population, government consumption (as a % of GDP) and real per capita GDP, respectively. Table 1.1 shows the net FDI inflows averaged over the sample period for each country and the corresponding average growth. The magnitude of the implied FDI multiplier shows the amount of growth that is driven by sources other than FDI. It is highest in Burundi (16.67x) and least in Liberia (0.19x). This indicates that, on average and in comparison, with other SSA countries represented in our sample, a larger portion of the observed growth is attributed to FDI in Liberia while sources other than FDI drive a larger portion of the observed growth in Burundi.

Table 1.1 – Average FDI and growth for SSA countries, 1985 – 2013

S/N	Country	FDI/GDP (%)	Growth (%)	Implied FDI multiplier (x)
1	Angola	5.66	5.74	1.01
2	Burundi	0.12	2.00	16.67
3	Benin	1.59	4.02	2.53
4	Burkina Faso	0.62	5.42	8.74
5	Botswana	2.81	5.91	2.10
6	Central Africa Rep	1.02	1.13	1.11
7	Ivory Coast	1.4	2.07	1.48
8	Cameroon	1.13	2.04	1.81
9	Congo, Democratic	2.32	0.52	0.22
10	Congo, Republic	9.12	2.41	0.26
11	Comorous	0.95	2.08	2.19
12	Djibouti	5.35	1.56	0.29
13	Eritrea	4.17	35.8	8.59
14	Ethiopia	1.89	5.62	2.97
15	Gabon	0.86	2.17	2.52
16	Ghana	2.98	5.59	1.88
17	Guinea	2.77	3.46	1.25
18	Guinea-Bissau	1.28	2.34	1.83
19	Equatorial Guinea	23.96	18.75	0.78
20	Kenya	0.55	3.83	6.96
21	Liberia	22.52	4.21	0.19
22	Lesotho	8.68	4.16	0.48
23	Madagascar	3.06	2.32	0.76
24	Mali	2.37	3.91	1.65
25	Mozambique	6.82	6.34	0.93
26	Mauritania	6.93	2.08	0.30
27	Mauritius	1.68	5.02	2.99

28	Malawi	1.59	3.79	2.38
29	Namibia	3.43	3.92	1.14
30	Niger	2.81	3.55	1.26
31	Nigeria	3.46	4.85	1.40
32	Rwanda	0.73	4.96	6.79
33	Sudan	2.39	4.01	1.68
34	Senegal	1.37	3.3	2.41
35	Sierra Leone	2.16	2.09	0.97
36	Somalia	-0.21	2.40	-12.00
37	Swaziland	3.99	4.40	1.10
38	Seychelles	9.39	4.13	0.44
39	Chad	5.32	6.22	1.17
40	Togo	2.04	2.81	1.38
41	Tanzania	3.15	5.25	1.67
42	Uganda	2.96	6.15	2.08
43	South Africa	1.07	2.38	2.22
44	Zambia	4.71	4.19	0.89
45	Zimbabwe	1.07	1.12	1.05

For Somalia, data samples less than others due to shorter time.

1.3.2 Empirical Methodology

In each model, the dependent variable is growth, and the focus regressor is FDI. There are six threshold variables, selected from the set of control variables, which give rise to a total of 6 panel threshold regression models that are each estimated to determine the FDI-growth nexus that exists for a given threshold variable. The 6 threshold regression models are:

$$y_{it} = \begin{cases} \mu_i + \beta_1^r FDI_{it}\boldsymbol{I}(r_{it} \leq \gamma^r) + \beta_2^r FDI_{it}\boldsymbol{I}(r_{it} > \gamma^r) + \phi^r C_{it} + \varepsilon_{it}^r \\ \mu_i + \beta_1^{\tilde{o}} FDI_{it}\boldsymbol{I}(\tilde{o}_{it} \leq \gamma^{\tilde{o}}) + \beta_2^{\tilde{o}} FDI_{it}\boldsymbol{I}(\tilde{o}_{it} > \gamma^{\tilde{o}}) + \phi^{\tilde{o}} C_{it} + \varepsilon_{it}^{\tilde{o}} \\ \mu_i + \beta_1^s FDI_{it}\boldsymbol{I}(s_{it} \leq \gamma^s) + \beta_2^s FDI_{it}\boldsymbol{I}(s_{it} > \gamma^s) + \phi^s C_{it} + \varepsilon_{it}^s \\ \mu_i + \beta_1^h FDI_{it}\boldsymbol{I}(h_{it} \leq \gamma^h) + \beta_2^h FDI_{it}\boldsymbol{I}(h_{it} > \gamma^h) + \phi^h C_{it} + \varepsilon_{it}^h \\ \mu_i + \beta_1^{\tilde{d}} FDI_{it}\boldsymbol{I}(\tilde{d}_{it} \leq \gamma^{\tilde{d}}) + \beta_2^{\tilde{d}} FDI_{it}\boldsymbol{I}(\tilde{d}_{it} > \gamma^{\tilde{d}}) + \phi^{\tilde{d}} C_{it} + \varepsilon_{it}^{\tilde{d}} \\ \mu_i + \beta_1^{\tilde{g}} FDI_{it}\boldsymbol{I}(\tilde{g}_{it} \leq \gamma^{\tilde{g}}) + \beta_2^{\tilde{g}} FDI_{it}\boldsymbol{I}(\tilde{g}_{it} > \gamma^{\tilde{g}}) + \phi^{\tilde{g}} C_{it} + \varepsilon_{it}^{\tilde{g}} \end{cases} \tag{1.24}$$

where $i = 1, \ldots, n$ represents individual countries, $t = 1, \ldots., T$ represents time period, μ_i is the time invariant country-specific fixed effect, y_{it} represents economic growth, ε_{it}^a is the error term associated with the threshold regression model generated by threshold variable a, where $a = r, \tilde{o}, s, h, \tilde{d}$ and $\tilde{g}$ and $\boldsymbol{I}(.)$ is the indicator function. The threshold variables are initial income (r_{it}), trade openness ($\tilde{o}_{it}$), inflation (s_{it}), human capital (h_{it}), financial markets development ($\tilde{d}_{it}$) and population growth ($\tilde{g}_{it}$). To estimate the model, each equation is divided into two different groups – one where the threshold variable exceeds the threshold value and another in which the threshold variable falls below the threshold value. On this basis, data samples are also split into two groups. The slope coefficients associated with each group are then determined. The a priori expectation for each of the threshold parameters is as follows: FDI is expected to accelerate (weaken) growth when inflation and population growth are below (above) their estimated threshold levels; FDI is expected to strengthen (decelerate) growth when trade openness, initial income, financial market development and human capital are above (below) their estimated threshold values. The subsamples that are obtained when each threshold variable is more (less) than its estimated threshold value represents the high (low) regime. In other words, the low and high regimes, a classification due to Hansen (1999), represent the split samples based on the estimated threshold values. They signify the subsamples obtained when the observed threshold variables are below and above their estimated threshold values.

In this paper, we aim to analyze the FDI-growth nexus via estimating, comprehensively, the six panel threshold models in (1.24) using the techniques of Hansen (1999) and Caner and Hansen (2004). As previously motivated, two scenarios will be considered – 1) when FDI is exogenous and 2) when it is endogenous. In general, in a threshold regression model with endogenous regressors, the endogenous explanatory variables and appropriate instruments need to first be identified. Then a reduced form regression for the endogenous explanatory variables as a function of the instruments is estimated. This is estimated to obtain the predicted values of the endogenous independent variables. The original endogenous variables are then replaced in the structural equation by their predicted values to give a new set of panel threshold regression models. Next is the least squares estimation of each of the new panel threshold regression models for a fixed threshold value γ^a, for $a = r, \tilde{o}, s, h, \tilde{d}$ and $\tilde{g}$. The estimated slope coefficients are then used to compute the sum of squared residuals, denoted by $S(\gamma^a)$. Several values of $S(\gamma^a)$ are computed for a strict subset of the support of each threshold variable in each equation. The estimator $\widehat{\gamma^a}$ of each threshold value γ^a is then selected from the support. This is the value that minimizes $S(\gamma^a)$.

Following Hansen (2000) and Caner and Hansen (2004), the critical values used to obtain the 95% confidence interval of the threshold value are given by $\Gamma = \{\gamma^a : LR(\gamma^a) \leq c(\alpha)\}$, where $c(\alpha)$ is the 95% percentile of the asymptotic distribution of the likelihood ratio statistic – $LR(\gamma^a)$. Once $\widehat{\gamma^a}$ is determined, the data samples are split into two regimes for each of the six panel threshold regression models and the slope coefficients associated with each regime are estimated.

1.4 Empirical Results

1.4.1 Growth and FDI, no thresholds (non-threshold analysis)

Although our main purpose in this paper is to perform a threshold regression analysis of FDI-growth nexus in SSA, as a starting exercise we begin with a comprehensive non-threshold analysis of the relationship between FDI and growth in SSA. By employing empirical specifications similar to Mankiw et al. (1992) and Alfaro et al. (2004), we look at the direct effects of FDI on economic growth in SSA. Following this, we examine the financial markets channel through which FDI influences growth in SSA. To do this, we interact FDI with financial markets and use the resulting interaction term as a regressor to determine the significance of financial markets in unlocking the growth benefits associated with FDI inflows in SSA. To ensure the interaction term does not proxy for FDI or the level of financial markets development in SSA, we follow Alfaro et al. (2004) and include both FDI and financial market development as standalone regressors. From these, the two regression models, as well as their estimated values, are presented below

$$\mathrm{Growth}_{\mathrm{it}}^{1} = \mu_i + \beta_1 \log(\mathrm{INITIAL\ GDP}_{it}) + \beta_2 \mathrm{FDI}_{\mathrm{it}} + \beta_3 \mathrm{FMD}_{\mathrm{it}} + \beta_4 \mathrm{CONTROLS}_{\mathrm{it}} + \varepsilon_{it} \tag{1.25}$$

$$\mathrm{Growth}_{\mathrm{it}}^{2} = \mu_i + \beta'_1\, \mathrm{FDI}_{\mathrm{it}} + \beta'_2(\mathrm{FDI}_{\mathrm{it}} \times \mathrm{FMD}_{\mathrm{it}}) + \beta'_3 \mathrm{FMD}_{\mathrm{it}} + \beta'_4 \mathrm{CONTROLS}_{\mathrm{it}} + \varepsilon_{it} \tag{1.26}$$

The general linear additive model and multiplicative interaction model associated with the estimated regression models respectively take the forms[2]

$$\widehat{\mathrm{Growth}}_{\mathrm{it}}^{1} = \hat{\beta}_1 \log(\mathrm{INITIAL\ GDP}_{it}) + \hat{\beta}_2 \mathrm{FDI}_{\mathrm{it}} + \hat{\beta}_3 \mathrm{FMD}_{\mathrm{it}} + \hat{\beta}_4 \mathrm{CONTROLS}_{\mathrm{it}} \tag{1.27}$$

$$\widehat{\mathrm{Growth}}_{\mathrm{it}}^{2} = \hat{\beta}_1'\ \mathrm{FDI}_{\mathrm{it}} + \hat{\beta}_2'\ (\mathrm{FDI}_{\mathrm{it}} \times \mathrm{FMD}_{\mathrm{it}}) + \hat{\beta}_3'\ \mathrm{FMD}_{\mathrm{it}} + \hat{\beta}_4'\ \mathrm{CONTROLS}_{\mathrm{it}}, \tag{1.28}$$

where hatted coefficients denote estimated values. The coefficients are estimated using the method of fixed effects.

