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The impact of HIV/AIDS on foreign direct investment: Evidence from Sub-Saharan Africa

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Abstract

We construct a theoretical model that examines the relationship between HIV/AIDS and foreign direct investment and employ panel data from 41 countries in Sub-Saharan Africa (SSA) to test the implications of the model. We find that HIV/AIDS has a negative but diminishing effect on FDI. Furthermore, the adverse effect occurs even when the HIV prevalence rate is as low as 0.1%. The result has important policy implications for SSA countries.

JEL classification: F21; I15; O19
Keywords: Foreign direct investment; HIV/AIDS

> When labor supply, its quality and potential productivity are diminished as a result of HIV/AIDS, these trends act to discourage foreign direct investment, that is essential for economic development.
>
> [ILO (2005:8).]

1. Introduction

The above quote suggests that foreign direct investment (FDI) is important for economic development and that HIV/AIDS impedes FDI.[3] Indeed, the negative effect of HIV/AIDS on FDI is consistent with the 2003 World Economic Forum (WEF) survey, where about 33% of business leaders in developing countries that participated in the survey reported that HIV/AIDS has "affected their country's access to FDI in the past five years."[4] It is important to note that examining the effect of HIV/AIDS on FDI is crucial for countries in Sub-Saharan African (SSA) for the following two reasons. First, FDI is crucial for poverty reduction in SSA, however, the region has received very little FDI and the investments are concentrated in only a few countries (Asiedu and Gyimah-Brempong, 2008; see Table 2). Second, a majority of the people infected with HIV/AIDS live in SSA (about 66% of the 33 million people infected with the disease live in SSA); the region has the highest new infection rates (in 2009, about 71% of newly infected adults lived in SSA); and the disease is the leading cause of death among adults in the region (UNAIDS, 2010).[5]

This paper theoretically and empirically examines the relationship between HIV/AIDS and FDI. Specifically, we construct a model that examines the relationship between HIV/AIDS and FDI and employ panel data from 41 countries in SSA

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[3] The growth enhancing and poverty reducing effect of FDI has also been documented in several empirical studies (e.g., Hansen and Rand, 2006).
[4] See Bloom et al. (2003) for a discussion of the survey results.
[5] Also, the top ten countries in the world with the highest HIV prevalence rates are all located in SSA: Swaziland (27%), Botswana (25%), Lesotho (25%), South Africa (21%), Zimbabwe (18%), Namibia (17%), Zambia (16%), Mozambique (14%), Malawi (13%) and Tanzania (7%).

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over the period 1990–2008 to test the implications of the model. For the theoretical model, we show that HIV/AIDS has a negative and non-linear effect on FDI, and we derive the conditions under which the non-linear effect is negative and diminishing. For the empirical analysis, we find that HIV/AIDS has a negative effect on FDI, the adverse effect occurs even when the prevalence rate is low (as low as 0.1%), and the negative effect diminishes as the HIV/AIDS prevalence rate rises. We also show that our results are robust: they hold when we control for market size, openness to trade, infrastructure development, and natural resource intensity in host countries.

The idea that HIV/AIDS may have an adverse effect on FDI is not implausible, for the simple reason that healthy workers are more productive than sick workers. As a consequence, one would expect the health status of workers in host countries to have an impact on FDI. It is therefore surprising that although there is an extensive empirical literature on the determinants of FDI to developing countries in general, and to Sub-Saharan African countries in particular, research on how the health status of workers in host countries affects FDI is scant and also recent.[6] We found only three papers that have included a measure of health as a determinant of FDI: Alsan et al. (2006), Azemar and Desbordes (2009), and Ghosh and Francesco (forthcoming). Alsan et al. (2006: 613) note that "To date, however, a relationship between population health and FDI has not been established in the empirical literature." They also assert that "To the best of our knowledge, this represents the first empirical investigation evaluating whether health directly affects FDI, ceteris paribus," (2006:614). This paper contributes to the thin literature on this important topic. Alsan et al. (2006) analyze the effect of life expectancy on FDI flows to developing countries.

The remainder of the paper is organized as follows. Section 2 presents the literature survey and Section 3 discusses some stylized facts about HIV/AIDS and FDI flows to SSA. Section 4 presents the theoretical model, Section 5 describes the data and the variables employed in the regressions, Section 6 reports of the empirical results and Section 7 concludes.

2. Literature review

As indicated in the introduction, our literature review revealed only three papers that have included a measure of health as a determinant of FDI. Alsan et al. (2006) analyze the effect of life expectancy on FDI flows to developing countries. Azemar and Desbordes (2009) analyze the indirect effect of HIV, tuberculosis and malaria on FDI to SSA countries. Specifically, they first analyze the impact of HIV, tuberculosis and malaria on life expectancy, and then examine the effect of life expectancy on FDI. Ghosh and Francesco (forthcoming) analyze the effect of communicable diseases on FDI to developing countries. All the studies conclude that good health promotes FDI.

This paper extends the health-FDI literature in three ways. First, unlike previous studies, the empirical analysis is based on a theoretical model with microfoundations. In addition, the model reflects two of the most important channels through which HIV/AIDS can affect FDI: a decline in productivity and an increase in absenteeism.[7] Second, the paper addresses some specification and endogeneity issues not considered in previous studies. Specifically, we find that the relationship between HIV/AIDS and FDI is non-linear, while in Azemar and Desbordes (2009) HIV is treated as linear in their regressions. With regard to endogeneity, the analysis of Oster (2009) and Herzer and Nunnenkamp (2012) points to the possibility that FDI may have a causal effect on HIV/AIDS, suggesting that the relationship between FDI and HIV/AIDS may be bi-directional.[8] Also, the data on HIV prevalence rates are likely to exhibit measurement errors (Bloom and Canning, 2008).[9] These two potential problems suggest that endogeneity may be a concern. In our empirical analysis, HIV/AIDS is treated as endogenous. Another issue is that several studies have found that past FDI is correlated with current FDI as in Busse and Hefeker (2007) and Asiedu et al. (2009). However, Alsan et al. (2006), Azemar and Desbordes (2009) and Ghosh and Francesco (forthcoming) do not take into account the persistent nature of FDI. We introduce the lagged FDI into the regression to capture its persistence. The system GMM estimator that we employ for our estimations accounts for unobserved country-specific effects, mitigates any potential endogeneity problems, permits the inclusion of lagged dependent variable as well as endogenous explanatory variables, and also accommodates panel data with short time periods.

