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Root Causes of African Underdevelopment

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Abstract

What is the root cause of Africa's current state of under-development? Is it the long history of slave trade, or the legacy of extractive colonial institutions, or the fallout of malaria? A precise answer still eludes us. This paper investigates the relative contribution of these historical factors using an instrumental variable approach. The results show that malaria matters the most and all other factors are statistically insignificant. The mechanism through which malaria impacts economic performance is demonstrated by a strong negative relationship between malaria and national savings and a two period overlapping generation model. The model shows that high malaria incidence adversely affects growth by increasing both mortality and morbidity. Increased mortality from malaria induces households to increase current consumption and save less for the future. Increased morbidity on the other hand adversely affects labour productivity. The combined impact of these two effects is a slowdown of capital accumulation and economic growth.

Keywords: Malaria; Colonial Institutions; Slave Trade; Economic Development

JEL classification: O11; O41; O57; N0

1. Introduction

It is well known that Africa is falling behind the rest of the world in terms of economic wellbeing. Even though global poverty is declining due to rapid economic growth in India, China, and other parts of the world, Africa's contribution to this decline is disappointing. Absolute poverty in many of the African nations is in fact rising (Sachs 2005). What is the fundamental cause behind this decline? Is there anything that we can do to arrest this decline and improve the situation for the African population? It is hard to think of any other question in development economics which has greater significance and relevance in the contemporary world than the abovementioned.

Perhaps because of the nature of this question, there has been no shortage of research on this topic. Even though it is extremely difficult to summarize this voluminous and multifaceted literature, it is perhaps fair to say that three strands of thoughts stand out.

The first is the disease view. According to this view, malaria and other infectious diseases have fatal as well as debilitating effects on the human population in Africa. It negatively influences productivity, savings, and investment and directly affects economic performance of the continent (Gallup and Sachs 2001; Bloom and Sachs 1998).[1] According to Bloom and Sachs (1998), the high incidence of malaria in sub-Saharan Africa reduces the annual growth rate of the continent by 1.3% a year and eradication of malaria in the 1950s would have resulted into a doubling of per capita income from what exists today.

The second is the colonial institutions view. According to this view, the persistent effect of colonial institutions can explain the huge differences in income across all ex-colonies

[1] Batten and Martina (2005) make similar argument about the role of diseases. However, their work is based on a cross-country sample which includes countries from all continents.

including Africa (Acemoglu et al. 2001, Rodrik et al. 2004, Bhattacharyya 2004).[2] The story goes as follows.

Europeans resorted to different style of colonisation depending on the feasibility of settlement. In a tropical environment the settlers had to deal with the killer malaria and hence a high mortality rate. This prevented colonisers from settling in a tropical environment and they erected extractive institutions in these colonies. On the other hand, in temperate conditions European settlers felt more at home and decided to settle. In these colonies they erected institutions characterised by strong protection of private property and efficient enforcement of contracts. These institutions created by the colonizers have persisted over time and they continue to influence the economic performance of the colonies even long after independence. The settlement colonies with better institutions continue to perform well in the economic arena, whereas the non-settlement colonies with poor institutions continue to struggle.

Finally, a third group of explanation relates to the economic impact of Africa's engagement in slave trade. According to this view, Africa's engagement in the slave trade caused massive depopulation of the continent over two centuries. This resulted into an implosion of the continent's production possibility frontier and an unambiguous reduction in welfare. The secular decline in welfare continued over more than two centuries plunging the continent into economic backwardness (Gemery and Hogendorn 1979; Inikori 1992; and Manning 1981).

Another theory within this group is proposed by Nunn (2004). He argues that Africa's engagement in slave trade had a detrimental impact on the development of domestic institutions.

[2] Earlier work by Easterly and Levine (1997) and Sachs and Warner (1997) also reports strong link between quality of state institutions and post-war growth (or the lack of it) in Africa. Easterly and Levine (1997) show that ethnic diversity in Africa has led to social polarization and the formation of several rival interest groups which increase the likelihood of selecting socially sub-optimal policies when an ethnic representative in the government fail to internalise the entire social cost of their rent seeking policies. Sachs and Warner (1997), on the other hand, stress on Africa's lack of openness to international markets and unfavourable geography as other contributors to poor growth in addition to poor quality institutions.

The frequent slave raids and the culture of violence attached with it severely damaged the security of private property and weakened the judicial system creating a persistent state of lawlessness in the society. These weak institutions persisted over time and are continuing to affect contemporary development.

These theories, even though plausible, do not tell us how much of the variation in income across the continent they can explain. In order to get a precise answer, one has to check the relative strength of these theories in explaining the variation when they are pitted against each other in a regression model.

In this paper we investigate the relative strength of these theories by setting up a simple regression model. In the regression model we use log GDP per capita in 2000 as the dependent variable and malaria risk, institutions, and total slave exports out of Africa as explanatory variables. We deal with the complex causality issues of this strategy by using appropriate exogenous instruments for malaria risk, institutions, and total slave exports. The results show that malaria matters the most and all other factors are statistically insignificant.

We explain the mechanism through which malaria impacts African development in two stages. First, we show that there is strong negative conditional correlation between malaria and savings. Second, by using a two period overlapping generation model we show that malaria incidence, which is external to the model, affects development by increasing both mortality and morbidity. Increased mortality resulting from malaria induces households to increase current consumption and save less for the future. Increased morbidity on the other hand adversely affects productivity. This slows down capital accumulation and economic growth.