The presence of the interactive term in the multiplicative interaction linear model alters the interpretation of the estimated coefficients in a fundamental way. The reason is that in the linear additive model, $\mathrm{FDI}_{\mathrm{it}}$ and $\mathrm{FMD}_{\mathrm{it}}$ are taken as independent of one another, whereas in the multiplicative interaction linear model, they are not. In other words, in the linear additive model, the effect of $\mathrm{FDI}_{\mathrm{it}}$ on $\mathrm{Growth}_{\mathrm{it}}^{1}$ is considered the same throughout the data set. In the multiplicative interaction model, this effect depends on the level of domestic financial market development, i.e. the values taken by $\mathrm{FMD}_{\mathrm{it}}$. Thus, $\hat{\beta}_2$ is the unconditional marginal effect of $\mathrm{FDI}_{\mathrm{it}}$ on $\mathrm{Growth}_{\mathrm{it}}^{1}$ while $\hat{\beta}_1'$ is the conditional marginal effect of $\mathrm{FDI}_{\mathrm{it}}$ on $\mathrm{Growth}_{\mathrm{it}}^{2}$ and the condition is that $\mathrm{FMD}_{\mathrm{it}} = 0\ \forall\ i, t$. Also, $\hat{\beta}_3$ is the unconditional marginal effect of $\mathrm{FMD}_{\mathrm{it}}$ on $\mathrm{Growth}_{\mathrm{it}}^{1}$ while $\hat{\beta}_3'$ is the conditional marginal effect of $\mathrm{FMD}_{\mathrm{it}}$ on $\mathrm{Growth}_{\mathrm{it}}^{2}$ and the condition is that $\mathrm{FDI}_{\mathrm{it}} = 0\ \forall\ i, t$.

For the interactive term in the multiplicative interaction model, the parameter $\hat{\beta}_2'$ captures the effect of $\mathrm{FDI}_{\mathrm{it}}$ on $\widehat{\mathrm{Growth}}_{\mathrm{it}}^{2}$ for different values of the modifying variable $\mathrm{FMD}_{\mathrm{it}}$ and allows this effect to vary. The overall conditional marginal effect of $\mathrm{FDI}_{\mathrm{it}}$ on $\widehat{\mathrm{Growth}}_{\mathrm{it}}^{2}$ is thus expressed as

$$\frac{\partial \widehat{\mathrm{Growth}}_{\mathrm{it}}^{2}}{\partial \mathrm{FDI}_{\mathrm{it}}} = \hat{\beta}_1' + \hat{\beta}_2'\ \mathrm{FMD}_{\mathrm{it}} \tag{1.29}$$

This specification is used to compute marginal effects of $\mathrm{FDI}_{\mathrm{it}}$ across different values of the modifying variables, i.e., $\mathrm{FMD}_{\mathrm{it}}$, for given values of $\mathrm{FDI}_{\mathrm{it}}$. Results for the estimated regression models are presented and discussed in subsequent sections.

[2] Note that data samples for $\mathrm{Growth}_{\mathrm{it}}^{1}$ and $\mathrm{Growth}_{\mathrm{it}}^{2}$ are the same. The superscripts are used to denote the discrepancies in the right-hand side of each equation, namely the choice of and differences in regressors. In equations 1.26 and 1.28, the log of initial income (lagged per capita GDP/per capita GDP in the previous period) is included in the controls for space preservation. Notice that β_4 is a vector of coefficients on the controls. In 1.26 and 1.28, it includes the coefficient on initial income.

Table 1.2: Growth and FDI. Dependent variable – growth rate of per capita GDP (equation 1.25)

	(a)	(b)
Initial income	-0.019 (-1.55)	-0.038*** (-3.05)
FDI/GDP	0.131*** (4.58)	0.049 (1.62)
Human Capital	0.052 (0.38)	0.195 (1.43)
Population growth	0.013*** (7.56)	0.012*** (6.50)
Government consumption	-0.051*** (-2.83)	-0.063** (-3.28)
Domestic investment		0.074*** (4.88)
Trade openness		0.074*** (2.95)
Inflation		-0.009* (-1.86)
No. of Observations	1,089	1,001
R^2	0.248	0.272

Notes: Human capital variable is the log of (1+years of secondary schooling), government consumption is the log of (government spending/GDP), domestic investment is log of (domestic investment/GDP), initial income is log of (initial per capita GDP), inflation is log of (1+average inflation rate) and trade openness is the log of (exports+ imports as a share of GDP). Estimates obtained by fixed effects estimation. All regressions report adjusted R^2 and have a constant term; t-values are in parenthesis and statistical significance, wherever achieved, is at 1%, 5%, and 10% level of significance, where * p<.1; ** p<.05; *** p<.0.01.

Table 1.3: Growth and FDI: the role of financial markets development (equation 1.26)

	(a')	(b')
Initial income	-0.023* (-1.85)	-0.038*** (-2.82)
FDI/GDP	0.283*** (3.47)	0.127 (1.45)
(FDI/GDP) × financial markets	-0.183** (-2.03)	-0.092 (-0.95)
Financial markets	-0.016 (-1.19)	-0.033** (-2.25)
Human Capital	-0.030	0.058

	(-0.21)	(0.40)
Population growth	1.455*** (5.98)	1.452*** (5.71)
Government consumption	-0.057*** (-2.70)	-0.065*** (-2.91)
Domestic investment		0.073*** (4.51)
Trade openness		0.079** (2.83)
Inflation		-0.009 (-1.60)
No. of Observations	1,016	931
R^2	0.064	0.141

Notes: All regressions report adjusted R^2 and have a constant term; t-values are in parenthesis and statistical significance, wherever achieved, is at 1%, 5% and 10% levels, where * p<.1; ** p<.05; *** p<.0.01. The financial market variable is private sector credit share of GDP, in logarithm. Human capital variable is the log of (1+years of secondary schooling), government consumption is the log of (government spending/GDP), domestic investment is log of (domestic investment/GDP), initial income is log of (initial per capita GDP), inflation is log of (1+average inflation rate) and trade openness is the log of (exports+ imports as a share of GDP). In the regressions, we specify initial income as in Kremer (2013) as GDP per capital from previous period, in log. Estimates obtained by fixed effects estimation based on Hausman test results.

Table 1.2 presents results of the direct effect of FDI on economic growth in SSA from 1985-2013 based on the regression equation in 1.25. Column (a) shows results for a selection of 4 control variables which include initial income, human capital, population growth and government consumption. For this sample of countries, FDI has a significant impact on growth and the relationship appears to be positive, as shown in Column (a). To check for the robustness of this result, we expand previous control variables to include inflation rate, trade openness and domestic investment, in line with the literature. The result, presented in Column (b), shows a notable reduction in the magnitude and significance of FDI coefficient, implying that the finding in Column (a), which establishes a strongly significant relationship between FDI and economic growth in SSA, is not robust to the inclusion of control variables. This indicates that the direct impact of FDI on growth is weakened when conditions are varied, and controlling for different conditions might alter the degree of significance of the FDI-growth nexus. This result clearly sums up a well-known problem in the analysis of FDI-growth nexus in the empirical growth literature: Although in theory, there is strong evidence to believe that FDI is highly growth-enhancing, this evidence is not always validated empirically. It is this ambiguity - coupled with the roles that different variables play in determining the growth effects of FDI - that forms part of the motivation for the research presented in this paper.

The regression results in Columns (a') and (b') of Table 1.3, based on equation 1.26, show the influence of FDI on growth via private sector credit, the proxy used for financial markets development in SSA. As shown in both Columns (a') and (b'), though FDI appears to bear a positive relationship with growth in SSA, the relationship is not robust. The main result, however, is that the interaction term turns out to impact growth negatively, which seems to imply that financial markets development, when interacted with FDI and used as a regressor to check for the role of financial markets in enhancing the positive externalities associated with FDI flows, does not necessarily enhance the growth effects of FDI in SSA. This conclusion is however not robust in significance. It changes from being significant, at the 5% level, to insignificant, at the same level, when additional macroeconomic variables controlled for.

Compared with the existing empirical growth literature, the result ties in with Hsu and Wu (2009) who find the coefficient of the interaction term to be negative, concluding that the growth of economies with better-developed financial markets does not necessarily benefit positively from FDI. In other words, sufficiently developed (credit) financial markets may not release the positive effects of FDI on growth. On the other hand, the result is at variance with previous findings such as Hermes and Lensink (2003) and Alfaro et.al (2004) who show that a positive and significant relationship exists between growth and the interaction of FDI and financial markets development. The result also shows that a strong private sector credit can be negative on growth, though the significance is not robustly established on all fronts. Similar conclusion was reached in Alfaro et.al (2004) who find that financial market indicators by themselves have insignificant negative effects on growth when the financial market indicators are non-stock market variables such as private sector credit. Nevertheless, as the current analysis concentrates on SSA economies and considers a different period, the result may not be entirely strictly comparable with findings in past studies. In fact, one factor that distinguishes our paper from existing studies is that countries are carefully chosen from the same region, i.e. SSA, so that results obtained are largely region-specific, though heterogeneity among countries in the region is a possibility and its effects on our finding has been considered using the fixed effects estimator that eliminates the omitted variable biases emanating from heterogeneity among countries, Williams (2017). Thus, we conclude that inferences obtained may not be directly comparable and thus extendable to other economies because, according to the stages of development hypothesis, economies on a given developmental stage are not directly comparable to economies on a dissimilar stage of development as policies which drive growth in one stage are different from those that promote growth in other stages, Costa and Kehoe (2016). As Asiedu (2002) noted, SSA is different and so inferences on SSA economies are not necessarily analogous to those from studies on other economies.