The third contribution of the paper to the health-FDI literature is that it is the first paper to analyze the direct effect of HIV/AIDS on FDI. We focus on the effect of HIV/AIDS on FDI for the following reasons. First, HIV/AIDS is a global epidemic and the disease "has inflicted the single greatest reversal in human development in modern history" (UNDP, 2005: 10). Furthermore, the adverse effect of ill health on FDI is more profound for HIV/AIDS than other chronic and infectious disease.[10] Finally,

[6] See Anyanwu (2012) and Asiedu (2002) for an analysis of the determinants of FDI to SSA.

[7] For example in Swaziland, about 25% of the workers are absent from work every month because of HIV/AIDS (IRIN, 2009). Also, data from the 2003 WEF global survey and the 2005 South African Business Coalition on HIV/AIDS suggest that lower productivity and increased absenteeism are the main channels through which HIV/AIDS affects businesses. See Bloom et al. (2003) for a discussion of the survey results.

[8] Oster (2009) finds that exports have a positive and significant effect on HIV/AIDS in Sub-Saharan Africa. This suggests that export-oriented FDI (which is the type of FDI in most developing countries) may have a significant impact on HIV. The data on FDI by sector are not readily available for most SSA countries so we are unable to test this hypothesis. Hezer and Nunnenkamp (2012) find that FDI has a negative and significant impact on life expectancy in host countries.

[9] See Bloom and Canning (2008) for a detailed discussion.

[10] This observation is consistent with the 2003 WEF survey data. Specifically, about 60% of the firms operating in SSA reported that HIV/AIDS has a "serious impact" on their businesses. This contrasts with 50% for malaria and 39% for tuberculosis. The relatively large adverse effect of HIV/AIDS on FDI, vis-a-vis other infectious diseases, can be largely attributed to the fact that unlike other diseases, the most vulnerable group to HIV infection are working-age adults. About 92% of the people infected with HIV/AIDS are in the 15–49 age group (UNAIDS, 2010). Furthermore, in many moderate and high epidemic countries, the disease has led to a significant reduction in the size of the labor force, in particular, educated/skilled workers. If human capital and physical capital are complementary, then a decrease in the quality and quantity of human capital will result in a decline in physical capital (Sala-i-Martin, 2005).

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we argue that life expectancy is not appropriate for analyzing the impact of the health of workers on FDI for the following reasons: (i) it reflects the health status of the total population, including children and the elderly, two groups that are not part of the labor force; (ii) it measures mortality rates—does not take into account morbidity (sickness) rates (Bloom et al., 2003); (iii) it is highly correlated with other country characteristics that affect FDI flows (e.g., income per capita, infrastructure development), and this makes it difficult to isolate the effect of health on FDI.

The paper also contributes to the small but increasing literature that examines the effect of HIV/AIDS on the growth rate of income per capita. The findings from these studies are mixed. Some studies find a positive effect of HIV/AIDS on growth (e.g.,Young, 2005; McDonald and Roberts, 2006), others find a negative effect (e.g., Juhn et al., 2008; Kalemli-Ozcan and Turan, 2010), and some conclude that HIV/AIDS has no significant effect on income per capita growth (e.g., Bloom and Mahal, 1997).[11] Haacker (2004) asserts that the existing studies underestimate the effect of HIV/AIDS on growth. He argues that the existing studies analyze only the direct effect of HIV/AIDS on growth, and do not take into consideration the fact that the disease can impact growth indirectly by decreasing FDI. This paper contributes to the literature by examining one of the channels through which HIV/AIDS may indirectly affect economic growth.

3. HIV and FDI to Sub-Saharan Africa: some stylized facts

This section provides some stylized facts about HIV and FDI flows to SSA from 1990–2013. Table 1 shows the HIV prevalence rate for ages 15–49, and Tables 2 and 3 show net-FDI flows and FDI as a share of GDP to SSA, respectively.

3.1. HIV stylized facts

- The HIV prevalence rate increased from 1990–2004 and declined from 2005–2013. Over the period 1990–1994 to 2000–2004, the HIV prevalence rate increased by about 96% (from 3.2% to 6.3%) and it declined by about 19% over the period 2004–2013 (from 6.3% to 5.2%).
- The HIV prevalence rate varies significantly across country. For example, the prevalence rate for the period 2010–2013 ranges from a low of 0.2% for Sudan and 0.5% for Senegal, to a high of 27.4% and 22.9% for Swaziland and Lesotho, respectively.
- The HIV prevalence rate is higher for the countries in Southern Africa. The top five countries are all located in Southern Africa. For example for the period 2010–2013, the prevalence rate for the countries in Southern Africa (Bostwana, Lesotho, Namibia, South Africa, Swaziland and Zimbabwe) was about 20.1%, compared to 2.8% for the other countries in the region.

[11] See Bloom et al. (2004) for a survey of the literature on the effect of health on growth.

Table 1
HIV prevalence rate for ages 15–49, 1990–2013.
Source: WDI (2011) and authors' calculations.

