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# The relationship between FDI and population health in Sub-Saharan Africa: The role of per-capita income

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## Abstract

This paper investigates the relationship between FDI and population health in Sub-Saharan Africa (SSA). Using a sample of 35 SSA countries over the period 1996-2020, results show a positive relationship between FDI and health albeit in a nonlinear way. Indeed, we found that FDI exhibits an inverted U-shaped relationship with life expectancy. Moreover, per-capita income is found to be a channel through which FDI promotes population health. Per-capita income, sanitation and trade openness are found to be determinants of population health. Furthermore, our findings are robust when considering different health proxies, alternative specifications. Finally, we use a system of simultaneous equations and results confirm a bi-directional relationship between FDI and life expectancy. Hence, FDI positively impacts life expectancy and a good health level attracts FDI to the region.

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# 1 INTRODUCTION

Economic development has been at the center of many studies within the field of development economics, with policymakers showing significant concern about advancing population health. For example, improving health conditions and in particular reducing both infant and child mortality by 2030, constitute an important aim of the Sustainable Development Goals (SDGs). Kiross et al. (2020) posit that Sub-Saharan Africa (SSA) remains one of the regions characterized by a low population health outcome despite observable improvements over the years due to the Millennium Development Goals (MDGs). SSA region alone accounted for around 53 percent of the world under-five deaths in 2019. More precisely, the region recorded a child mortality rate of 76 deaths per thousand births. Analogously, SSA recorded for the same year a neonatal mortality rate of 27 deaths per thousand live births making it the region with the highest neonatal mortality (UN IGME, 2020). However, it is worth indicating that, the low health outcomes in the region have been worsened by the Covid-19 pandemic. Therefore, it is important to understand how population health can be improved. Some empirical studies highlight the determinants of population health. For example, trade is found to enhance health outcome (Herzer, 2017; Novignon et al. 2018). Other determinants of health are: health aid (Mishra & Newhouse, 2009), economic complexity (Vu, 2020) and remittances (Zhunio et al. 2012; Amega, 2018).

Foreign Direct Investment (FDI) plays a very important role in the process of economic development in low-income countries. Noorbakhsh et al. (2001) indicate that many developing countries believe that FDI helps overcome both resource and skills constraints. Therefore, FDI is complementary to domestic capital in promoting economic development in the recipient economy. Following this, many studies have investigated the macroeconomic effects of FDI and concluded that it stimulates economic growth (Borensztein et al. 1998; Li & Liu, 2005; Baiashvili & Gattini, 2020), promotes economic complexity (Kannen, 2020) and increases expenditure on education (Zhuang, 2013). Despite the vast literature showing the positive spillover effect of inward FDI on different sectors of the economy, very few studies focus on assessing the potential effect of FDI on population health.

From a theoretical point of view, FDI inflow can produce a mixed effect on population health. On the one hand, inward FDI might improve health outcomes through several ways. First, FDI inflows can stimulate income growth which in turn leads to an increase in both public and private expenditure in the health care sector (Nagel et al., 2015; Immurana, 2020). Secondly, horizontal FDI increases accessibility of medical goods and services in the host country by making them available at a lower price. Furthermore, FDI through spillovers of technology and medical knowledge can indirectly increase the productivity of domestic enterprises operating in the health care sector (Nagel et al., 2015). Moreover, multinational companies can positively affect population health by building hospitals and providing drinking water infrastructure as part of their corporate social responsibilities (Immurana, 2020). On the other hand, skeptics argue that FDI worsens health outcomes by raising the pollution level or by increasing the consumption of unhealthy food or harmful products like tobacco (Jorgenson, 2009; Burns et al. 2017). In addition, multinational enterprises may oust domestic firms leading to an increase in both unemployment and inequality, thereby lowering health outcomes (Immurana, 2020). Furthermore, the adverse effect of FDI on population health may lead to an increase in workers' stress caused by higher competition dynamics induced by the foreign firms (Herzer & Nunnenkamp, 2012).

Empirical evidence presents an inconclusive result on the impact of FDI on health outcomes. As earlier mentioned, the FDI-health nexus has received little attention in the literature. One strand of the literature suggests that FDI inflow promotes health outcomes in the host country. Nagel et al. (2015) assess the impact of FDI on population health using a sample of 179 countries comprising both developed and developing countries. The authors found that FDI reduces infant mortality. Similarly, Burns et al. (2017) investigate the FDI-health nexus using a sample of 85 low and middle income countries over the period from 1974 to 2012 and found that FDI promotes life expectancy.

However, they did not find any impact of FDI on both infant and child mortality. The authors argue that this mixed result could be explained by the fact that, FDI promotes life expectancy by increasing the wages of skilled workers thereby bettering their living conditions. A more recent study by Immurana (2020) corroborates the result on the positive linkage between FDI and population health using a panel of 43 African countries. The author employed a fixed effect estimator and found that FDI net inflow increases life expectancy on the continent. Conversely, Herzer & Nunnenkamp (2012) found a negative long-run relationship between FDI and population health in 14 developed countries over the period 1970 - 2009. More precisely, empirical results showed that an increase in FDI produces an adverse effect on life expectancy in the developed countries.