The stability of the positive and significant relationship between domestic investment and economic growth, a well-known result in the literature, is further confirmed in this paper as domestic investment enters significantly in all the regressions – leading to the conclusion that a strong, positive and significant relationship exists between domestic investment and economic growth in SSA. This is one of the few more consistent empirical results to have emerged from the different growth regressions performed by researchers over the years, irrespective of the continent or region of focus, suggesting that domestic investment is an important growth determinant. After controlling for this important growth determinant in Column (b') as a robustness check for the result in Column (a') that finds a positive and significant FDI effect on growth, we find that FDI no more bears a robust and significant direct relationship with growth. In fact, further regressions as shown in columns (c') and (d') of Table 1.4 appear to suggest that FDI could possibly shrink growth when domestic investment is held fixed, and this is supported by the marginal effect of FDI, which is the sum of coefficients on the non-interacted FDI and components from the interaction terms, that turns out negative in (d') for a unit rise in each interaction variable. Thus, one could argue that the reason FDI is not robust in this analysis of FDI-growth nexus is because domestic investment has been controlled for. With this variable, FDI fails the robustness check.

At this point, as domestic investment enters significantly in all regressions and the direct effect of FDI on growth is not robust after controlling for domestic investment, an intuitive question arises in passing: if FDI affects growth, does it operate via physical capital accumulation from domestic investment? To answer this question, we follow Alfaro et.al (2009) and regress domestic investment on FDI and the other control variables. The results, reported in Appendix A.2, show that FDI bears a positive and significant relationship with domestic investment, which implies that FDI crowds in domestic investment in SSA. FDI encourages physical capital accumulation via domestic investment. On this basis, the answer to the previous question is this: in instances where FDI influences growth, it operates via physical capital accumulation from domestic investment, and this holds even when we consider interaction effects with the absorptive capacities of the economy. This result is at variance with Alfaro et.al (2009) who find that, for their collection of countries, FDI plays no significant role in inducing domestic physical capital accumulation and thus does not impact domestic investment significantly, a finding which leads them to conclude that the effect of FDI on growth does not seem to function via domestic investment (physical capital accumulation). Instead, we find that FDI accelerates domestic investment which leads to physical capital accumulation that enhances growth, irrespective of the pre-existing state of domestic investment. Additionally, one of the by-products of the result is that the relationship between financial markets development, represented as credit to the private sector, and domestic investment is positive. This finding supports the conclusion reached in Alfaro et.al (2009) and suggests that a well-developed domestic financial market, which encourages growth in private sector credit, positively drives domestic investment and, by extension, physical capital accumulation.

In a related vein, we check whether any level of human capital accumulation is a channel through which the effects of FDI on growth, wherever such effects exist, are materialized in SSA. To achieve this, we investigate whether FDI induces human capital accumulation. As in the case of domestic investment, this requires regressing human capital on FDI and the controls. The results, also available in Appendix A.2, suggest that, against its effect on physical capital accumulation (i.e. domestic investment), FDI does not play a significant role in inducing human capital accumulation and, as seen in Tables 1.2 and 1.3, no evidence exists that human capital accumulation on its own spurs growth. Thus, of the two-factor accumulation – physical and human capital accumulation – physical capital accumulation seems to be a more important channel by which the effects of FDI on growth are manifested in SSA. Not only does it benefit from FDI, it also spurs growth. The results also show that the relationship between financial markets development and human capital is mostly negative and significant whereas the relationship is positive between financial markets development and domestic investment. Hence, a well-developed financial market, while positive for physical capital accumulation, is a disincentive for human capital accumulation in SSA.

Returning to our growth regressions, we streamline our question and, rather than open-endedly examine whether any level of human capital serves a channel through which FDI influences growth, we instead investigate whether existing high human capital accumulation (whatever its drivers might be) influences the effects of FDI on growth. To accomplish this, we include the interaction between FDI and human capital since this interaction term, when used as a regressor in growth regressions, has been found to have a significant positive effect on economic growth, for instance see Borenzstein et al. (1998) and Xu (2000). We also include interactions between FDI and trade openness to the regression to see the effects that high openness has on the FDI-growth nexus. Results are reported in Columns (c') and (d') of Table 1.4.

Table 1.4: Growth and FDI: the role of financial markets – Further robustness checks

	(a')	(b')	(c')	(d')
Initial income	-0.023* (-1.85)	-0.038*** (-2.82)	-0.035*** (-2.64)	-0.029** (-2.23)
FDI/GDP	0.283*** (3.47)	0.127 (1.45)	-3.692*** (-4.48)	-3.187*** (-3.84)
(FDI/GDP) × financial markets	-0.183** (-2.03)	-0.092 (-0.95)	0.221* (1.89)	0.257** (2.21)
Financial markets	-0.016 (-1.19)	-0.033** (-2.25)	-0.035** (-2.42)	-0.036** (-2.53)
Human Capital	-0.030 (-0.21)	0.058 (0.40)	-0.107 (-0.73)	-0.096 (-0.66)
Population growth	1.455*** (5.98)	1.452*** (6.47)	1.416*** (5.63)	1.394*** (5.58)
Government consumption	-0.057*** (-2.70)	-0.065*** (-2.91)	-0.070*** (-3.18)	-0.073*** (-3.35)
Domestic investment		0.073*** (4.51)	0.066*** (4.08)	0.069*** (4.35)
Trade openness		0.079*** (2.83)	0.078*** (2.85)	0.086*** (3.14)
Inflation		-0.009 (-1.60)	-0.011** (-1.97)	-0.010* (-1.69)
(FDI/GDP) × Human capital			4.054*** (4.66)	2.457** (2.56)
(FDI/GDP) × Trade				0.365*** (3.81)
No. of Observations	1,016	931	931	931
R^2	0.064	0.141	0.166	0.196

Notes: All regressions report adjusted R^2 and have a constant term; t-values are in parenthesis and statistical significance, wherever achieved, is at 1%, 5% and 10% levels, where* p<.1; ** p<.05; *** p<.0.01. Human capital is the log of (1+years of secondary schooling), government consumption is log of (government spending/GDP), domestic investment is log of (domestic investment/GDP), initial income is log, inflation is log (1+average inflation rate) and openness is log of (exports+ imports as a share of GDP).

While human capital and FDI each registers negative effects on growth in Columns (c') and (d'), the negative effects of FDI is significant while those of human capital continue to be insignificant. However, the interaction between FDI and human capital registers both positive and significant effects on growth. Relating this to the previous finding connecting FDI, human capital accumulation and growth, this result makes clear that although FDI does not speed-up human capital accumulation to spur growth, the presence of a high level of existing high human capital accumulation is important as it interacts with FDI to accelerate growth. Put another way, even though FDI might not be responsible for high human capital accumulation, the presence of an already high level of human capital, whatever the driver of such level might be, releases the positive benefits of FDI on growth. In the same way, the interaction between FDI and trade openness is positive and significant for growth. Moreover, the effects of trade openness alone on growth are positive, and significant. The positive interaction of FDI and human capital on growth is in line with previous findings such as Borensztein et.al (1998) but contrasts with the negative interaction obtained in Alfaro et.al (2004). Meanwhile, the interaction between FDI and financial markets, which was negative, becomes positive and more significant when interactions between FDI and human capital and between FDI and trade openness are included in the regressions. So, in this instance, FDI interacts favourably with financial markets development to enhance growth, and the relationship is significant and the degree of significance appears to increase markedly especially following the inclusion of the interaction between FDI and trade openness. From this, it follows that well-developed financial markets could enhance the growth effects of FDI in SSA if there also exists some level of interaction between FDI and trade openness as well as between FDI and enhanced human capital. However, as seen in Column (c') and in Column (d'), high human capital alone might impede growth in the absence of FDI, though the relationship is insignificant. Meanwhile, even in the absence of FDI interactions, trade openness alone remains positive for growth in SSA. Thus, whether or not SSA countries are able to attract FDI, a more liberalised/open trade appears to be positive for growth based on the finding in this part of our empirical analysis. Reconciling the results from Table 1.4 with results from the earlier tables, we find that the mixed findings are due to the omission of some important conditions such as the fixed interactions between FDI and other important factors such as openness and enhanced human capital. The presence of these factors and their interactions are required for the interaction effects of FDI and trade openness to be positive for growth in SSA.

1.4.2 Possibility of Endogeneity of Independent Variables

In the preceding empirical exercises, regressors in the growth regressions have been treated as exogenous. In practice, however, this assumption might be too restrictive. It is a well-known concern in the empirical growth literature that bidirectional relationships often exist between growth and each of FDI and financial markets development. In such instances, not only do these variables impact growth but they themselves are also influenced by movements in growth. Such a possibility, without being account for, would imply an imprecise statement of the effects of these variables and their interactions on growth. In view of these, there is a need to adopt a technique that addresses such endogeneity concerns. Two major techniques have been proposed in the literature. The first method involves appropriately instrumenting the suspected endogenous regressors while the second method relies on constructing proxies of their contemporaneous values using their one-period lagged values. In this section, we will implement both techniques; this would offer us a chance to also investigate a well-known criticism that using lagged values of contemporaneous endogenous regressor neither eliminates endogeneity nor provides consistent results similar to those obtained by instrumental variables estimation such as the GMM.