Country	1990–1994	1995–1999	2000–2004	2005–2009	2010–2013
Sub-Saharan Africa (SSA)	3.2	5.6	6.3	5.8	5.2
Southern African	6.9	18.0	22.1	21.0	20.1
Outside Southern Africa	2.66	3.68	3.85	3.40	2.80
Botswana	9.7	23.9	27.3	24.7	21.9
Lesotho	3.6	16.6	22.0	22.1	22.9
Namibia	3.0	11.3	16.6	15.8	14.3
Southern Africa					
Botswana	9.7	23.9	27.3	24.7	21.9
Lesotho	3.6	16.6	22.0	22.1	22.9
Namibia	3.0	11.3	16.6	15.8	14.3
South Africa	1.5	9.1	16.5	18.7	19.1
Swaziland	5.1	18.7	25.6	26.3	27.4
Zimbabwe	18.4	28.0	24.9	18.3	15.0
Outside Southern Africa					
Angola	0.5	1.4	1.8	2.0	2.4
Benin	0.5	1.3	1.5	1.3	1.1
Burkina Faso	3.8	3.3	2.1	1.2	0.9
Burundi	0.6	1.7	2.5	1.9	1.0
Cape Verde	0.3	0.4	0.5	0.5	0.5
Cameroon	2.1	4.2	5.3	5.1	4.3
Central African Republic	5.2	8.4	8.4	6.0	3.8
Chad	1.6	2.7	3.6	3.5	2.5
Congo, Dem. Rep.	1.4	1.5	1.5	1.4	1.1
Congo, Rep.	5.1	5.7	4.8	3.6	2.5
Cote d'Ivoire	4.5	6.6	6.4	4.5	2.7
Eritrea	1.0	2.1	2.0	1.1	0.6
Ethiopia	1.8	3.8	3.7	2.2	1.2
Gabon	1.5	3.9	5.8	5.5	3.9
Gambia	0.2	0.5	1.0	1.4	1.2
Ghana	1.2	2.1	2.2	1.9	1.3
Guinea	0.4	1.0	1.3	1.6	1.7
Guinea-Bissau	1.1	2.6	3.7	4.0	3.7
Kenya	5.7	10.4	8.4	6.3	6.0
Liberia	1.4	2.8	3.0	2.0	1.1
Madagascar	0.4	0.7	0.7	0.7	0.4
Malawi	14.5	17.0	17.1	14.2	10.3
Mali	0.6	1.4	1.5	1.3	0.9
Mauritius	0.1	0.4	0.9	1.3	1.1
Mozambique	1.5	4.8	9.1	11.3	10.8
Niger	0.4	0.8	1.1	0.8	0.4
Nigeria	1.5	2.8	3.6	3.7	3.2
Rwanda	6.1	5.7	4.3	3.2	2.9
Sao Tome	0.2	0.7	1.3	1.3	0.6
Senegal	0.5	0.5	0.6	0.6	0.5
Sierra Leone	0.1	0.5	1.0	1.6	1.6
Somalia	0.2	0.6	0.7	0.6	0.5
South Sudan	0.6	1.8	2.4	2.5	2.2
Sudan	0.1	0.1	0.1	0.2	0.2
Tanzania	6.8	8.7	7.7	6.2	5.0
Togo	1.2	2.9	4.0	3.5	2.3
Uganda	12.2	9.3	6.7	6.4	7.4
Zambia	14.3	14.7	14.3	13.4	12.5

3.2. FDI stylized facts

- FDI to SSA has increased substantially since 1990. Over the period 1990–1994 to 2010–2013, FDI increased by about 170% in real terms (1980 constant US dollars), from $1503

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Table 2
Foreign direct investment net inflows for selected countries in Sub-Saharan Africa, 1990–2013 (constant 1980 US$, millions).
Source: WDI (2011) and authors' calculations.

Country	1990–1994	1995–1999	2000–2004	2005–2009	2010–2013
Total FDI to SSA	1503.35	4197.99	6560.78	13,732.27	17,719.06
Top four oil exporting countries	911.82	1595.69	2740.64	4437.15	3085.93
Other SSA countries	591.53	2602.31	3820.14	9295.12	14,633.13
Share of FDI to top four oil exporting countries (%)	60.65	38.01	41.77	32.31	17.42
Top four oil exporting countries	911.82	1595.69	2740.64	4437.15	3085.93
Angola	147.11	581.70	1069.74	159.50	−1944.03
Equatorial Guinea	13.19	123.30	271.51	321.42	963.22
Nigeria	742.44	784.14	896.16	3154.81	3077.72
Sudan	9.09	106.55	503.23	801.42	989.02
Other SSA countries	591.53	2602.31	3820.14	9295.12	14,633.13
Benin	37.22	19.15	25.02	14.23	91.01
Botswana	−29.01	46.75	248.07	173.37	174.42
Burkina Faso	3.47	6.02	9.21	23.89	98.81
Burundi	0.44	0.53	1.30	0.51	1.29
Cape Verde	1.11	16.09	18.20	71.75	36.94
Cameroon	−13.77	48.36	139.26	121.18	255.13
Central African Republic	−2.87	3.99	4.23	25.23	19.00
Chad	7.81	20.34	296.93	13.77	164.59
Comoros	0.25	0.26	0.35	2.66	6.22
Congo, Dem. Rep.	0.35	3.83	121.23	347.43	1038.67
Congo, Rep.	46.84	106.05	98.53	900.73	1122.13
Cote d'Ivoire	−0.07	200.11	129.51	193.92	150.85
Ethiopia	4.70	81.96	193.90	131.75	239.33
Gabon	−9.11	−140.72	42.65	213.65	306.32
Gambia	6.81	6.27	20.45	32.11	14.76
Ghana	56.05	89.99	65.42	701.26	1368.27
Guinea	10.70	15.40	24.22	110.11	188.18
Guinea-Bissau	1.84	2.21	1.15	4.90	5.31
Kenya	31.76	36.47	30.11	97.94	143.44
Lesotho	8.22	157.51	21.05	58.45	69.12
Liberia	25.18	66.66	53.15	70.95	424.96
Madagascar	10.56	13.62	28.43	327.70	364.41
Malawi	2.77	13.38	29.27	52.63	52.83
Mali	0.88	28.80	75.52	152.66	208.11
Mauritania	4.69	2.31	75.12	140.01	363.17
Mali	0.88	28.80	75.52	152.66	208.11
Mauritania	4.69	2.31	75.12	140.01	363.17
Mauritius	14.56	21.54	38.42	108.67	190.78
Mozambique	16.73	97.11	146.72	211.09	1894.42
Namibia	56.88	58.86	36.33	287.40	358.59
Niger	9.01	4.31	8.31	106.58	371.81
Rwanda	2.72	1.98	3.09	33.16	46.74
Sao Tome	−0.32	0.99	1.92	17.83	15.08
Senegal	18.46	55.08	33.53	154.00	131.44
Seychelles	13.28	29.59	25.85	73.08	68.62
Sierra Leone	3.24	1.30	14.30	39.51	258.26
Somalia	1.13	0.33	−0.58	44.10	47.78
South Africa	76.58	991.87	1241.94	3021.20	2294.50
Swaziland	45.17	38.67	24.47	27.47	43.00
Tanzania	11.15	139.72	203.91	411.57	741.40
Togo	2.05	17.16	27.93	33.50	52.86
Uganda	19.01	96.00	110.24	327.52	422.56
Zambia	85.88	97.76	144.23	380.05	637.24
Zimbabwe	9.20	104.70	7.25	35.62	150.81

million to $17,719 million (Table 2). In addition, FDI as a share of GDP increased by about 360%, from 1.52% to about 6.98% (Table 3).