Our study differs from Immurana (2020) and enhances the limited existing literature on the FDI - health nexus in several ways. Firstly, our focus is on SSA countries while Immurana (2020) used a sample of 43 African countries including some MENA countries. To the best of our knowledge, no existing study ascertains the relationship between FDI net inflows and health for the specific case of the SSA region. Secondly, we analyze a potential channel through which FDI indirectly affects population health. The literature shows the role of income in promoting population health (Asiedu et al., 2015). Hence, we examine the interaction between FDI and per-capita income to investigate the role the latter plays on the FDI-health nexus. Furthermore, as the empirical strategy, we use the system Generalized Method of Moments (SGMM) but we also estimate a Simultaneous Equation Model (SEM) to show the bi-directional causational link between FDI and life expectancy meaning that FDI promotes life expectancy in the region and, in turn, a higher level of life expectancy attracts FDI.

In this research, we consider life expectancy as the primary proxy for population health for three main reasons. First, it depends on both infant mortality as well as other mortality rates, thereby encompassing mortality rates across all phases of life. Second, it is unaffected by age distribution. Third, data on life expectancy are available for a substantial number of countries and various time periods (Herzer, 2017).

Our study reveals several interesting results. Firstly, FDI promotes population health in SSA. Secondly, we find an inverted U-shaped relationship between FDI and life expectancy. Moreover, we show that FDI promotes population health in the SSA region through the per-capita income channel. Finally, results reveal a bi-directional causal relationship between life expectancy and FDI. In other words, FDI promotes life expectancy but at the same time, a higher level of life expectancy attracts FDI.

The rest of this paper is organized as follows. Section 2 presents the data and descriptive evidence. In section 3 we discuss the empirical strategy. The main results are discussed in section 4. Finally, we conclude and highlight some policy recommendations in section 5.

## 2 DATA AND DESCRIPTIVE EVIDENCE

We used a data set comprising 35 SSA countries over the period 1996- 2020. The variables used in this study were collected from both the World Development Indicator (WDI) and the World Governance Indicator (WGI). It is important to indicate that the choice of the period of analysis was guided by the availability of data. For example, Political Stability and Absence of Violence/Terrorism which was sourced from the WGI begins from 1996 onward.

Table 1 presents the summary statistics and description of the variables. This shows that in SSA region, life expectancy over the period of analysis varies from approximately 40 to 77 years with a mean of approximately 57 years. Furthermore, per- capita income growth has a mean of 1.8. Sierra Leone is the country which had the highest infant mortality rate in 1996 and the lowest infant mortality rate was recorded in Seychelles in the year 2000. Finally, child mortality rate ranges from 13,9 to 268.6 per thousand live births over the period of analysis.

**Table 1 : Summary statistics and description of variables**

| *Variable* | Description | Mean | Min | Max | *Std.Dev.* |
|---|---|---|---|---|---|
| *Infant mortality (INFANTM)* | It is the number of infants dying before reaching one year of age per 1000 live births | 61.8 | 11.9 | 147.5 | *26.3* |
| *Child mortality (CHILDM)* | It is the probability per 1,000 that a newborn baby will die before reaching age five, if subject to age-specific mortality rates of the specified year, per 1000 live births | 97.9 | 13.9 | 268.6 | *47.8* |
| *Adult mortality (ADULTM)* | Adult mortality rate is the probability of dying between the ages of 15 and 60 per 1000 adults | 338.5 | 124.9 | 763.9 | *112.4* |
| *Life expectancy (LIFEEXP)* | The number of years that a newborn infant would live (years) | 57.4 | 40.6 | 77.2 | *6.9* |
| *Survival to age 65 (SURVIVAL)* | The percentage of a cohort of newborn infants that would survive to age 65 (% of cohort) | 50.9 | 15.4 | 79.5 | *12.0* |
| *Per-capita Income growth (PI)* | GDP per capita growth (Annual %) | 1.8 | -36.8 | 140.8 | *7.2* |
| *Political Stability and Absence of Violence/Terrorism (PS)* | measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism (In units of a standard normal distribution, ranging from -2.5 to 2.5)) | -0.4 | -2.7 | 1.3 | *0.8* |
| *FDI* | Foreign direct investment, net inflows (%GDP) | 3.8 | -17.3 | 161.8 | *8.4* |
| *Trade openness (TRADE)* | Sum of imports and exports (%GDP) | 67.6 | 21.0 | 222.1 | *35.0* |
| *GOVHEALTHEXP* | Domestic general government health expenditure (% of general government expenditure) | 7.0 | 0.7 | 17.9 | *3.3* |
| *PHYSICIANS* | Physicians per 1000 people | 0.3 | 0.01 | 2.7 | *0.4* |
| *SANITATION* | People using at least basic Sanitation (% of population) | 34.4 | 3.4 | 100 | *23.1* |
| *Tertiary enrollment (HC)* | Population of the age group that officially corresponds to the level of education (% gross) | 7.4 | 0.3 | 42.8 | *7.4* |
| *Inflation rate (INFL)* | Inflation, consumer prices (annual %) | 7.0 | -9.0 | 557.2 | *22.1* |

Notes: Authors' compilation

Table 2 displays the 35 countries used for our research along with the average values of both the dependent variable (life expectancy) and the variable of interest (FDI) over the period from 1996 to 2020. We notice that both variables are heterogeneous across countries over the period of analysis. Seychelles has the highest life expectancy followed by Mauritius, Gabon, Mauritania and Senegal.