For the first part of the empirical exercise in this section, we follow Buch et.al (2013), Clemens et.al (2012) and Vergara (2012) and begin with the second and less ambitious technique. We replace contemporaneous values of suspected endogenous variables with their one-period lagged values in an effort to strip them off, or at least lessen, the effects of endogeneity biases, wherever they exist. It is thought that, this way, endogeneity diminishes and is unlikely to be of major concern in our analysis. Not only is this specification plausible empirically, it is theoretically justifiable as it takes some time to see the effects of new capital on output growth. For instance, Juma (2012) notes that new capital generally influences output growth in the period subsequent to that in which it is received, or that it takes some time for new capital to be used in production. Meanwhile, as far as omitted variables and unobserved heterogeneity go, we utilise a wide range of controls and have employed the fixed effects model which is suitable in our case since our time dimension is fairly large, which helps to further lower any endogeneity bias from lagged values of income[3]. So, we worry less about these issues. The results are presented below in Table 1.5.

Table 1.5: Growth and FDI: the role of financial markets development

	(a'')	(b'')	(c'')	(d'')
Initial income	-0.036***	-0.039***	-0.030**	-0.017
	(-3.01)	(-3.16)	(-2.53)	(-1.46)
FDI/GDP	0.656***	0.727***	-6.675***	-4.216***
	(8.87)	(8.99)	(-8.54)	(-5.37)
(FDI/GDP) × financial markets	-0.246***	-0.368***	0.246**	0.093
	(-2.89)	(-3.95)	(2.25)	(0.88)
Financial markets	0.007	0.002	-0.006	-0.007
	(0.60)	(0.15)	(-0.49)	(-0.57)
Human Capital	-0.009	0.005	-0.247*	-0.018
	(-0.07)	(0.04)	(1.90)	(-1.47)
Population growth	1.550***	1.499***	1.443***	1.459***
	(6.86)	(6.34)	(6.42)	(6.83)
Government consumption	-0.066***	-0.074***	-0.063***	-0.067***
	(-3.48)	(-3.71)	(-3.32)	(-3.69)
Domestic investment		0.063***	0.055***	0.061***
		(4.30)	(3.92)	(4.57)
Trade openness		0.017	0.002	-0.004
		(0.67)	(0.09)	(0.20)

[3] The fixed effects estimator eliminates the unobserved heterogeneity or country-specific fixed effects that potentially correlates with regressors and lagged values of dependent variable. This is achieved by using the within group demean transformation. However, this demeaning process creates new terms which are demeaned lagged values that are correlated with the demeaned error term. That is, emphasizing on lagged values, demeaning yields $y_{it} - \bar{y}_i = \gamma(y_{it-1} - \bar{y}_{i-1}) + (\varepsilon_{it} - \bar{\varepsilon}_i)$. In this equation, $(y_{it-1} - \bar{y}_{i-1})$ and $(\varepsilon_{it} - \bar{\varepsilon}_i)$ are correlated because $\bar{y}_{i-1}$ and $\bar{\varepsilon}_i$ are correlated, even if the error term is uncorrelated. This is because the average term $\bar{\varepsilon}_i$ contains both present and past values of ε_{it}, in particular ε_{it-1}, which is correlated with y_{it-1} contained in $\bar{y}_{i-1}$. According to Nickel (1981), this introduces a (downward) bias of order $1/T$, leading to inconsistency of estimators. However, this bias is relatively small or even eliminated when T is fairly, reasonably or sufficiently large regardless of the value of N.

Inflation		-0.005 (-0.87)	-0.008* (-1.65)	-0.007 (-1.50)
(FDI/GDP) × Human capital			7.869*** (9.52)	2.943*** (3.13)
(FDI/GDP) × Trade openness				0.858*** (9.58)
No. of Observations	978	899	899	899
R^2	0.276	0.325	0.395	0.475

Notes: All regressions report adjusted R^2 and have a constant term; t-values are in parenthesis and statistical significance, wherever achieved, is at 1%, 5% and 10% levels, where * p<.1; ** p<.05; *** p<.0.01. Human capital is the log of (1+years of secondary schooling), government consumption is log of (government spending/GDP), domestic investment is log of (domestic investment/GDP). The suspected endogenous variables being FDI and financial markets are replaced with their one period/one year lagged values in order to lessen or mitigate simultaneity/endogeneity problems. We have used fixed/random effects estimator is estimating the coefficients of our covariates.

The estimated coefficients of initial income are highly significant in most results reported in Tables 1.5 just as they are in Tables 1.2 to 1.4, providing some empirical evidence of conditional convergence that has been reported in various growth studies, such as Barro (1991) and Mankiw et.al (1992). Conditional convergence is the hypothesis which predicts that, conditioned on the presence of other growth determinants, growth is higher for countries with lower starting income levels. That is, growth tends to subsequently slow down the richer countries become and quicken for poorer countries. Taken together, the modal magnitude of the estimated coefficients of initial income implies convergence in SSA occurs at the rate of about 3 percent per year. Table 1.5 also shows that the direct effect of human capital on growth is mostly insignificant and or its impact on growth is negative. This outcome between human capital and growth is a well-known puzzle in the growth literature where human capital is often either insignificant or bears a negative nexus with growth, see Benhabib and Spiegel (1994), Islam (1995), Hamilton and Monteagudo (1998) and Pritchett (2001), suggesting that the proposition that countries can directly raise their growth by further channelling resources towards public education seems questionable and is not necessarily supported empirically. In the context of SSA, the absence of a direct positive influence of human capital on growth could be attributable to the accumulation of low, rather than high, skilled human capital, where quantity of human capital dominates quality. Drawing upon the experiences of countries that have experienced growth, quality rather than quantity of human capital has been crucial for their growth. Another viable explanation for the dampening impact of human capital on contemporaneous growth, due to Oreva (2015), is that workers who otherwise would contribute to the labour force and increase productivity are instead spending years getting more education, resulting in a trade-off of current economic performance for future growth.

In columns (a’’), (b’’), (c’’) and (d’’), FDI is found to exert a significant effect on growth. The effects are, however, different and not always the same. In columns (a’’) and (b’’), FDI exerts a positive influence on growth whereas in columns (c’’) and (d’’), it is found to dampen growth. When FDI is interacted with financial markets development (i.e. private sector credit), the situation reverses. In this case, the effect of the interaction on growth is significant in all but column (d’’) and the pattern in which financial markets development influences the impact of FDI on growth in SSA seems convoluted. Indeed, in the first two columns, the interaction term is negative, but positive in the last two columns. In many ways, this compares with the results in Table 1.4 where the interaction between FDI and financial markets development is negative in the first two columns and positive in the last two columns. Thus, the results continue to support the finding that the influence of well-developed financial markets in enhancing the growth-promoting characteristics of FDI appears unestablished in SSA. This deduction is equivalent to that proposed by the results reported in Table 1.4 in which all regressors are treated as exogenous. Both results provide two mutually exclusive findings – on the one hand, they suggest FDI promotes growth through well-development financial markets as in Alfaro et.al (2004) and, on the other hand, they suggest FDI dampens growth in the presence of well-developed financial markets, in line with Hsu and Wu (2009). Accordingly, the evidence that a well-developed financial market enhances the impact of FDI on growth in SSA appears to be rather mixed. Notwithstanding, both results provide some evidence that existing high levels of human capital and trade openness in SSA enhance the relationship between FDI and growth and this is in line with Borensztein et al. (1998) who find that FDI has a positive growth effect once human capital becomes above average, and Balasubramanyam et al. (1996, 1999) who posit that FDI promotes growth in the presence of high openness. We observe that the coefficients increase noticeably in values in Table 1.5 compared with those reported in Table 1.4. Alfaro et.al (2004) notes that accounting for endogeneity, as attempted in this section, corrects for the classical measurement error that typically biases coefficients to zero and might be responsible for the observed increase in the estimated values of the coefficients. Meanwhile, the overall marginal effect of FDI on growth is positive for a unit increase in the interaction variables in (a”), (b’’) and (c’’) and negative in (d’’).

Moving now to the next part of the empirical exercise in this section, we execute the first technique where we instrument the suspected endogenous variables and adopt the generalized method of moments (GMM) to address the issue of endogeneity in the regressors. The GMM is a more efficient and consistent estimator and works well for dynamic panel models. Broadly speaking, GMM is suitable for several reasons – in addition to eliminating fixed effects by first differencing and instrumenting the endogenous variables in the dynamic panel model using internal instruments, where the internal instruments are longer lags of regressors, it provides platforms to assess the short and long run effects of regressors on growth. The consistency of GMM estimator relies on the validity of the appropriately lagged instruments. To address this issue of instrument validity, two core specification tests are considered. The first is the Sargan test of over-identifying restrictions, which tests the overall validity of instruments. The null hypothesis for this test is that the instruments are valid, uncorrelated with the transformed error terms and over-identifying restrictions exist. Thus, failure to reject the null hypothesis (large p-values) gives support to the model and implies that the number of instruments used in the estimation is appropriate for the model. The second test is a test for serial autocorrelation. The null hypothesis in this case is that the error term is not serially correlated. Non-rejection of the null hypothesis (high p-values) implies that serial correlation does not exist. When the test fails to reject the null hypothesis of the absence of second-order serial correlation, we conclude that the original error term is serially uncorrelated and continue with the GMM estimation. The results of the GMM regressions can be found in Table 1.6.

Table 1.6a: Growth and FDI: the role of financial markets development: GMM Estimation

	(a''')	(b''')	(c''')	(d''')
Initial income	-0.104***	-0.139***	-0.046***	-0.046***
	(14.35)	(-5.51)	(-3.08)	(-3.92)
FDI/GDP	0.305***	-0.429***	-1.456***	-1.62**
	(19.93)	(-6.37)	(-2.73)	(-2.33)
(FDI/GDP) × financial markets	-0.26***	0.306***	0.261***	0.362***
	(16.93)	(5.39)	(12.45)	(5.34)
Financial markets	0.087***	0.05**	-0.057***	-0.121***
	(14.09)	(2.29)	(3.16)	(5.92)
Human Capital	1.88***	1.461***	2.169***	1.543***
	(6.83)	(2.74)	(6.93)	(6.97)
Population growth	0.534	4.718***	2.408***	0.293
	(1.39)	(4.55)	(6.83)	(0.16)
Government consumption	-0.22***	-0.046***	-0.123***	0.017
	(25.74)	(2.63)	(3.40)	(0.59)
Domestic investment		0.041***	0.0218***	0.031*
		(3.21)	(3.16)	(1.89)
Trade openness		0.142***	0.233***	0.213***
		(6.41)	(12.64)	(4.18)
Inflation		-0.023***	-0.018***	-0.0004
		(3.46)	(4.60)	(0.06)
(FDI/GDP) × Human capital			1.295**	4.693***
			(2.11)	(6.20)
(FDI/GDP) × Trade openness				-1.35***
				(14.20)
No. of instruments	44	58	65	51
No. of observation	1048	961	961	961
A-B (1)	0.007	0.011	0.014	0.011
A-B (2)	0.237	0.418	0.402	0.357
Sargan Test	0.655	0.983	0.99	0.977

***,** & * indicate that a coefficient is statistically significant at 1%, 5% and 10% significance level, respectively. The figures in parenthesis ( ) are absolute t/z ratios while figures in brackets [ ] are p-values. A-B is the serial correlation test proposed by Arellano and Bond, where A-B (1) and A-B (2) represent p values for the test of first and second order serial correlation, and Sargan Test is the test for over identifying restriction.