- FDI to SSA is concentrated in oil exporting countries. However, the degree of concentration has declined substantially over time. For example the share of FDI to the top four oil exporting countries (Angola, Equatorial Guinea, Nigeria and Sudan) declined from about 61% in 1990–1994 to about 14% in 2010–2013 (Table 2). In addition FDI to the four oil exporting countries increased by about 12% in real terms over the period 1990–1994 to 2010–2013 (from $911.82 million to $3085.93 million). This compares with an increase of about

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Table 3
Foreign direct investment net inflows (% of GDP) for selected countries in Sub-Saharan Africa, 1990–2013.
Source: WDI (2011) and authors' calculations.

Country	1990–1994	1995–1999	2000–2004	2005–2009	2010–2013
Angola	3.22	16.31	17.37	0.84	−2.68
Benin	3.48	1.45	1.27	0.68	2.21
Botswana	−1.15	1.53	7.70	3.56	3.91
Burkina Faso	0.08	0.36	0.41	0.71	1.72
Burundi	0.07	0.06	0.00	0.07	0.08
Cape Verde	0.37	4.69	4.03	10.94	6.88
Cameroon	−0.21	0.98	2.33	1.17	1.91
Central African Republic	−0.46	0.65	0.83	3.43	2.80
Chad	0.48	2.04	27.50	0.27	1.75
Comoros	0.18	0.13	0.28	1.33	2.28
Congo, Dem. Rep.	0.01	0.23	2.76	4.95	7.39
Congo, Rep.	4.25	7.70	5.70	22.84	21.40
Cote d'Ivoire	−0.17	2.83	1.87	1.99	1.52
Equatorial Guinea	17.00	68.22	29.44	7.57	10.79
Ethiopia	0.02	2.00	4.65	1.47	1.37
Gabon	−0.03	−3.63	1.49	3.71	3.77
Gambia, The	2.03	1.35	6.67	8.71	5.47
Ghana	0.75	2.08	1.50	6.84	7.63
Guinea	0.66	0.85	1.51	6.32	11.97
Guinea-Bissau	1.40	1.78	0.54	1.61	1.67
Kenya	0.88	0.49	0.27	0.90	0.84
Lesotho	1.70	29.78	4.39	8.22	8.26
Liberia	5.68	25.07	27.32	20.02	54.06
Madagascar	0.60	0.67	0.96	10.19	8.88
Malawi	−0.02	1.31	2.43	2.52	2.62
Mali	−0.08	1.17	4.26	4.31	4.46
Mauritania	0.66	0.20	9.72	4.54	17.91
Mauritius	0.77	0.90	0.35	3.20	4.06
Mozambique	1.01	4.31	6.51	5.69	24.64
Namibia	2.55	2.01	1.14	7.59	7.27
Niger	0.64	0.36	0.67	5.08	11.37
Nigeria	4.02	3.73	2.74	3.99	2.56
Rwanda	0.24	0.19	0.26	1.92	1.94
Senegal	0.30	2.08	0.96	3.04	2.45
Seychelles	4.20	8.22	7.54	17.45	14.69
Sierra Leone	1.04	0.09	1.66	3.54	16.81
South Africa	0.04	1.17	2.06	2.21	1.48
Sudan	−0.06	1.90	5.96	3.72	3.61
Swaziland	5.48	4.12	2.32	2.73	2.40
Tanzania	0.19	2.88	3.08	4.35	5.18
Togo	−0.05	1.80	3.37	2.42	3.12
Uganda	0.42	2.58	3.12	5.93	5.91
Zambia	4.55	5.04	6.79	7.27	6.07
Zimbabwe	0.14	2.58	0.17	1.12	2.62
Sub-Saharan Africa	1.52	4.87	4.91	5.02	6.98

280% (from \$591.53 million to \$14,633.13 million) for the other SSA countries.

4. A model of HIV/AIDS and FDI

As pointed out earlier, two of the most important channels through which HIV/AIDS can affect FDI is a reduction in labor productivity and an increase in absenteeism. We incorporate the productivity/absenteeism effect of the epidemic on FDI by including three features in the model. First, we assume that infected workers have lower productivity than uninfected workers. Second, infected workers take days off from work when they fall sick.[12] The third feature is related to a negative externality of the disease. The morbidity (sickness) rate and the mortality (death) rate of HIV/AIDS are quite high. The sickness and death of infected co-workers may affect the working environment and lower morale at the workplace. In addition, uninfected workers may be reluctant to interact with infected workers for fear of being infected. Clearly, these factors lead to a reduction in overall productivity at the workplace. We incorporate such a negative externality by assuming that infected workers lower the productivity of all workers. Thus the total (labor-augmented) productivity can be decomposed into two parts: the "idiosyncratic" part which is determined by the individual's HIV status and "non-idiosyncratic" part which is determined by the overall health of the entire labor force. Therefore, the HIV prevalence rate enters the goods production function as a determinant of effective units of labor.[13] Later we show that the existence of such an externality is crucial in establishing the non-linear effect of HIV/AIDS on FDI.

We now describe the model. Consider an environment where a host country maximizes utility by choosing consumption, labor and foreign capital (i.e., FDI). Specifically, the country uses capital, k, and labor, n, to produce output according to the following production function:

$$f(k,n) = k^{\theta} n^{1-\theta}. \tag{1}$$

Here, $k = k_d + k_f$, where k_d is domestic capital and k_f is foreign-owned capital. Assume that capital depreciates completely, thus k_f is simply FDI. We assume that k_d is exogenously determined and k_f earns a rate of return r, determined by the world capital market.