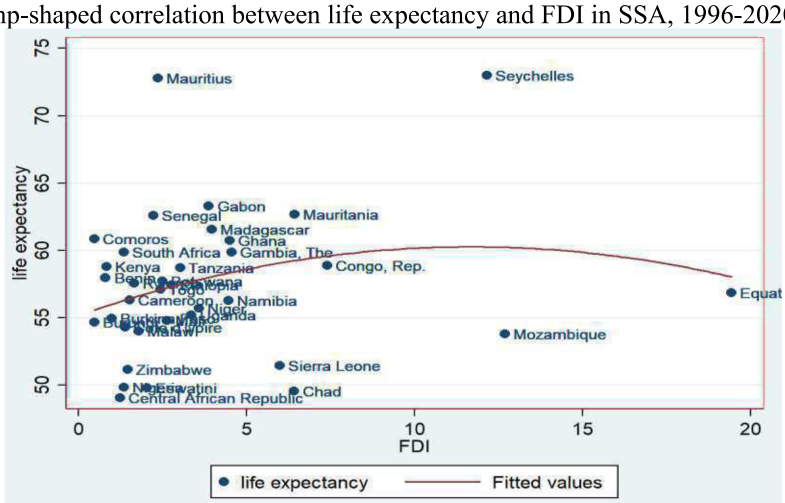
**Table 2: Countries and summary statistics**

| | Avg LIFEEXP | Avg FDI | | Avg LIFEEXP | Avg FDI |
|---|---|---|---|---|---|
| *Benin* | 58.0 | 0.8 | Madagascar | 61.5 | *4.0* |
| *Botswana* | 57.7 | 2.5 | Malawi | 54.0 | *1.8* |
| *Burkina Faso* | 55.0 | 1.0 | Mali | 54.8 | *2.6* |
| *Burundi* | 54.7 | 0.5 | Mauritania | 62.7 | *6.4* |
| *Cameroon* | 56.3 | 1.5 | Mauritius | 72.8 | *2.4* |
| *Central African, Rep* | 49.0 | 1.2 | Mozambique | 53.8 | *12.7* |
| *Chad* | 49.6 | 6.4 | Namibia | 56.2 | *4.5* |
| *Comoros* | 60.9 | 0.5 | Niger | 55.7 | *3.6* |
| *Congo, Rep* | 58.9 | 7.4 | Nigeria | 49.8 | *1.4* |
| *Cote d'Ivoire* | 54.3 | 1.4 | Rwanda | 57.5 | *1.7* |
| *Equatorial Guinea* | 56.8 | 19.4 | Senegal | 62.6 | *2.2* |
| *Eswatini* | 49.8 | 2.1 | Seychelles | 73.0 | *12.1* |
| *Ethiopia* | 57.4 | 2.8 | South Africa | 59.9 | *1.3* |
| *Gabon* | 63.3 | 3.9 | Sierra Leone | 51.5 | *6.0* |
| *Rep,The Gambia* | 59.9 | 4.6 | Tanzania | 58.7 | *3.0* |
| *Ghana* | 60.7 | 4.5 | Togo | 57.1 | *2.4* |
| *Kenya* | 58.8 | 0.8 | Uganda | 55.1 | *3.4* |
| | | | Zimbabwe | 51.2 | *1.5* |

Notes: Authors' compilation. The acronym Avg stands for average*

On the other hand, the country with the lowest life expectancy is Central African Republic followed by Chad, Eswatini and Nigeria. The SSA country with the highest net FDI inflows was Equatorial Guinea followed by Mozambique, Seychelles and Republic of Congo.

Fig 1. Hump-shaped correlation between life expectancy and FDI in SSA, 1996-2020




Source: Authors' computation.

Figure 1 shows a non-linear inverted U-shaped relationship between life expectancy and FDI net inflows for 35 SSA countries from 1996 to 2020.