Table 1.6b: Implied long run effects of growth determinants on growth

	(a')	(b')	(c')	(d')
LR FDI Effect	0.276	-0.376	-1.391	-1.548
LR FDI Effect via Financial Markets	-0.236	0.269	0.249	0.346
LR Financial Markets Effect	0.079	0.044	-0.054	-0.116
LR Human Capital Effect	1.703	1.283	2.074	1.475
LR Population Growth Effect	0.484	4.142	2.302	0.280
LR Government Consumption Effect	-0.199	-0.040	-0.118	0.016

LR Domestic Investment Effect	0.035	0.021	0.030
LR Trade Openness Effect	0.125	0.223	0.204
LR FDI Effect via Human Capital		1.238	4.487
LR FDI Effect via Trade Openness			-1.291

Notes: LR stands for 'long run'. If β represents the coefficient of lagged initial income, the LR effect of each regressor on growth is obtained by dividing its coefficient by $1-\beta$

Table 1.6a reports the GMM results. From these results, the long-run effects of all regressors are computed and reported in Table 1.6b. The absolute value of the coefficients of initial income reported in all of the columns is less than 0.50 despite increasing the number of regressors from 7 in column (a') to 11 in column (d'). The absolute values of initial income, though an improvement from earlier estimates, continue to imply that the rate of conditional convergence is gradual. Also, it suggests that the difference between short and long-run estimates of the regression coefficients is small. This can be confirmed by taking difference of regression coefficients in Tables 1.6a and 1.6b.

For some of the pertinent variables, the overall gist of the results is quite different compared to results in the preceding sections and those obtained using the first technique. Although FDI shows some mixed impact on growth as in the previous results, we find that the direct effect on growth is mostly negative while the overall marginal effect, for a unit rise in interaction variable, is mostly positive after instrumentation of the suspected endogenous variables and estimation of their coefficients via GMM. The results also slightly advance the consensus reached by the camp that suggests that well-developed domestic financial markets enhance the benefits of FDI on growth as the coefficients on the interaction between FDI and financial markets are now mostly positive, though the mixed outcome is not fully erased. As before, we find that existing high human capital releases the positive impact of FDI on growth, but we unexpectedly now find that openness dampens the impact of FDI on growth, a finding at variance the regressions in previous section.

Moving now to the other variables, the puzzle between human capital and growth appears to have vanished and human capital now has a benign impact on growth. This could imply that the aforementioned studies which find such puzzles disregarded the possibility of endogeneity of some of their regressors, leading to inconsistent coefficients. One of the variables that retain its invariant effect on growth is domestic investment whose positive impact on growth has been unaltered whether or not we account for the endogeneity of regressors. We also find that trade openness has a consistently positive direct impact on growth and that the effect of government consumption on growth in SSA remains mostly negative. The results also emphasize a positive relationship between population growth and economic growth in SSA, though not always significant, while the mixed effects of financial markets development on growth are now significant and well highlighted. Lastly, the results suggest that the negative relationship between inflation and growth, obtained in previous sections, gains some legitimacy through an improvement in statistical significance so that it is somewhat safe to say that high inflation is growth-excluding in SSA, providing some insight into the reason many SSA countries favour policies to lower domestic inflation.

On the whole, the results here obtained by instrumentation via GMM are not entirely equivalent to those obtained either when all regressors are assumed exogenous or when the suspected endogenous variables are replaced with their one-period lagged values. This finding appears to suggest that GMM addresses the endogeneity bias that is neither well captured nor eliminated when the suspected endogenous variables are replaced with their one-period lagged values. Thus, the criticism of using lagged values as a proxy for contemporaneous endogenous variables – a criticism recently advanced by Reed (2015)[4] and Bellemare et al. (2015) who find that lagging an endogenous variable does not enable one to escape endogeneity bias – appears to have some support in SSA. This is because results obtained when FDI is replaced with its lagged value for the purposes of causal inference are not entirely equivalent to those obtained when FDI is instrumented in the GMM style. Thus, when endogeneity, in the form of reverse causality or simultaneity, is suspected, replacing the endogenous regressor with its lagged value may produce misleading results.

[4] It is Reed (2015) who notes that a common practice in applied economics research consists of replacing a suspected simultaneously determined explanatory variable with its lagged value and shows that replacing an endogenous variable with its one-period lagged value does not enable one to avoid simultaneity bias and that the associated estimates are still inconsistent, and hypothesis testing is invalid

Given the sometimes-conflicting results obtained in the preceding section for the direct impact of FDI on growth, a natural question that arises is whether there are certain levels of macroeconomic variables that suggest the type of relationship which FDI would bear with growth in SSA. This leads to/motivates the threshold analysis of FDI-growth nexus in SSA, presented in the next section of this paper.

1.5 Threshold Analysis of FDI-growth nexus

A major restriction posed by the preceding empirical analysis, and a likely cause of some of the results discrepancy, is the assumption of global linearity or monotonicity of the growth regression models. Specifically, the previous modelling strategy (non-threshold analysis) imposes an implicit à priori assumption that the relationship between FDI and growth g is linear or monotonically increasing or decreasing with regresssors R (which may contain the threshold variables), so that whenever an increase in FDI (i.e. $FDI > 0$) implies an increase or decrease in growth (i.e. $g > 0$ or $g < 0$), then this is true for all values of the regressors R (i.e. for both $R < 0$ and $R > 0$); similarly, whenever a decrease in FDI (i.e. $FDI < 0$) implies a decrease or increase in growth (i.e. $g < 0$ or $g > 0$), then this is also true for all values of the regressors R (i.e. for both $R < 0$ and $R > 0$). Moreover, the interaction terms $FDI \times R$ bear linear relationships with g such that g can be written as a linear combination of FDI, R and the interaction terms $FDI \times R$, and the estimated slope (beta) coefficients in the regressions are qualitatively or quantitatively equivalent at all values of each regressor. However, in general, these assumptions do not necessarily hold always as there are cases where, for instance, $FDI > 0$ implies $g > 0$ only for some R, i.e. for either $R < 0$ or $R > 0$, but not for all $R > 0$ and $R < 0$. That is, it is plausible to have $FDI > 0$ and $g < 0$ for higher R, i.e., $R > 0$ and $FDI > 0$ and $g > 0$ for lower R, i.e., $R < 0$ or some other similar type combinations that suggest different kinds of relationships between FDI and g along the range of different values of R. These are cases that empirical strategies employed in previous sections fail to acknowledge. As noted in Alfaro et.al (2004) and implied in Borensztein et.al (1998), 'one explanation for our results discrepancy could be that we have forced a globally linear relationship on what is essentially a nonlinear relationship'. A possible nature of the nonlinear relationship is that there exists at least one value of at least one of the explanatory variables in the regression equation after which the link between FDI and growth changes.

In this section, we use the threshold regression analysis, to address this concern. This is a non-linear approach that allows for instances in which the relationships between two variables, say FDI and growth, g, can be different at some sections or range of values of the data samples. It involves splitting samples into two parts $R > r_1$ and $R < r_1$ for all values of FDI, where $r_1 \in \mathbb{R}$, i.e. r_1 is any real number which can include but not restricted to zero. In this case, the analysis would look at the impact of FDI on growth by taking care of all possible scenarios, i.e. $R > r_1$ and $FDI > 0$, $R > r_1$ and $FDI < 0$, $R < r_1$ and $FDI > 0$ and, finally, $R < r_1$ and $FDI < 0$. The variable $R \in \bar{\bar{R}}$, where $\bar{\bar{R}}$ is the set of all possible individual regressors in the model, is called the threshold variable which splits samples into different parts, while r_1 is the threshold value associated with R, where r_1, which is usually estimated, is an element of the support of R. This framework provides a more generalized and flexible specification as it accommodates different kinds of FDI-growth relationships for different levels of thresholds and allows the relationship between FDI and growth to be piecewise, not necessarily globally linear, with the threshold variables acting as a regime-switching trigger[5]. It is based on this framework that we provide an analysis of the direct impact of FDI on growth in SSA, without the usual restrictions posed by the assumption of global linearity, i.e. same slope assumption. The hypothesis of interest to be tested is that there are threshold effects in the FDI-growth nexus; that is, the link between FDI and growth is altered by certain values of the threshold variables. In this section, the six threshold variables introduced in equation 1.24 will be used to investigate this alteration in the FDI-growth nexus, so R can be thought of as each of the threshold variables, each having a threshold value, $r_1 \in \mathbb{R}$. The six threshold variables give rise to six panel threshold models, where each model contains exactly one of the six threshold variables.

1.5.1 Results of threshold analysis of FDI-Growth Nexus in SSA

We estimate the models in equation 1.24, by fitting them to data as in Hansen (1999), and present the empirical results in Table 1.7 below. The first section of the table displays the threshold variables, their estimated threshold values and the corresponding

[5] This description is coined by Azman-Saini et.al (2010)

95% confidence interval, while $\hat{r}_1^A$ and $\hat{r}_1^B$ represent the estimated threshold values without and with consideration of regressor endogeneity, respectively, where the focus regressor is FDI. The second and third sections show the regime-dependent coefficients of FDI on growth. In particular, $R \leq \hat{r}_1$ and $R > \hat{r}_1$ represent low and high threshold regimes, respectively, while $\hat{\beta}_L$ and $\hat{\beta}_U$ denote the effects of FDI on growth in the low and high threshold regimes.