The population of workers in the host country is normalized to unity. Let $h \in (0,1)$ be the share of the workers that are HIV positive. We use subscripts "1" and "2" to refer to uninfected and infected workers, respectively. Denoted by n_1 the labor supply of uninfected workers, and n_2 the labor supply of infected workers. Then the effective labor supply is equal to $(1-h)n_1$ and $\alpha h n_2$, respectively, with $\alpha \in (0,1)$ reflecting the assumption that infected workers have lower productivity. To take into account the negative externality, we introduce a discount factor on the quality of labor supplied by all workers, $\gamma(h)$, with $\gamma(h) \in (0,1)$. We assume $\gamma'(h) < 0$. This assumption implies that the negative externality gets bigger as the prevalence rate increases. Note that α pertains to only infected workers (i.e., the "idiosyncratic" productivity parameter) but $\gamma(h)$ affects all workers (i.e., the "non-idiosyncratic" productivity parameter).

[12] Grossman (1972) also includes sick time as a source of disutility, based on the argument that health capital differs from other forms of human capital: a person's stock of knowledge affects his market and nonmarket productivity while his stock of health determines the total amount of time available for his market and nonmarket activities.

[13] In the health-development literature, health is usually considered an important component of human capital and enters the goods production function either as a factor of input (Bloom et al, 2004; McDonald and Roberts, 2006), or as a determinant of the total factor productivity (e.g., Acemoglu and Johnson, 2008).

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Thus, the aggregate effective labor supply (adjusted for quality) is given by

$$n = \gamma(h)[(1-h)n_1 + h\alpha n_2]. \tag{2}$$

For simplicity, we assume that the utility function is separable in consumption, c, and leisure time, l, and takes the form:

$$u(c,l) = lnc + \eta lnl, \tag{3}$$

where $\eta > 0$. The time endowment is normalized to be equal to one. Let s be the sick time taken off by infected workers, then the effective time endowment of infected workers is $1 - s$. Therefore the time constraint faced by healthy and infected workers are given by Eqs. (4) and (5), respectively:

$$n_1 = 1-l_1, \tag{4}$$

$$n_2 = 1-s-l_2. \tag{5}$$

Finally the resource constraint for the host country is:

$$(1-h)c_1 + hc_2 = f(k_d + k_f, n) - rk_f. \tag{6}$$

The host country chooses c_1, c_2, l_1, l_2, and k_f to maximize:

$$U = (1-h)u(c_1,l_1) + hu(c_2,l_2), \tag{7}$$

subject to Eqs. (1)–(6).

Let λ be the Lagrangian multiplier associated with the resource constraint (Eq. (6)). The first order conditions are given by:

$$c_1 : \frac{1}{c_1} = \lambda, \tag{8}$$

$$c_2 : \frac{1}{c_2} = \lambda, \tag{9}$$

$$k_f : \theta(k/n)^{\theta-1} = r, \tag{10}$$

$$l_1 : \gamma(h)(1-\theta)(k/n)^{\theta} = \frac{c_1}{l_1}, \tag{11}$$

$$l_2 : \alpha\gamma(h)(1-\theta)(k/n)^{\theta} = \frac{c_2}{l_2}. \tag{12}$$

Clearly Eqs. (8) and (9) imply that $c_1 = c_2 = c$.[14] Eq. (10) shows that the marginal product of capital equals the world interest rate, yielding a constant capital–labor ratio:

$$\frac{k}{n} = \left(\frac{\theta}{r}\right)^{\frac{1}{1-\theta}}.$$

The next two first-order conditions reflect that workers' marginal rate of substitution between consumption and leisure equals their marginal product of labor. It is straightforward that these two equations imply

$$l_1 = \alpha l_2. \tag{13}$$

Since infected workers have lower productivity ($\alpha < 1$) and take sick time off ($s > 0$), thus $n_1 > n_2$, infected workers supply less labor. Combining Eqs. (6) and (10), and substituting Eqs (4), (5), and (13) into Eq. (2), we end up with the following two equations determining n and l_1 in the equilibrium:

$$\gamma(h)(1-\theta)\left(\frac{k}{n}\right)^{\theta} = \left(\frac{k}{n}\right)^{\theta} n - \theta\left(\frac{k}{n}\right)^{\theta-1}\left(\frac{k}{n}n - k_d\right),$$

$$n = \gamma(h)[(1-h)(1-l_1) + h\alpha(1-s-l_1/\alpha)].$$

Totally differentiating the above with respect to h yields

$$\frac{dn}{dh} = \frac{\gamma(h)[\alpha(1-s)-1] + \gamma'(h)[1-h+h\alpha(1-s)]}{1+\eta}.$$

And the effect of HIV/AIDS on FDI is summarized by

$$\frac{dk_f}{dh} = \frac{k}{n}\frac{dn}{dh} = \frac{-\gamma(h)[1-\alpha(1-s)] + \gamma'(h)[(1-h) + h\alpha(1-s)]}{(1+\eta)(r/\theta)^{\frac{1}{1-\theta}}}, \tag{14}$$

and

$$\frac{d^2k_f}{dh^2} = \frac{-2\gamma'(h)[1-\alpha(1-s)] + \gamma''(h)[(1-h) + h\alpha(1-s)]}{(1+\eta)(r/\theta)^{\frac{1}{1-\theta}}}. \tag{15}$$

Clearly $dk_f/dh < 0$ as long as any one of the following three conditions is satisfied: (i) $\alpha < 1$; (ii) $s > 0$ or (iii) $\gamma'(h) < 0$. This implies that HIV/AIDS has an adverse effect on FDI: (i) when infected workers have a lower productivity relative to uninfected workers, $\alpha < 1$; or (ii) when infected workers take sick time off, $s > 0$; or (iii) when the negative externality generated by HIV/AIDS increases with the prevalence rate, $\gamma'(h) < 0$.

From Eq. (15) we can see that $d^2k_f/dh^2 > 0$ if and only if

$$2\gamma'(h)[1-\alpha(1-s)] < \gamma''(h)[(1-h) + h\alpha(1-s)].$$

This condition is easy to satisfy. For example, if $\gamma(h)$ is concave, then $\gamma''(h) > 0$ and hence $d^2k_f/dh^2 > 0$ Note that defining γ as a function of h is critical for the non-linearity result. It is still possible to have $dk_f/dh < 0$ as long as $\alpha < 1$ or $s > 0$. However d^2k_f/dh^2 will be equal to 0 once γ is independent of h, suggesting that the effect of HIV/AIDS on FDI, although still negative, will be the same across different values of the prevalence rate. In summary, our model implies that HIV/AIDS has a non-linear negative effect on FDI, and the effect is diminishing under certain condition.