## 3 EMPIRICAL STRATEGY

Our model is inspired from the literature on the determinants of population health (Mishra & Newhouse, 2009; Immurana, 2020). We specify three different models which allow us to assess both the linear and non-linear effects of FDI on health. Our baseline equation takes the following form:

$$\text{LIFEEXP}_{it} = \beta_0 + \beta_1 \text{ LIFEEXP}_{i,t-1} + \beta_2 FDI_{it} + \beta_i X_{it} + \mu_i + \eta_t + \varepsilon_{it} \qquad (1)$$

Where $\text{LIFEEXP}_{it}$ stands for life expectancy, $\text{LIFEEXP}_{i,t-1}$ is the lagged term of life expectancy, $FDI_{it}$ represents foreign direct investment net inflows and $X_{it}$ is a matrix of controls comprising determinants of population health; per-capita income growth, sanitation, trade and political instability. The parameter $\mu_i$stands for country specific fixed-effects, $\eta_t$ is the time specific-effect and $\varepsilon_{it}$, the error term. We then proceed by estimating a specification where the squared term of FDI is included (in equation 1) as an additional explanatory variable. This helps us capture a possible non-linear linkage between FDI and health. Finally, to assess the role that per-capita income plays on the FDI-health nexus, we construct an interaction term between FDI and income per-capita. This newly constructed variable is then added in equation (1) as an explanatory variable.

We estimate all three specifications using a Generalized Method of Moments (GMM) estimator (Arellano & Bover, 1995; Blundell & Bond, 1998) which improves the efficiency and avoids the weak instruments problem observed in the first-difference GMM by Arellano and Bond (1991). This includes the lagged dependent variable as an explanatory variable enabling us to capture both endogenous and predetermined variables. However, Nickell (1981) indicates that dynamic panel bias is caused by the correlation between the lagged dependent variable and the fixed effects in the error term, but this can be corrected by taking the first difference of the original model. But the differenced lagged dependent variable (and other endogenous variables) and the disturbance term can still be correlated. Therefore, we use external instruments in addition to the internal instruments, that is, both the lagged dependent variable and the differenced lagged dependent variable. This is because, internal instruments alone do not suffice to eliminate the endogenous components in the data. We also report regressions results using both the OLS and FE estimators. In the OLS regression, the lagged dependent variable is positively correlated with the error term giving rise to an upward biased coefficient, while the FE gives a downward biased coefficient (Nickell, 1981). Hence, SGMM estimates are consistent if its lagged dependent variable lies between that of the OLS and FE.

The Hansen-J test of over-identification and the Arellano-Bond test for autocorrelation are used to ensure that our SGMM estimates are consistent. The Hansen's test confirms the validity of our instruments while the Arellano-Bond test verifies the absence of no second order serial correlation.

# 4 MAIN RESULTS AND DISCUSSION

## 4.1 Linear impact of FDI on health

The regression results are displaced in Table 3, we control for political stability, per-capita income and trade and sanitation. Columns (1) and (2) report results using the OLS and the FE respectively, while column (3) displays our baseline results obtained using the SGMM estimator.

The diagnostic tests performed are the Hansen-J test of over-identification and the Arellano-Bond test. The former tests the null hypothesis that the instruments used for the estimation analysis are valid instruments and are uncorrelated with the error term. The null hypothesis of the Arellano bond test is that there is no autocorrelation. The results confirm both the validity of the instruments and the absence of second order serial correlation.

The empirical findings obtained reveal that the coefficient on FDI is positive and statistically significant at 1% level of significance. This shows that an increase in FDI to the SSA region leads to an increase in life expectancy. This result supports the view that FDI promotes population health and confirms the result obtained by Nagel et al. (2015); Burns et al. (2017); Immurana (2020) but contrasts with Herzer & Nunnenkamp (2012) who found a negative linkage between FDI and health in developed countries.

| Table 3: Linear impact of FDI on health | | | |
|---|---|---|---|
| | Col (1) shows OLS | Col (2) shows FE | Col (3) shows SGMM |
| **VARIABLES** | LIFEEXP | LIFEEXP | LIFEEXP |
| **L.LIFEEXP** | 0.973*** | 0.963*** | 0.970*** |
| | (0.004) | (0.008) | (0.013) |
| **FDI** | 0.009* | 0.006 | 0.075*** |
| | (0.005) | (0.005) | (0.025) |
| **PS** | 0.009 | -0.065 | 0.072 |
| | (0.033) | (0.060) | (0.105) |
| **PI** | 0.021*** | 0.020*** | 0.067** |
| | (0.005) | (0.005) | (0.027) |
| **TRADE** | -0.003*** | -0.006*** | -0.011* |
| | (0.001) | (0.002) | (0.006) |
| **SANITATION** | 0.004*** | 0.005 | 0.009 |
| | (0.001) | (0.006) | (0.006) |
| **Constant** | 2.009*** | 2.733*** | 2.294*** |
| | (0.239) | (0.391) | (0.811) |
| **Obs** | 619 | 619 | 529 |
| **R-squared** | 0.993 | 0.979 | |
| **AR (1)** | | | 0.011 |
| **AR (2)** | | | 0.971 |
| **Hansen test (p-value)** | | | 0.890 |

Notes: Authors' compilation. Robust standard errors are reported in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We argue that the positive impact of FDI on population health in the region could be explained by the fact that FDI raises income per-capita enabling Sub-Saharan Africans to afford health care, better living conditions in terms of access to drinking water, healthier food and better housing conditions.