Table 1.7: Threshold value estimates and regime dependent slope coefficients

Threshold Variables ($\boldsymbol{R}$)	Estimated Thresholds ($\hat{\boldsymbol{r}}_1^A$)	95% Confidence Intervals	Estimated Thresholds ($\hat{\boldsymbol{r}}_1^B$)	95% confidence
s_{it}	10.23	[9.98, 10.25]	6.19	[6.10, 6.30]
$\boldsymbol{r_{it}}$	128.20	[124.83, 131.55]	119.78	[116.63, 122.91]
$\tilde{d}_{it}$	14.58	[14.23, 14.63]	5.50	[5.33, 5.56]
h_{it}	7.00	[6.00, 8.00]	7.00	[6.00, 8.00]
$\tilde{o}_{it}$	87.48	[83.77, 87.80]	182.68	[178.73, 184.50]
$\tilde{g}_{it}$	3.09	[3.06, 3.10]	0.39	[0.26, 0.40]

A. Impact of FDI on growth

Threshold variables ($\boldsymbol{R}$)	Lower regime ($R \leq \hat{r}_1$) $\hat{\beta}_L$	Upper regime ($R > \hat{r}_1$) $\hat{\beta}_U$	Difference $\Delta = \lvert\hat{\beta}_U - \hat{\beta}_L\rvert$	Upper region (%) of observations
s_{it}	0.17*** (6.30)	-0.08* (1.86)	0.25	33.20
$\boldsymbol{r_{it}}$	0.49*** (8.35)	0.03 (1.12)	0.46	97.01
$\tilde{d}_{it}$	0.18*** (6.02)	-0.01 (0.27)	0.19	40.60
h_{it}	0.03 (0.88)	0.21*** (5.86)	0.18	45.01
$\tilde{o}_{it}$	0.45*** (8.55)	0.04 (1.45)	0.52	29.36
$\tilde{g}_{it}$	-0.10*** (2.94)	0.28*** (8.96)	0.38	24.05

B. Impact of FDI on growth

Threshold variables ($\boldsymbol{R}$)	Lower regime ($R \leq \hat{r}_1$) $\hat{\beta}_L$	Upper regime ($R > \hat{r}_1$) $\hat{\beta}_U$	Difference $\Delta = \lvert\hat{\beta}_U - \hat{\beta}_L\rvert$	Upper region (%) of observations
s_{it}	0.94*** (14.05)	-0.04 (0.68)	0.98	60.53
$\boldsymbol{r_{it}}$	-2.43*** (13.00)	0.66*** (12.78)	3.09	96.99
$\tilde{d}_{it}$	1.16*** (16.88)	-0.12** (2.04)	1.28	80.89
h_{it}	-0.30*** (4.60)	1.10*** (16.68)	1.40	45.02
$\tilde{o}_{it}$	-0.14** (2.37)	1.35*** (18.07)	1.49	2.10
$\tilde{g}_{it}$	-0.92*** (6.03)	0.49*** (9.29)	1.41	97.00

In A, FDI is exogenous, in B it is endogenous and instrumented. When FDI is exogenous, estimates are obtained using the standard Hansen (1999) procedure; however, we use fixe effects 2SLS in the spirit of Carner and Hansen (2004) and Hansen (1999) in part B when FDI is taken as endogenous, where FDI is instrumented with its lags to strip of the effects o endogeneity. Estimates of the other regressors and control variables can be found in the appendix section. In all estimations, threshold variables are taken as exogenous as the Hansen (1999) an Carner and Hansen (2004) procedure are based on exogenous thresholds. $\hat{\boldsymbol{r}}_1^A$ and $\hat{\boldsymbol{r}}_1^B$ represent the estimated threshold values without and with consideration of regressor endogeneity respectively, where the focus regressor is FDI is exogenous and endogenized, respectively. We note that our main findings are largely unaltered by inclusion or exclusion of initial incom from regressions.. In both A and B, the threshold variables are assumed to be exogenous, in line with Hansen (1999) and Carner and Hansen (2004). Income level (r_{it}), trade openne ($\tilde{o}_{it}$), inflation (s_{it}), human capital ($_{it}$), financial market development ($\tilde{d}_{it}$) and population growth ($\tilde{g}_{it}$). ***,** & * indicate that a coefficient is statistically significant at 1%, 5 and 10% significance level, respectively.

1.5.2 Analysis of Results and Findings

Table 1.7 presents empirical results of the estimations. Economically, the threshold values signify target levels that the identified threshold variables should either exceed or precede for certain economic outcomes to be achieved. This is the economic meaning of the threshold value. The first section of the results shows the estimated threshold value for each threshold variable. The second section, part (A), and third section, part (B), represent results obtained for the direct impact of FDI on growth when FDI is taken as exogenous and endogenous, respectively. When inflation s_{it} is the threshold variable, results show that its estimated threshold value is approximately 10.23% which then drops to 6.19% upon taking cognizance of the potential endogeneity of FDI. About 33% of observations fall into the upper inflation regime in part A while 61% of observations fall into the upper inflation regime in part B. In both parts A and B, results suggest that in the years from 1985 – 2013, at least 39% of the time, SSA countries have inflation rates below the estimated threshold values.

One notable outcome is the issue of low initial income levels in SSA. The results show that the threshold estimate for income level in SSA is a maximum of $128.20 for parts A and B. Compared to a threshold income level of $3,327.22 obtained in Jyun-Yi and Chih-Chiang (2008) for developing countries, the low threshold estimate in SSA reflects the low starting income level in the region. The results also show that more than 95% of the observations are above the estimated threshold income level in parts A and B, respectively. For credit to the private sector (a proxy for financial market development), there is a significant discrepancy between results in parts A and B. In particular, in part A, the threshold value is 14.58% and around 41% of observations fall into the high financial market development regime. However, when the threshold value drops to 5.5% in part B, the proportion of observations above the threshold value rises significantly, to about 81%, suggesting that in the period under consideration, more SSA countries have had a level of financial market development that is higher than the estimated threshold value when the estimated threshold level is low than when it is high. The difference in the estimated threshold values in part A compared to part B in due to the assumption on FDI. In part A, FDI is assumed exogenous while it part B it is taken as endogenous and thus appropriately instrumented.

When human capital h_{it} is the threshold variable, the estimated threshold value, i.e. average schooling years, is 7 years and this is the same in both parts A and B where 45% of observations fall into the high human capital regime. In both cases, there is a consensus that schooling years, which is the proxy for human capital, is more than 7 years for nearly one half of the countries across SSA over time. Turning to the other threshold variables, we see that the estimated threshold values for trade openness and population growth are 87.48% and 3.09% in part A and 182.68% and 0.39% in part B, respectively. The high trade openness of 182.68% indicates the relative importance of international trade to SSA economies, suggesting that aggregate international trade was almost twice the size of the economy of at least one SSA country in at least one of the years under study. Furthermore, when openness is the threshold variable, results show that about 29% of observations fall into the high trade openness regime in part A but this drops to less than 5% in part B following the rise in the estimated threshold value. In this regard, the results in both cases are not in full agreement and suggest that even though there has been vast trade liberalization in SSA, most SSA countries still have room to become more open to trade. Meanwhile, population growth as a threshold variable produces mixed results. In part A, the threshold estimate of 3.09% for population growth implies about 29% of observations are beyond the threshold value. This seems to suggest that less than half of the time SSA countries from 1985 – 2013 grew at more than 3.09% per year, implying that the growth rate in SSA was either experienced in few years and or by few countries. However, in part B where the estimated threshold value has decreased to 0.39%, the proportion of observations falling above the estimated threshold for population growth rises to over 95%, revealing that very few times did SSA countries experience a considerably low or stunted population growth or very few SSA countries experienced such population growth.

In all these, the results show that in terms of the proportion of observations falling above the estimated thresholds, there appears to be a consensus in parts A and B in two instances, with the harmony occurring when the threshold variables are human capital and initial income. Meanwhile, we note that in both parts A and B, the estimated 95% confidence intervals are quite narrow, which suggests that there is less uncertainty in the estimation of the threshold values as the narrow confidence intervals imply some adequate levels of precision.

The results for the empirical relationships between FDI and growth, based on the six threshold variables, are also presented in parts A and B of Table 1.7. Estimating relevant coefficients using procedures outlined in the previous sections, we obtain results that provide instances and required levels of the threshold variables for which the merits or demerits of FDI on growth begin to manifest. Our intent is to ascertain whether the relationship between FDI and growth is altered when the abovementioned threshold variables exceed or fall below their estimated threshold values. Particularly, we aim to determine how different threshold levels might alter the relationships between FDI and growth. We now shift our focus to parts A and B of Table 1.7 to discuss the impact of FDI on growth for the different threshold variables.

In part A, results show that FDI enhances growth in SSA when inflation rates are single digits or benignly below the estimated threshold value of 10.23%. However, the positive impact of FDI on growth begins to diminish as inflation increases and potentially turns negative when inflation exceeds the 10.23% mark. This seems to suggest that SSA countries with increasingly low inflation rates are much better able to reap the positive benefits of FDI inflows than those with inflation rates in the double digits. This finding suggests that SSA countries with low inflation levels have the benefit that high FDI inflows can enhance their growth rates. In other words, attracting large FDI inflows without addressing high domestic inflation could hinder growth. Thus, to unlock the growth benefits of FDI, it is more reasonable to implement policies that target and achieve benign levels of inflation before implementing pro-FDI policies. For initial income, the result suggests that the positive influence of FDI on growth is more visible for SSA countries with initial income level below $128 per year. As the income level rises, the positive influence of FDI on growth declines until it reaches a point where no more evidence exists that FDI spurs growth. This occurs when the income level exceeds the estimated threshold value. Based on this evidence, SSA countries that are likely to make more visible gains from FDI are those with apriori income levels below the estimated income threshold. The result also shows that the magnitude of the impact of FDI on growth is higher in the low regime than in the high regime, which suggests that correlation between FDI and economic growth is stronger for low income SSA countries.