[14] This result comes from the assumption that healthy and infected workers have the same utility function. If infected workers, due to illness, derive less enjoyment than healthy workers from same quantity of consumption goods, then c_1 and c_2 will be different. The consumption choice is not essential for our result.

5. The data and the variables

The empirical analyses utilize panel data from 41 countries in Sub-Saharan Africa over the period 1990–2008. We focus on the post-1990 years because although the HIV virus was identified in the 1980s, global awareness of the disease began in the 1990s. Furthermore, the HIV data prior to 1990 are deemed unreliable (UNAIDS, 2010).

The dependent variable is *fdi* where *fdi* = ln(1 + *FDI*), and *FDI* is net FDI inflows.[15] As it is standard in the literature, we average the data over three years to smooth out cyclical fluctuations. We use the percentage of adults that are HIV positive in a country, *hiv*, to capture the severity of the HIV/AIDS epidemic. Table 1 shows the value of *hiv* averaged from 1990 to 2008, for the countries in our sample.

5.1. Control variables

Following the literature on the determinants of FDI, we include the following control variables in our benchmark regressions: *trade*/*GDP* as a measure of openness to trade, gross fixed capital formation as a share of GDP, *infrac*, to measure infrastructure development.[16] All else equal, openness to trade and a better physical infrastructure should have a positive effect on FDI. Large domestic markets imply a greater demand for goods and services and therefore make the host country more attractive for FDI. However, it is possible that the size of the market needs to achieve a certain minimum threshold for the positive effect to be realized (Asiedu and Lien, 2003). Therefore following Asiedu and Lien (2003), we include *lgdp* = *Ln* (*GDP*) and the square of GDP, *lgdp* × *lgdp* as explanatory variables in the regressions. These variables are included in the benchmark regressions.

5.2. Robustness variables

The discussion in Section 2 suggests that FDI in SSA is concentrated in natural resources. Therefore, as a robustness check, we determine whether our main results hold when we control for natural resource intensity in host countries. We employ three measures that reflect natural resource intensity in host countries: (i) the share of fuels in the total merchandise exports (*fuels*); (ii) the share of minerals in the total merchandise exports (*minerals*); and (iii) the share of fuels and minerals in total merchandise exports (*natexp* = *fuels* + *minerals)*. We do not include the measures of natural resources in the benchmark regressions because the data are not available for several countries. Specifically, the number of countries drops from 41 to 35, and the number of observations decreases from 198 to 143.

Table 4 shows the summary statistics of the variables included in our analysis and Table 5 shows the HIV prevalence rate for the countries in our sample, averaged over the period 1990–2008. All the data are from the World Development Indicators (WDI) published in 2011.

Table 4
Summary statistics.

Variables	Obs.	Mean	Std. dev.	Min	Max
Foreign direct investment/GDP (%)	276	0.02	0.05	−0.08	0.51
HIV prevalence (%)	249	5.13	6.65	0.10	28.7
Ln (GDP)	272	1.28	5.79	−31.3	38.3
Infrastructure: fixed investment/GDP (%)	261	19.7	10.2	3.47	90.3
Trade/GDP (%)	269	74.1	38.8	12.8	245.8
Fuels	181	11.4	24.4	0.00	99.4
Minerals	194	12.3	20.8	0.00	87.7
Natexp	181	23.9	29.5	0.00	99.7

6. Empirical results

We proceed in two steps. We first estimate the benchmark model where we control for openness to trade, market size and infrastructure in host countries. In addition, we determine the share of countries for which HIV/AIDS is negatively correlated with FDI. In step 2, we test whether our results are robust when we control for natural resource intensity in host countries.

We estimate a linear dynamic panel-data (DPD) model to capture the effect of previous FDI flows on current flows. In particular, we estimate the equation:

$$fdi_{it} = \alpha hiv_{it} + \beta hiv_{it}^2 + \rho fdi_{it-1} + \Sigma_{j=1}^{J}\gamma_j Z_{jit} + \theta_i + \lambda_t + \varepsilon_{it} \quad (16)$$

where *i* refers to countries, *t* to time, *fdi* = ln(1 + *FDI*), *hiv* is HIV adult prevalence rate, *Z* is a vector of control variables,

Table 5
HIV/AIDS prevalence rates for selected countries in Sub-Saharan Africa, averaged 1990–2008.
Source: WDI (2011) and authors' calculations.

Country	HIV rate	Country	HIV rate
Angola	1.40	Liberia	1.49
Benin	1.12	Madagascar	0.10
Botswana	23.2	Malawi	12.4
Burkina Faso	1.89	Mali	1.23
Burundi	3.77	Mauritania	0.50
Cameroon	5.32	Mauritius	0.51
Central African Republic	5.82	Mozambique	8.70
Chad	2.92	Namibia	12.0
Comoros	0.10	Niger	0.60
		Nigeria	2.97
Congo, Rep.	4.71	Rwanda	4.97
Cote d'Ivoire	5.48	Senegal	0.45
Equatorial Guinea	2.67	Sierra Leone	1.26
Eritrea	1.22	South Africa	13.4
Ethiopia	2.29	Sudan	1.37
Gabon	4.74	Swaziland	21.2
Gambia, The	0.62	Tanzania	6.93
Ghana	2.03	Togo	3.27
Guinea	1.07	Uganda	8.82
Guinea-Bisau	1.45	Zambia	16.6
Lesotho	20.3	Zimbabwe	24.2

[15] The data on net FDI from the WDI are in thousands of dollars. Furthermore, some of the observations are negative. We converted the data to billions of dollars and added one to ensure that all the observations are positive.

[16] Gross fixed capital formation includes funds spent on the construction of roads, railways, schools, commercial and industrial buildings and land improvements.

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Table 6
Benchmark regressions. The effect of HIV/AIDS on FDI in SSA.