We also find that the coefficient on trade openness is negative and statistically significant. This indicates that an increase in trade openness will decrease life expectancy. This contrasts with the results obtained by Herzer (2017) and Novignon et al. (2018). The negative impact of trade openness on health could be due to several reasons. First, trade might increase income inequality, consequently negatively impacting public health. Second, it might reduce the availability of resources to local population to favor exports. Finally, the globalization process has spread the adoption of unhealthy habits such as the consumption of unhealthy food, drugs and tobacco. In addition, results show positive and significant effect of per-capita income on life expectancy. This is consistent with Pritchett & Summers (1993); Mishra & Newhouse (2009); Nagel et al. (2015); Asiedu et al. (2015) and Jetter et al. (2019) who found a positive significant relationship between per-capita income and health. This could be explained by the fact that higher per-capita income leads to better housing and increases the possibility of paying for medical services. Moreover, higher per-capita income growing countries are countries with better health infrastructures.

Table 4 displays results when we extend equation (1) with the quadratic (squared term) FDI term to capture a possible nonlinear relationship between FDI and health. Column (1) and column (2) show the OLS and FE results respectively, while column (3) displays our preferred regression results using the SGMM estimator.

| Table 4: Extended estimations: Evidence of an inverted U-shaped curve | | | |
|---|---|---|---|
| | Col (1) shows OLS | Col (2) shows FE | Col (3) shows SGMM |
| **VARIABLES** | LIFEEXP | LIFEEXP | LIFEEXP |
| **L.LIFEEXP** | 0.9734*** | 0.9637*** | 0.9732*** |
| | (0.004) | (0.008) | (0.018) |
| **FDI** | 0.005 | -0.002 | 0.130*** |
| | (0.008) | (0.008) | (0.043) |
| **PS** | 0.010 | -0.067 | -0.010 |
| | (0.034) | (0.060) | (0.077) |
| **PI** | 0.021*** | 0.021*** | 0.013 |
| | (0.005) | (0.005) | (0.010) |
| **TRADE** | -0.003*** | -0.006*** | -0.008*** |
| | (0.001) | (0.002) | (0.003) |
| **SANITATION** | 0.004*** | 0.005 | 0.009 |
| | (0.001) | (0.006) | (0.008) |
| **$FDI^2$** | 0.0001 | 0.0003 | -0.001* |
| | (0.0002) | (0.0002) | (0.001) |
| **Constant** | 2.007*** | 2.726*** | 1.830* |
| | (0.240) | (0.391) | (0.935) |
| **Obs** | 619 | 619 | 549 |
| **R-squared** | 0.993 | 0.979 | |
| **AR (1)** | | | 0.006 |
| **AR (2)** | | | 0.503 |
| **Hansen test (p-value)** | | | 0.801 |

Notes: Authors' compilation. Robust standard errors are reported in parentheses, $^{*}\ p < 0.10$, $^{**}\ p < 0.05$, $^{***}\ p < 0.01$.

Findings reveal that the coefficient of the standalone effect of FDI on population is still positive and statistically significant at 1% level. The coefficient on the squared FDI term is negative and statistically significant. This suggests an inverted U-shaped relationship between FDI and life expectancy. In particular, FDI is detrimental to life expectancy when its percentage share to GDP is higher than 52.5%[1]. This can be explained by the fact that above this threshold, FDI increases the level of pollution in the recipient country. Furthermore, it might also be because of an increase in the stress of workers. Additionally, multinational enterprises may oust domestic firms leading to an increase in both unemployment and inequality as observed by Immurana (2020).

## 4.2 FDI- Health nexus: The role of income per capita

The regression results which incorporate effects of the interaction between FDI and per-capita income growth are reported in Table 5. Columns (1) and (2) show the OLS and FE results respectively while column (3) displays our preferred results.

Empirical results obtained confirm the positive impact of FDI on life expectancy. The standalone coefficient of FDI is still positive and statistically significant. Looking at other controls, the coefficient on sanitation becomes positive and statistically significant. This means that good sanitation raises life expectancy in the region. This result is consistent with Rahman et al. (2022), suggesting that, inadequate sanitation leads to the spread of numerous diseases like cholera, diarrhea, typhoid, and more, thereby reducing life expectancy.

[1] We therefore calculate the threshold level by partially differentiating the non-linear equation with respect to FDI and equating it to zero. δ LIFEEXP/δ FDI = 0.1302 - 2(0.00124) X=0, this gives us a threshold of X equal to 52.5