Looking at private sector credit, the regression slope estimates of the effect of FDI on growth show that when private sector credit is 14.58% or below, the positive coefficient of 0.49 implies a positive relationship between FDI and economic growth, but for private sector credit above 14.58%, the coefficient turns negative and insignificant, suggesting that either FDI has no impact on growth or the impact is a negative one. Therefore, while a well-developed financial market is not bad in itself, the efficiency rather than size of the financial market might be more important as the result suggests that private sector credit beyond the estimated threshold level may in fact diminish efficiency and cause the effect of FDI on growth to turn negative in SSA. Our finding thus suggests that credit to the private sector in SSA should not be indiscriminately high. The most level it can rise to is 14.58% because, beyond this threshold level, the benefit of FDI to economic growth will either decline or disappear.

The third, fourth and fifth rows in part A assess the level of human capital, openness and population growth that influences the relationship between FDI and growth. For human capital, the result indicates that the direct impact of FDI on growth is significantly positive only when human capital exceeds the estimated threshold level of 7 years. Below this level, FDI fails to enhance growth. Thus, we find evidence that there is minimum years of education required by the workforce in order for FDI to boost growth. Accordingly, an important finding is that the level of human capital in the host country influences the relationship between FDI and growth as FDI is found to accelerate economic growth in SSA countries with human capital in the high threshold regime, i.e. higher than 7 years. Similar findings are reached in Borensztein et al. (1998) but the minimum human capital was not estimated and focus was not on SSA.

For openness, while it is true that high openness is encouraged, our results suggest that some checks and balances must still be in place if FDI is to be growth enhancing. In particular, we find that openness above the estimated threshold value of 87.48% might no more support the growth enhancing benefits of FDI as the coefficient of the effect of FDI on growth, though positive, loses its significance when openness exceeds this threshold. Finally, we assess whether the relationship between FDI and growth varies with population growth in SSA. In recent decades, there has been a widespread view that accelerated population growth is mostly bad for growth (see Heady and Hodge (2009) for a detailed review of such studies), especially in Sub-Saharan Africa (SSA), yet the contingent role that population growth can potentially play, whether or not such role is advantageous, has so far been ignored in the literature. As a result, it remains unknown how population growth influences the impact of FDI on economic growth in SSA. This is a question which this part of our analysis seeks to answer. Our result reveals that FDI impacts economic growth positively when population growth exceeds its estimated threshold value of 3.09%. For population growth below this level, the effect of FDI on growth is mostly negative. Thus, population growth plays a favourable contingent role in the relationship between FDI and growth in SSA. As such, the high population growth in SSA can be a strength, rather than a weakness, in unlocking the growth impact of FDI.

Turning now to part B which takes possible endogeneity of FDI into consideration, we find that, although there are some plausible and revealing results, they sometimes contradict several findings in part A. First, income beyond the estimated threshold value of $119.78 now induces a significantly positive impact of FDI on growth while the effect of FDI on growth is mostly negative for initial income below this threshold. At variance with the previous finding, this suggests that SSA countries with income levels higher than the estimated threshold are able to unlock the accelerating effects of FDI on growth while those with income levels beneath the estimated threshold cannot. The positive effect of FDI on growth for higher-than-threshold income countries is similar to the finding of Blomstrom et.al (1994). However, we continue to find that correlation between FDI and economic growth is stronger for low income SSA countries as the result shows that the magnitude of the impact of FDI on growth is higher in the low regime than in the high regime. In a similar vein, and at variance with the previous result, we find that FDI decelerates growth when openness is lower than the estimated threshold of 182.68% while it significantly accelerates growth for openness above this level. Although in relation to part A we find some consistence in the effect of FDI on growth when human capital is beyond its estimated threshold of 7 years – FDI accelerates growth in high human capital regime –, our result now indicates that the effect of FDI on growth is mostly negative for human capital below this threshold.

On a more favourable note, the conclusion on the impact of FDI on growth when the threshold variables are inflation, financial market development and population growth remain largely unchanged in both regimes in relation to part A. Just as in part A, but with different estimates of the threshold values, we continue to find robust evidence that 1) FDI is positively correlated with economic growth in SSA if inflation is less than the estimated threshold value but loses this positive impact for inflation rates greater than the threshold value; 2) Excessive private sector credit at a level higher than its estimated threshold might decelerate the positive effect of FDI on growth and accelerate the impact of FDI on growth when it is below its estimated threshold; and 3) FDI enhances growth in SSA when population growth is higher than the threshold, while the opposite is true for population growth below the threshold. The negative and positive impact of FDI on growth for population growth below and above its threshold is several times higher in part B than in A, but both provide the same gist – that SSA's high population growth is a strength, rather than a weakness, in unlocking the growth impact of FDI. Thus, population growth does have a positive side that can be favourably harnessed and this finding is in line with recent calls by the World Bank (2015) for 'government policies and actions that will increase the likelihood of capturing the potential social and economic benefits from population growth'.

Overall, the differences in results indicate that, although threshold effects exist in both parts A and B, the results or consequences of the effects, as reported in part B, are not robust to the consideration of endogeneity of FDI. This means that the diverging results in part A signify a possible bias emanating from ignoring the possibility of endogeneity. When endogeneity is considered (as in part B), then FDI is instrumented, which gives rise to new FDI samples. The result is a change in the dynamics of the new FDI relative to the original FDI used in part A. The instrumented FDI gives rise to a set of new estimates of the threshold values. The new threshold values then split the samples at new 'cut-off' points different from those in part A. Together with the new FDI samples, the new cut-off points split the samples in a way that generates inferences or threshold effects in part B that are different from those in part A for some threshold variables. This explains the differences in results in parts A and B for some of the threshold variables.

Nonetheless, the most consistent finding in the threshold analysis of FDI-growth nexus, which offers some consensus in both parts A and B as per where the results largely agree, is that FDI enhances growth in SSA when inflation and private sector credit are lower than their thresholds, and human capital and population growth are higher than their thresholds. In deciding on the consistent finding, we are more interested in those results that are robust or qualitatively invariant in both parts A and B as such results provide sufficient evidence or confirmation that inferences or conclusions reached are more likely to be plausible. Hence, we consider this as a robustness check and base our final decision on those outcomes where results are robust in both parts A and B in at least one of the threshold regimes.

An economic intuition that can be gleaned from the rather unexpected private sector credit result is that there should be a distinction between a well-developed financial market in terms of size and in terms of efficiency. That a financial market is well-developed in terms of size, i.e. a high private sector credit, does not imply that it would be efficient enough to sufficiently unlock the growth benefits of FDI. It could be that the high private sector credit is a consequence of large amounts of credits concentrated in the hands of a privileged few, within the economy, whose aim is not even to participate in ventures that enhance the domestic economy. In this instance, even with a rise in FDI, the opportunity to take advantage of the technological and managerial benefits and spillover effects of FDI would be non-existent. Efficiency rather than size of private sector credit would be more favourable in unlocking the growth benefits of FDI. Efficiency ensures that the high private sector credit is concentrated not just in the hands of a privileged few in the economy but also within the reach of a wider range of economic agents who have intentions of partaking in activities that enhance the real sector and hence growth of the economy. In order words, the level of development of local financial markets in terms of efficiency, rather than size alone, is crucial for the favourable effects of FDI on growth to be realized; the efficiency and size of the financial market must go hand in hand to release the positive benefits of FDI on growth. Another consistent outcome is that there is no globally congruent relationship between FDI and growth in SSA for all values of the prevailing macroeconomic variables (i.e. threshold variables) as the relationships in both high and low threshold regimes are either different or one of them is not significant. This provides some evidence for threshold effects – there is a need to target certain threshold levels of relevant economic variables in order to uncover the optimum growth benefits of FDI.

1.6 Conclusion

The estimation of threshold models has, in recent times, taken an increasingly prominent role as a new approach to study the relationship between FDI and growth. This is an approach which assumes the relationship between FDI and growth need not be globally congruent. In other words, there exists a point at which the FDI-growth nexus could possibly change across given data samples. Using six threshold variables – income level (r_{it}), trade openness ($\tilde{o}_{it}$), inflation (s_{it}), human capital (h_{it}), financial market development ($\tilde{d}_{it}$) and population growth ($\tilde{g}_{it}$) – this paper applies threshold models of Hansen (1999) and Caner and Hansen (2004) to investigate the relationships between FDI and economic growth, based on a panel of SSA countries from 1985 - 2013.

Of these threshold variables, we find that FDI accelerates economic growth when SSA countries have achieved certain threshold levels of inflation, population growth, human capital and financial markets development and this evidence is largely invariant and robust even after the consideration of endogeneity of FDI. The finding suggests that the presence of other factors, which act as important economic catalyst, is crucial for FDI to be positive on growth. In particular, our results suggest that FDI enhances growth in SSA when inflation and private sector credit are in the low regime, below their threshold levels, and population growth is above its threshold level. Until these are achieved, the benefits of FDI might either be non-existent or not fully harnessed. For the other threshold variables, the evidence is not robust as findings seem sensitive to the assumptions on FDI in at least one regime, making it impossible to take a unique stance. More importantly, our evidence of a threshold effect of population growth in the FDI-growth nexus is a revealing highlight of this paper because the contingent role of population growth in the FDI-growth relation has been hardly investigated in the literature.

Our finding that inflation rates above threshold decelerate the benign effects of FDI on growth is in line with previous studies that found high inflation to be deleterious to the economy and points to the need for the adoption of a more tempered level of inflation. The result that financial markets development beyond its threshold level does not unlock the growth benefits of FDI in SSA, is rather unexpected and points to the need for a more efficient rather than sizable financial markets in SSA. It could be that large size (private sector credit beyond its threshold) as a representative of financial market development does not enhance the positive impact of FDI on growth because it becomes less efficient whereas small size with a much better efficiency does. In any case, there is some evidence that the presence of a well-developed financial market may not be *the be-all and end-all* condition for FDI to be growth-enhancing – the type of development, whether size or efficiency, is crucial and other domestic factors also have to be favourable. These are imperative for the positive effects of FDI on growth to be released. Nonetheless, interpretation of the private sector finding should rather be treated with some caution as we believe such result that conflict with conventional wisdom in the literature would require some further studies.