	(1)	(2)	(3)	(4)
HIV prevalence rate (%), *hiv*, $\hat{\alpha}$	−0.0025***	−0.0035***	−0.0031***	−0.0038***
	(0.000)	(0.000)	(0.000)	(0.000)
hiv × hiv, $\hat{\beta}$	0.0001***	0.0001***	0.0001***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)
Other variables				
Lagged *FDI*	−0.3052***	−0.3328***	−0.1040***	−0.0714***
	(0.000)	(0.000)	(0.000)	(0.000)
lgdp = Ln(*GDP*)	−0.4149***	−0.4607***	−0.3782***	−0.4320***
	(0.000)	(0.000)	(0.000)	(0.000)
lgdp × lgdp	0.0103***	0.0114***	0.0093***	0.0105***
	(0.000)	(0.000)	(0.000)	(0.000)
Trade/*GDP* (%)	0.0002**	0.0003***	0.0002***	0.0002***
	(0.000)	(0.000)	(0.000)	(0.000)
Fixed investment/*GDP* (%)	0.00002	0.0002***		
	(0.777)	(0.009)		
Constant	4.1528***	4.6473***	3.8216***	4.4542***
	(0.000)	(0.000)	(0.000)	(0.000)
Critical value of *hiv*, *hiv** (%)	12.5	17.5	15.0	19.0
% of countries with $\overline{hiv} < hiv^*$	85.0	90.0	87.0	90.0
Number of observations	191	191	198	198
Number of countries, *n*	40	40	41	41
Number of instruments, *i*	35	50	34	49
Instrument ratio, *r* = *n*/*i*	1.1429	0.8000	1.2058	0.8367
Hansen J test (*p*-value) [a]	0.5521	0.6328	0.1574	0.4484
Serial correlation test (*p*-value) [b]	0.4572	0.3929	0.2945	0.2780
Limited instruments?	Yes	No	Yes	No

Notes: *hiv* is the percentage of adults that are HIV positive, $\overline{hiv}$ is the value of *hiv* averaged from 1990 to 2008; $hiv = hiv^*$ when $\partial fdi/\partial hiv = 0$.
p-Values in parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.
[a] The null hypothesis is that the instruments are not correlated with the residuals.
[b] The null hypothesis is that the errors in the first difference regression exhibit no second order serial correlation.

and θ_i and λ_t are country-specific and time-specific effects, respectively.

We now provide some details about our estimation strategy. First, we use the two-step GMM system estimator proposed by Blundell and Bond (1998), which is asymptotically efficient and robust to all kinds of heteroskedasticity. Second, as noted earlier, *hiv*, and therefore hiv^2 are likely to be endogenous. Therefore in our regressions, we specify *hiv* and hiv^2 as endogenous variables. Third, the control variables are treated as strictly exogenous. Finally, our regressions utilize only internal instruments—we do not include additional (external) instruments.[17] Note that the effect of HIV/AIDS on FDI can be derived from Eq. (16) as $\partial fdi/\partial hiv = \alpha + 2\beta \times hiv$. Therefore, the parameters of interest are α and β.

6.1. Benchmark regressions

Table 6 reports the estimation results for the benchmark regressions. In columns (1) and (2) we control for market size, trade openness and infrastructure development, *infrac*. However, the coefficient of *infrac* is not significant (*p*-value = 0.777) in the regression where the number of instruments is curtailed (column 1). When the number of lags of the variables used in instrumentation is unrestricted, the coefficient of the measure fixed investments is rather significant at the 1% level of significance (column 2). In columns (3) and (4), we exclude *infrac* and we re-estimate the model.

Three notable points follow from Table 6. First, the *p*-values for the test for autocorrelation and the Hansen J test show the validity of the instruments and the absence of second order autocorrelation in the first differenced errors. Second, $\hat{\alpha}$ and $\hat{\beta}$ are significant at the 1% level in all the regressions. The third point is that $\hat{\alpha} < 0$ and $\hat{\beta} > 0$, implying that HIV/AIDS has a negative and diminishing effect on FDI. It also implies that there exists a critical value of *hiv*, which we denote by *hiv**, such that $\partial fdi/\partial hiv = \hat{\alpha} + 2\hat{\beta} \times hiv^* = 0$. Note that *hiv** takes on a different value for each regression. Furthermore, $\partial fdi/\partial hiv < 0$ when $hiv < hiv^*$, suggesting that HIV/AIDS is negatively correlated with FDI when $hiv < hiv^*$. To facilitate the interpretation of our result, we define $\overline{hiv}$ as the value of *hiv* averaged over the period 1990–2008, and we compute the value of $\overline{hiv}$ for each of the countries in our sample (see Table 5). In Table 6 we also report the value of *hiv** and the percentage of countries for which $\overline{hiv} < hiv^*$. This percentage reflects the share of countries for which HIV/AIDS is negatively correlated with FDI. Note that the value of *hiv** is quite high—it ranges between 12.5% and 19%. Furthermore, HIV/AIDS has an adverse effect on FDI in at least 85% of the countries.

To further elucidate our results, we evaluate the estimated value of $\partial fdi/\partial hiv$ at reasonable values of *hiv*. Specifically, we

[17] See Asiedu and Lien (2003) for a detailed discussion about the system GMM estimation procedure.

Table 7
$\partial fdi/\partial hiv = \hat{\alpha} + 2\hat{\beta} \times hiv$, evaluated at different values of *hiv*.

Percentile of $\overline{hiv}$	Value of *hiv*	Corresponding country	$\partial fdi/\partial hiv$
25^{th}	1.12	Benin	−0.0029*** (0.000)
50^{th}	2.67	Equatorial Guinea	−0.0026*** (0.000)
Mean	5.78	Central Africa	−0.0019*** (0.000)
75^{th}	6.93	Tanzania	−0.0017*** (0.000)
90^{th}	13.38	South Africa	−0.0004*** (0.000)

Notes: *hiv* is the percentage of adults that are HIV positive, and $\overline{hiv}$ is the value of *hiv* averaged from 1990 to 2008.
p-Values in parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.

evaluate $\partial fdi/\partial hiv$ at the 25th, 50th, 75th, and 90th percentiles and the mean of $\overline{hiv}$ for each sample group and we report the values in Table 7. As shown in Table 7, the estimated value of $\partial fdi/\partial hiv$ is negative and significant at the 1% level for the various values of *hiv*, suggesting that overall, HIV/AIDS has a negative impact on FDI flows. We use the regressions reported in column (3) to illustrate our point. With the estimated coefficients, we have $\partial fdi/\partial hiv = -0.0031 + 2 \times 0.0001 \times hiv$. The 25th, 50th, 75th, and 90th percentiles and the mean of $\overline{hiv}$ roughly corresponds to the average value of *hiv* for Benin, Equatorial Guinea, Tanzania, South Africa and Central African Republic respectively (see Table 5).