| Table 5: Extended estimations: Interaction variable with Per-capita income | | | |
|---|---|---|---|
| | Col (1) shows OLS | Col (2) shows FE | Col (3) shows SGMM |
| **VARIABLES** | LIFEEXP | LIFEEXP | LIFEEXP |
| **L.LIFEEXP** | 0.973*** | 0.963*** | 0.965*** |
| | (0.004) | (0.008) | (0.013) |
| **FDI** | 0.010** | 0.007 | 0.071** |
| | (0.005) | (0.005) | (0.031) |
| **PS** | 0.007 | -0.06 | 0.014 |
| | (0.034) | (0.060) | (0.093) |
| **PI** | 0.026*** | 0.023*** | 0.145*** |
| | (0.006) | (0.006) | (0.047) |
| **TRADE** | -0.003*** | -0.006*** | -0.009 |
| | (0.001) | (0.002) | (0.006) |
| **SANITATION** | 0.004*** | 0.005 | 0.009* |
| | (0.001) | (0.006) | (0.005) |
| **FDI*PI** | -0.001 | -0.001 | -0.014** |
| | (0.001) | (0.001) | (0.007) |
| **Constant** | 2.015*** | 2.724*** | 2.469*** |
| | (0.239) | (0.391) | (0.824) |
| **Observations** | 619 | 619 | 619 |
| **R-squared** | 0.993 | 0.979 | |
| **AR (1)** | | | 0.006 |
| **AR (2)** | | | 0.511 |
| **Hansen test (p-value)** | | | 0.956 |

Notes: Authors' compilation. Robust standard errors are reported in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Regarding the interaction term (FDI × PI), its coefficient is negative and significant. This result implies that the positive effect of FDI on life expectancy is stronger in slower per-capita income growing countries than in faster growing ones. Moreover, results suggest that FDI increases life expectancy in the region when per-capita income growth rate is below 5.07[2].

## 4.3 Robustness checks

In this subsection, we carry out several robustness checks to confirm our results. We begin by assessing if the results obtained are robust to alternative proxies for population health. These indicators are- child mortality rate, infant mortality rate, adult mortality rate and survival to the age of 65.

Table 6 presents the results using the above mentioned four alternative proxies for health. Columns (1), (2), (3) and (4) indicate results when child mortality rate, infant mortality, adult mortality rate and survival to age of 65 are employed as dependent variables respectively.

[2] The threshold value of PI can be calculated by equating the marginal effect of FDI to zero, that is, when: $\delta\ INFANTM \backslash \delta\ FDI = 0.071 - 0.014X = 0$. This gives a result of x equal to 5.07.

| Table 6: Alternative Proxies for health | | | | |
|---|---|---|---|---|
| **VARIABLES** | Col (1) shows CHILDM | Col (2) shows INFANTM | Col (3) shows ADULTM | Col (4) shows SURVIVAL |
| **L.CHILDM** | 0.943*** | | | |
| | (0.013) | | | |
| **L.INFANTM** | | 0.956*** | | |
| | | (0.015) | | |
| **L.ADULTM** | | | 0.962*** | |
| | | | (0.0141) | |
| **L.SURVIVAL** | | | | 0.961*** |
| | | | | (0.009) |
| **FDI** | -0.216** | -0.113* | -0.880* | 0.083** |
| | (0.103) | (0.061) | (0.509) | (0.039) |
| **PS** | 0.045 | 0.094 | 9.107 | 0.054 |
| | (0.265) | (0.157) | (6.422) | (0.120) |
| **PI** | -0.287** | -0.101* | -1.769** | 0.171*** |
| | (0.118) | (0.054) | (0.666) | (0.059) |
| **TRADE** | 0.033*** | 0.017** | 0.163 | -0.011 |
| | (0.010) | (0.00682) | (0.117) | (0.007) |
| **SANITATION** | -0.064*** | -0.0287* | -0.583* | 0.014* |
| | (0.020) | (0.0167) | (0.298) | (0.008) |
| **FDI*PI** | 0.037** | 0.0143* | 0.285** | -0.011** |
| | (0.017) | (0.00769) | (0.136) | (0.005) |
| **Constant** | 2.763 | 1.242 | 23.83** | 2.608*** |
| | (1.660) | (1.176) | (11.15) | (0.520) |
| **Obs** | 610 | 610 | 426 | 379 |
| **AR (1)** | 0.007 | 0.024 | 0.008 | 0.004 |
| **AR (2)** | 0.850 | 0.428 | 0.148 | 0.242 |
| **Hansen test (p-value)** | 0.994 | 0.979 | 0.923 | 1.000 |

Notes: Authors' compilation. Robust standard errors are reported in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The empirical results corroborate our previous findings on the positive role of FDI on health irrespective of the health indicator used. Also, the conditional effect of per-capita income on the linkage between FDI and population health is further confirmed. Columns (1) to Columns (3) show that the coefficient on FDI (for the three different mortality rates) is negative and statistically significant at 5 % level. Moreover, the interaction variable in these regressions is positive and significant. In addition, we found that FDI inflow increases survival to the age of 65. This clearly indicates that a rise in FDI promotes health. The coefficient of the interaction term is negative and statistically significant at 5% level indicating that FDI promotes survival to the age of 65 more in low per-capita income countries than in higher per-capita income countries.

Furthermore, we verify if the results are robust to alternative specifications. To do this, we add in different steps three explanatory variables. Findings are displayed in Table 7 and Column (1), (2), (3) show regression results when we add general government health expenditure, human capital and physicians per 1000 respectively. In addition, column (4) displays results when we add the three additional controls together in the model.