With regard to policy, the result of this paper suggests that SSA countries should design and implement policies, both fiscal, monetary and even macro-prudential, aimed at improving domestic macro conditions before making an effort to attract FDI as any sacrifice aimed at stimulating FDI inflows would be beneficial and meaningful only when domestic conditions are supportive. The costs of attracting FDI are substantial and these costs include, among other, a significant loss of tax revenues in many SSA countries. As our results have shown, such costs would be incurred in vain if domestic conditions are suboptimal and not good enough to release the positive spillovers that allow host economies to maximize FDI gains. Our finding that population growth can be a strength rather than a weakness fits well with the recent call by the World Bank (2015) for SSA government to harness the strengths of population growth in SSA. In their words, 'Government policies and actions today will increase the likelihood of capturing the potential social and economic benefits from population growth'. So, population growth, especially via decreased mortality of skilled individuals, can have some positives.

A major weakness of this paper is that we have imposed exogeneity on all threshold variables, as is standard in existing threshold models, and used empirical models which are built to accept exogenous threshold variables, and we have treated the threshold variables consecutively rather than simultaneously or jointly. Thus, two ambitious but important extensions of this paper for future research are possible. The first extension will be to develop an improved threshold model that accepts endogenous threshold variables and accommodates jointly distributed, multiple threshold variables. The second is to analyse the FDI-growth nexus using the improved threshold model. Results from such analysis would be unrestrictive since the improved threshold model would be broader in the sense that it would accept any type of variables as thresholds and eliminate the restrictive assumption of exogeneity on threshold variables. It is also worth noting that this paper estimates the level of thresholds for the combined SSA countries. However, this approach may well be too simplistic as individual countries may have varying characteristics which could potentially alter outcomes, especially given the heterogeneous nature of some SSA countries, thus necessitating threshold variables that are largely peculiar to individual countries. Therefore, there is a need to analyse the country-specific impact of FDI on growth for the different threshold regimes peculiar to each of the SSA countries. In addition, the discovery of additional threshold variables, alongside accounting for possible cross connections among the threshold variables, might provide fresh perspectives on the FDI-growth nexus. We leave these extensions for future research.

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Appendix

A.1 Tables

Table 1a: List of variables in the sample

Variable	Definition	Source
Growth	Growth of real GDP per capita	World Bank
FDI	Net FDI inflows are a proportion of GDP	World Bank/IFS
Initial GDP	Real per capita GDP in the initial period	
Human capital	Measured as average years of secondary school for the population	World Bank
Government consumption	Aggregate expenditure of central government as a share of GDP	World Bank
Domestic investment	Total domestic investment as a proportion of GDP	World Bank
Inflation	Annual percentage changes in the consumer price index	World Bank/IFS
Trade volume(openness)	Sum of exports and imports as a share of GDP	World Bank
Private sector credit	Total credit to the private sector as a share of GDP	World Bank
Population growth	Yearly change in total population	World Bank

Table 1b: List of countries in the sample

Angola	Congo, Democratic	Guinea-Bissau	Mauritius	Somalia
Benin	Congo, Republic	Ivory Coast	Mozambique	South Africa
Botswana	Djibouti	Kenya	Namibia	Sudan
Burkina Faso	Equatorial Guinea	Lesotho	Niger	Swaziland
Burundi	Eritrea	Liberia	Nigeria	Tanzania
Cameroon	Ethiopia	Madagascar	Rwanda	Togo
Central Africa Rep	Gabon	Malawi	Senegal	Uganda
Chad	Ghana	Mali	Seychelles	Zambia
Comorous	Guinea	Mauritania	Sierra Leone	Zimbabwe

According to the Consultative Group to Assist the Poor (CGAP), Sub-Saharan Africa comprises 48 countries and 47% of the people live on less than $1.25 a day (UN 2012), so our data samples comprising more than 90 percent of the SSA countries are quite representative of the region. We note that there are missing data for some variables across time for a small fraction of the countries. This unbalanced panel poses little or no issue for the non-threshold analysis. We fill these missing points using approximation techniques inclusive of interpolation by moving average as a balanced panel is required for the threshold regression analysis of Hansen (1999) implemented in this paper. We consider this to be a weakness in our data gathering process in this paper as a more accurate scenario would have been one in which data for all countries across all time periods are available. Nonetheless, we normally would not expect this to alter all results significantly as the missing observations proportion is quite low

A.2 Impacts of other covariates on growth

Table 1c: Exogenous FDI

	$\widetilde{g}_{it}$	$\widetilde{o}_{it}$	s_{it}	h_{it}	$\widetilde{d}_{it}$	r_{it}
$\widetilde{g}_{it}$	1.817***	1.841***	2.104***	2.141***	1.999***	1.936***
	(8.67)	(8.69)	(9.98)	(10.09)	(9.37)	(9.20)
$\widetilde{o}_{it}$	0.064***	0.071***	0.069***	0.047**	0.051**	0.077***

	(3.04)	(3.33)	(3.19)	(2.17)	(2.36)	(3.57)
s_{it}	-0.015***	-0.012**	-0.010**	-0.015***	-0.014***	-0.014***
	(2.89)	(2.35)	(1.97)	(2.88)	(2.74)	(2.79)
g_{it}^c	-0.077***	-0.055**	-0.067***	-0.071***	-0.063***	-0.061***
	(4.32)	(3.08)	(3.70)	(3.90)	(3.45)	(3.40)
h_{it}	0.034	0.103	0.061	0.022	0.052	0.066
	(0.47)	(1.41)	(0.83)	(0.29)	(0.70)	(0.91)
d_{it}^i	0.069***	0.065***	0.070***	0.068***	0.073***	0.077***
	(5.10)	(4.73)	(5.09)	(4.90)	(5.25)	(5.65)
$\tilde{d}_{it}$	-0.032***	-0.046***	-0.036***	-0.029**	-0.028**	-0.040***
	(2.87)	(4.08)	(3.25)	(2.54)	(2.41)	(3.62)
r_{it}	-0.006	-0.014*	-0.020***	-0.014*	-0.014*	-0.015**
	(0.74)	(1.78)	(2.54)	(1.78)	(1.76)	(1.98)

Notes: The top of each column represents the threshold variables while the rows are the non-regime dependent covariates. Results in each column represent the effects of the covariates on growth when the threshold variable is the variable at the top of the column. The threshold variables are trade openness ($\tilde{o}_{it}$) in %, inflation (s_{it}) in %, human capital (h_{it}) in years, initial income (r_{it}) in \$, financial market development ($\tilde{d}_{it}$) in % and population growth ($\tilde{g}_{it}$) in %. The control variables which also contain the thresholds include govt consumption g_{it}^c, and domestic investment d_{it}^i. Significance is denoted by * p<.10; ** p<.05; *** p<.01 at 10%, 5% and 1% levels.

Table 1d: Endogenous FDI

	$\tilde{g}_{it}$	$\tilde{o}_{it}$	s_{it}	h_{it}	$\tilde{d}_{it}$	r_{it}
$\tilde{g}_{it}$	1.504***	2.160***	2.201***	2.203***	1.889***	1.814***
	(6.98)	(11.38)	(11.10)	(11.50)	(9.82)	(9.38)
$\tilde{o}_{it}$	0.044**	0.009	0.042**	0.008	0.0291	0.029
	(2.14)	(0.45)	(2.08)	(0.39)	(1.47)	(1.51)
s_{it}	-0.012**	-0.012**	-0.008	-0.012**	-0.012**	-0.01**
	(2.42)	(2.53)	(1.46)	(2.50)	(2.52)	(2.39)
g_{it}^c	-0.059***	-0.085***	-0.076***	-0.077***	-0.052***	-0.060***
	(3.39)	(5.23)	(4.48)	(4.70)	(3.14)	(3.66)
h_{it}	0.060	0.010	0.019	0.214***	0.019	0.036
	(0.85)	(0.15)	(0.28)	(3.12)	(0.29)	(0.54)
d_{it}^i	0.061***	0.078***	0.070***	0.066***	0.079***	0.067***
	(4.60)	(6.34)	(5.43)	(5.33)	(6.37)	(5.38)
$\tilde{d}_{it}$	-0.025***	-0.018*	-0.027***	-0.005	0.021**	-0.029***
	(2.29)	(1.74)	(2.55)	(0.45)	(1.96)	(2.87)
r_{it}	-0.021***	-0.004	-0.013*	-0.016	-0.013*	-0.025***
	(2.72)	(0.62)	(1.74)	(1.63)	(1.78)	(3.47)

Notes: The top of each column represents the threshold variables while the rows are the non-regime dependent covariates. The results in each column represent the effects of the covariates on growth when the threshold variable is the variable at the top of the column. The threshold variables are trade openness ($\tilde{o}_{it}$) in %, inflation (s_{it}) in %, human capital (h_{it}) in years, initial income (r_{it}) in \$, financial market development ($\tilde{d}_{it}$) in % and population growth ($\tilde{g}_{it}$) in %. The control variables/covariates which also contain the threshold variables include government consumption g_{it}^c, and domestic investment d_{it}^i. Significance is denoted by * p<.10; ** p<.05; *** p<.01 at 10%, 5% and 1% levels respectively.

Table 1e: A: Domestic Investment, FDI and Financial Markets & B: Human Capital, FDI and Financial Markets

A. Dependent Variable: Domestic Investment			*B:*	*Dependent Variable: Human Capital*
	Fixed Effects	Random Effects	Fixed Effects	Random Effects
FDI/GDP	0.49***	0.49***	0.02	0.02
	(13.95)	(13.99)	(0.13)	(0.15)
Human capital	0.02**	0.018**	---	---
	(2.54)	(2.34)	---	---
Openness	0.19***	0.19***	-0.03	-0.03
	(16.33)	(17.06)	(0.61)	(0.72)

Financial markets	0.05***	0.04***	-0.20***	-0.20***
	(3.79)	(3.53)	(4.48)	(4.47)
Controls	Yes	Yes	Yes	Yes
Observations	965	965	982	982
R^2	0.57	0.58	0.01	0.01

Notes: t-statistics in bracket. * Significant at 10%; ** significant at 5%; *** significant at 1%. 'Financial markets' is measured by private sector credit as a share of GDP. Estimations using fixed and random effects estimators are provided for both A and B. Controls are population growth, inflation, openness and government consumption.

A.3 Graphs of net FDI and growth for SSA countries