Table 7 also portrays the diminishing effect of HIV on FDI. One may conclude, by examining the magnitude of $\hat{\beta}$ in Table 6, that the diminishing effect of HIV/AIDS on FDI is economically small. In fact, it is not. Table 7 shows that the magnitude of $\partial fdi/\partial hiv$ declines significantly as *hiv* increases from the 25th percentile to the 90th percentile. For example, the adverse impact of a one percentage point increase in *hiv* on FDI for the 25th percentile country (i.e., Benin, with $\overline{hiv} = 1.12$) is equal to about 7.25 times the effect in the 90th percentile country (South Africa, with $\overline{hiv} = 13.38$). This result implies that overall, HIV/AIDS deters FDI in Sub-Saharan Africa, however, FDI is more sensitive to HIV/AIDS in low prevalence countries than in high prevalence countries.

6.2. Robustness regressions

Table 8 reports the result of the robustness regressions. Column (1) shows the results where we include only *fuels*, column (2) includes only *mineral* and column (3) includes

Table 8
Robustness regressions. The effect of HIV/AIDS on FDI in SSA.

	(1) Fuel	(2) Minerals	(3) Fuels & minerals	(4) Natexp
hiv, $\hat{\alpha}$	−0.0022***	−0.0025***	−0.0021***	−0.0021***
	(0.000)	(0.000)	(0.000)	(0.000)
$hiv \times hiv$, $\hat{\beta}$	0.0001***	0.0001***	0.0001***	0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)
Other variables				
Lagged *FDI*	−0.7733***	−0.5803***	−0.7589***	−0.6801***
	(0.000)	(0.000)	(0.000)	(0.000)
$lgdp = Ln(GDP)$	−0.9229***	−0.7026***	−0.9452***	−0.8611***
	(0.000)	(0.000)	(0.0000	(0.000)
$lgdp \times lgdp$	0.0213***	0.0165***	0.0218***	0.0199***
	(0.000)	(0.000)	(0.0000	(0.000)
Trade = *GDP* (%)	−0.0001***	0.0001***	−0.0001***	−0.0001***
	(0.000)	(0.000)	(0.000)	(0.000)
Fixed investment/*GDP* (%)	0.0008***	0.0010***	0.0008***	0.0010***
	(0.000)	(0.000)	(0.000)	(0.000)
Fuel	0.0015***		0.0014***	
	(0.000)		(0.000)	
Minerals		0.0003***	0.0001***	
		(0.000)	(0.000)	
Natexp = fuel + minerals				0.0007***
				(0.000)
Constant	9.9714***	7.4505***	10.225***	9.2712***
	(0.000)	(0.000)	(0.000)	(0.000)
Critical value of *hiv*, *hiv** (%)	11.0	12.5	10.5	10.5
% of countries with $\overline{hiv} < hiv^*$	80.0	85.0	80.0	80.0
Number of observations	143	143	143	143
Number of countries, *n*	35	36	35	35
Hansen J test (*p*-value)[a]	0.6335	0.5527	0.7033	0.6927
Serial correlation test (*p*-value)[b]	0.1170	0.9436	0.1147	0.0643

Notes: *hiv* is the percentage of adults that are HIV positive, $\overline{hiv}$ is the value of *hiv* averaged from 1990 to 2008; $hiv = hiv^*$ when $\partial fdi/\partial hiv = 0$.
p-Values in parenthesis. ***$p < 0.01$, **$p < 0.05$, *$p < 0.10$.
[a] The null hypothesis is that the instruments are not correlated with the residuals.
[b] The null hypothesis is that the errors in the first difference regression exhibit no second order serial correlation.

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both *fuels* and *minerals*. In column (4) we *natexp*, where *natexp* = *fuels* + *minerals*.

Two main points emerge from Table 8. First, the coefficients of all the measures of natural resource intensity are positive and significant at the 1% level, suggesting that natural resources are positively correlated with FDI flows to SSA. Second, and more importantly, the results are robust: $\hat{\alpha}$ is negative and significant at the 1% level and $\hat{\beta}$ is positive and significant at the 1% level in all the regressions. In addition, the magnitudes of $\hat{\alpha}$ and $\hat{\beta}$ are fairly stable across specifications.

7. Conclusion

This paper theoretically and empirically examines the relationship between HIV/AIDS and FDI. We derive two main results. First, HIV/AIDS deters FDI to SSA countries. If FDI promotes growth and reduces poverty (Asiedu and Gyimah-Brempong, 2008), then our results suggest that policies that reduce the infection rate will enhance development in SSA countries. We also find that the adverse effect of HIV/AIDS on FDI is non-linear and that the negative effect diminishes as the HIV/AIDS prevalence rate decreases. This implies that all else equal, a reduction in the HIV/AIDS prevalence rate will be more beneficial to countries with low prevalence rates than countries with high prevalence rates. Thus, for high prevalent rate countries, an initial reduction in the prevalence rate would not generate sizable FDI; however, the flows will increase as the prevalence rate decreases.

With regard to policy, we draw from the 2014 World AIDS Day document which specifies five ways to reduce the epidemic: encourage HIV testing, reduce discrimination, promote HIV/AIDS education, encourage proper health care, and affirm support for people living with HIV/AIDS.[18] We also note that access to good health care, in particular, access to antiretroviral (ARV) drugs boosts the immune system of HIV patients. In addition, there is some evidence that ARV drugs help increase labor supply, raise productivity and reduce absenteeism at the workplace (Rosen et al., 2008; Thirumurthy et al., 2008). Thus making ARV drugs available to infected workers may also mitigate the adverse effect of HIV/AIDS on FDI.

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[18] World AIDS Day was December 1, 2014. See http://facing.aids.gov/ for details.

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