Table 7 indicates that our results are robust to alternative specifications. More precisely, the coefficient on FDI is still positive and statistically significant in all the different estimates. Furthermore, the role of per-capita income on the FDI-population health nexus is further confirmed.

| Table 7: Alternative specifications | | | | |
|---|---|---|---|---|
| **VARIABLES** | Col (1) shows LIFEEXP | Col (2) shows LIFEEXP | Col (3) shows LIFEEXP | Col (4) shows LIFEEXP |
| **L.LIFEEXP** | 0.958*** | 0.955*** | 0.949*** | 0.950*** |
| | (0.017) | (0.016) | (0.013) | (0.020) |
| **FDI** | 0.077** | 0.037** | 0.055** | 0.065** |
| | (0.028) | (0.017) | (0.024) | (0.025) |
| **PS** | 0.120 | 0.100 | 0.055 | 0.113 |
| | (0.136) | (0.096) | (0.056) | (0.106) |
| **PI** | 0.128*** | 0.080* | 0.093** | 0.103** |
| | (0.046) | (0.044) | (0.039) | (0.047) |
| **TRADE** | -0.015 | -0.011* | -0.009** | -0.010 |
| | (0.010) | (0.006) | (0.004) | (0.007) |
| **SANITATION** | 0.015 | 0.013*** | 0.010* | 0.008* |
| | (0.012) | (0.004) | (0.005) | (0.004) |
| **FDI*PI** | -0.012* | -0.006** | -0.008* | -0.010** |
| | (0.006) | (0.003) | (0.004) | (0.005) |
| **GOVHEALTHEXP** | -0.018 | | | 0.020 |
| | (0.066) | | | (0.039) |
| **HCT** | | 0.009 | | 0.024 |
| | | (0.017) | | (0.025) |
| **PHYSICIANS** | | | 0.023 | -0.297 |
| | | | (0.266) | (0.411) |
| **Constant** | 3.236* | 3.135*** | 3.414*** | 3.260** |
| | (1.604) | (0.859) | (0.815) | (1.202) |
| **Obs** | 610 | 398 | 298 | 201 |
| **AR (1)** | 0.008 | 0.005 | 0.013 | 0.028 |
| **AR (2)** | 0.575 | 0.833 | 0.632 | 0.195 |
| **Hansen test (p-value)** | 0.929 | 0.996 | 0.983 | 0.997 |

Notes: Authors' compilation. Robust standard errors are reported in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We earlier argued that per-capita income is an important channel through which FDI impact health in SSA. One way to empirically verify this argument is by estimating an equation where per-capita income growth is the dependent variable and is a function of explanatory variables.

$$PI_{i,t} = \beta_0 + \beta_1 PI_{i,t-1} + \beta_2 FDI_{it} + \beta_i X_{it} + \mu_t + \eta_i + \varepsilon_{it} \tag{2}$$

Where $PI_{i,t}$ represents per-capita income growth. $FDI_{it}$ is foreign direct investment and $X_{it}$ is matrix of controls which is made up of variables which might impact per- capita income. These variables are: political stability, trade and life expectancy. Empirical findings are reported in Table 8. Columns 1, 2 and 3 show results when using the OLS, FE and SGMM estimators respectively. Looking at column (3), the SGMM estimation, we find that FDI inflow increases per-capita income growth in SSA, confirming our hypothesis.

| | Table 8: Per- capita income channel | | |
|---|---|---|---|
| | Col (1) shows OLS | Col (2) shows FE | Col (3) shows SGMM |
| **VARIABLES** | PI | PI | PI |
| **L.PI** | 0.277*** | 0.184*** | 0.223** |
| | (0.038) | (0.039) | (0.085) |
| **FDI** | 0.056 | 0.044 | 0.435** |
| | (0.038) | (0.040) | (0.167) |
| **PS** | 0.277 | 0.515 | 0.519 |
| | (0.264) | (0.450) | (0.873) |
| **TRADE** | -0.005 | 0.034** | 0.055 |
| | (0.006) | (0.014) | (0.037) |
| **LIFEEXP** | -0.033 | -0.103** | -0.226** |
| | (0.031) | (0.047) | (0.108) |
| **Constant** | 2.998 | 4.791 | 9.181 |
| | (1.857) | (2.963) | (5.991) |
| **Obs** | 656 | 656 | 625 |
| **R-squared** | 0.087 | 0.066 | |
| **AR (1)** | | | 0.001 |
| **AR (2)** | | | 0.164 |
| **Hansen test (p-value)** | | | 0.999 |

Notes: Authors' compilation. Robust standard errors are reported in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Lastly, our study might suffer from reverse causation. That is, an increase in inward FDI might offer better health opportunities for a population. At the same time, FDI inflow can be affected by population health. More specifically, population health might raise workers' productivity via the human capital channel which in turn can attract FDI. On the other hand, a country might be less attractive to foreign firms if high rates of employee turnover or absenteeism are observed (Alsan et al., 2006). Consequently, we specify a structural model of two equations: In this model, we specify two equations: the population health equation (equation 3) and the FDI equation (equation 4). This specification allows us to further consider explicitly reverse causation between health and FDI. The specification of the structural form of the model is as follow:

$$\begin{cases} LIFEEXP = \alpha_{(1)} + \beta_{(1)} FDI_{it} + \lambda_{(1)} X_{(1)it} + \mu_i + \Gamma_t + \varepsilon_{it} & (3) \\ FDI = \alpha_{(2)} + \beta_{(2)} LIFEEXP_{it} + \lambda_{(2)} X_{(2)it} + \mu_i + \Gamma_t + \varepsilon_{it} & (4) \end{cases}$$

$X_{(1)}$ and $X_{(2)}$ denote the vectors of exogenous variables appearing in equation $(1)$ and $(2)$ respectively. $\gamma_{(1)}$ and $\gamma_{(2)}$ represent the vectors of parameters associated with each element of $X_{(1)}$ and $X_{(2)}$. $\varepsilon_{(1)}$ and $\varepsilon_{(2)}$ are the usual error terms with $E(\varepsilon)=0$. The health equation controls for FDI, political stability (PS), per-capita income (PI) , trade and physicians. The FDI equation controls for life expectancy, political stability, per-capita income, trade and inflation (INFL).

Results of the simultaneous equation model is displayed in Table 9. The J statistic of the Hansen test of over-identification of restrictions is not significant indicating that the over-identifying restrictions are valid. Column 1 displays the result of the health equation (3) whilst column 2 shows the results of the FDI equation (4). The results displayed in column 1 show that the coefficient of FDI is positive and statistically significant at 1 percent. Column 2 shows that the coefficient of life expectancy is positive and statistically significant at 1 percent. This suggests a bi-directional relationship between FDI and life expectancy meaning that FDI promotes life expectancy in the region and, in turn, a higher level of life expectancy attracts FDI.

**Table 9: Results of the simultaneous equation model**

| VARIABLES | Col (1) shows LIFEEXP | Col (2) shows FDI |
|---|---|---|
| **FDI** | 0.542*** | |
| | (0.130) | |
| **LIFEEXP** | | 0.132*** |
| | | 0.048 |
| **PS** | 0.465 | -0.563 |
| | (0.610) | (0.427) |
| **PI** | -0.657 | 0.382 |
| | 0.577 | (0.491) |
| **TRADE** | -0.101 *** | 0.046*** |
| | (0.023) | (0.016) |
| **PHYSICIANS** | 27.093*** | |
| | (8.839) | |
| **INFL** | | 0.010 |
| | | (0.012) |
| **Constant** | -8.375** | -8.375** |
| | (3.637) | (3.724) |
| **Hans's J chi2** | 5.794 | 5.794 |
| **P-value** | 0.122 | 0.122 |
| **Number of countries** | 35 | 35 |
| **Nmber of observations** | 276 | 276 |

Notes: Authors' compilation. Robust standard errors are reported in parentheses, * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

## 5 CONCLUSION AND POLICY RECOMMENDATIONS

The objective of this paper was to investigate both the linear and non-linear impact of FDI on population health in 35 Sub-Saharan African countries over the period from 1996 to 2020 using a system Generalized Method of Moments (SGMM). We contributed to the literature by shedding more light on this linkage which hitherto has received little attention.

Results from the linear specification show that FDI has a direct positive impact on population health in SSA. This result is consistent with Nagel et al. (2015); Burns et al. (2017); Immurana (2020) but contrasts with Herzer et al. (2012). We show that FDI promotes population health by increasing the per-capita income of Sub-Saharan Africans which enables them afford health care and better living conditions. Furthermore, we found that FDI exhibits an inverted U-shaped relationship with life expectancy. Moreover, per-capita income is a channel through which FDI affects population health in the region. This result is robust to alternative proxies for population health and alternative specifications. Our analysis further shows that per-capita income growth and trade openness and sanitation are determinants of population health in Sub-Saharan Africa. Lastly, using the simultaneous equation model, we confirm a bi-directional relationship between FDI and life expectancy.

We formulate a set of policy recommendations in view of achieving the Sustainable Development Goal (SDG 3) related to health especially in SSA. First, the less developed and slowly growing SSA countries are encouraged to improve their institutional quality to attract more FDI inflows. This can be done by reducing corruption levels, enforcing property rights. Secondly, efforts should be done towards increasing income per-capita in SSA. This could be achieved by reducing bureaucratic bottlenecks faced by entrepreneurs and by increasing private investments. Third, the governments of more growing SSA countries should control for good health outcomes through regulations and laws to prevent FDI from negatively affecting population health.

Future research on the FDI-health nexus should explore different research questions to help better understand the linkage between FDI and population health. First, studies should be carried out to analyze both the long and short-run impact of FDI on population health. This is because FDI might raise per-capita income after a certain period. Therefore, it is important to understand the differential impact of FDI on population health. Second, investigating morbidity (incidence rate or incidence proportion) rather than mortality might be a shortcoming of this research (Nagel et al., 2015). Therefore, we suggest that future research endeavors could focus on investigating the connection between Foreign Direct Investment (FDI) and morbidity.

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