Our analysis proceeds in four stages. In section 2, we introduce the empirical model. The explanatory variables – malaria risk, institutions, and total slave exports – can be endogenous. It can very well be the case that the causality between malaria and per capita income may run in the opposite direction than what we predict in our model. The same may also happen with institutions and total slave exports. In that case the coefficient estimates will be biased. Hence, to correct for this problem, we use the instrumental variable strategy. We choose malaria ecology, log settler mortality, and distance from the coast as instruments for malaria risk, institutions, and total slave exports respectively. Malaria ecology is a geography based measure – correlated with malaria incidence but exogenous to the model – which makes it a valid instrument. We follow Acemoglu et al. (2001) and Rodrik et al. (2004) and use log settler mortality as an instrument for institutions. For total slave exports we use distance from the coast as an instrument. This is based on the logic that, the further the country from the coast, the smaller will be the number of slaves exported from that country. This approach is also followed by Nunn (2004). Further, the use of instrumental variable in case of slave exports is also aimed at correcting for measurement error in the construction of data for slave exports (Nunn 2004).

In section 3, we present the empirical results. Malaria risk is the only statistically significant variable in our preferred model and it appears to have a large effect on per capita income. It also explains the bulk of the variation in per capita income and growth in Africa. This result is robust to the choice of additional controls – trade openness, religion, legal origin, schooling, ethnic fractionalisation, linguistic fractionalisation, proportion of primary exports in 1970, and proportion of GDP from mining. However, the result is not robust if alternative measures of disease are used. The result holds when we use yellow fever as an alternative measure but does not hold when we use dengue and AIDS as alternatives. This is perhaps indicative of the historical importance of malaria in the African development process vis a vis other diseases. Even though the problem of AIDS is quite severe in the continent, our regression model is not picking up the effect. This is perhaps indicative of the fact that AIDS is a recent phenomenon rather than historical.

In section 4, first we present regression results showing strong negative conditional correlation between savings and malaria. Then we present the two period overlapping generation model and discuss its dynamics. The model unequivocally shows that both mortality and morbidity resulting from malaria slows down capital accumulation and economic progress. It also shows that high incidence of disease over a long period can result into large scale persistent poverty. This implication fits well with our empirical findings highlighting the importance of malaria in Africa and what we observe in the continent.

Finally, section 5 concludes the analysis with some implications. The question that may be of interest to a policymaker is that why malaria persists in Africa whereas some other parts of the globe managed to overcome the disease. The answer perhaps follows from our model and also the regression results. Due to the geographic roots of malaria, fighting the disease is extremely costly from the households' point of view. Eradicating the disease also has huge positive externalities which are not internalised by the individual households. Therefore, for a household the costs are too high and the benefits are too low. Hence, any meaningful strategy to combat the impact of malaria must involve large scale intervention by the state or other international organisations which can internalise the cost and distribute the benefits among all households.

This is precisely what Singapore and the US did in their respective battles against malaria and yellow fever. Singapore almost eradicated malaria with a large scale public health intervention. The US efforts in building the Panama Canal was backed up by public health interventions to fight yellow fever.

In case of Africa, using state funding in order to fight the disease may not be an option due to the thin fiscal resources of a typical African state. The only viable option is international aid. Sachs (2005) argues that the aid should be used to fund a large scale development planning exercise. Easterly (2006), however, expresses his faith on micro level projects. The issues are wide open for debate and consensus still eludes us. A more pragmatic approach for the policymakers is perhaps to adopt a mix of the two.

2. The Empirical Strategy

The core specification that we estimate in this paper is the following:

$$\log y_i = \lambda + \alpha \text{MAL}_i + \beta \text{INS}_i + \gamma \text{SLVX}_i + \varepsilon_i \qquad (1)$$

where y_i, MAL_i, INS_i, and SLVX_i are per capita income in country *i*, measure of malaria, measure of institutions, and measure of slave exports respectively. ε_i is the random error term. We are interested in the size, sign, and significance of the three coefficients $\alpha, \beta,$ and γ.

The estimation of equation (1) is based on a dataset consisting of per capita GDP levels, measure of malaria risk, measure of institutions, and measure of slave exports in (up to) 49 countries in Africa. The definitions and sources for all the variables used in this study is summarised in the Data Appendix. Table 1 presents summary statistics for the key variables of interest.

GDP per capita in 2000 data is from the Penn World Table 6.1. According to these figures, Tanzania is the poorest country in Africa in 2000.

Malaria risk is measured by the share of population at risk from malaria in 1997. The variable lies between 0 and 1 and a higher value indicates greater risk for the population. Most of the countries in the sample registers high malaria incidence except Algeria, Tunisia and Egypt.

Executive constraint in 2000 is used as a measure of institutions. Acemoglu et al. (2001, 2005) also uses executive constraint as a proxy for institutions. The advantage of using this measure as a proxy for institutions is that it captures the quality of property rights institutions. Higher the degree of institutionalised constraint on the executive, less is the risk of expropriation, and hence better is the quality of institutions.

Slave exports data is reconstructed using Nunn (2004) methodology. Nunn (2004) uses 'shipping records' and 'ethnicity records' of slaves to construct the cross country series of slave exports. The 'shipping record' is typically the number of slaves exported to the new world and other destinations from African ports. The 'shipping record' for the Atlantic Slave trade is available from Eltis et al. (1999) CD-ROM and Elbl (1997). Eltis et al. (1999) CD-ROM covers the period 1527 to 1866 whereas Elbl (1997) covers the period 1450 to 1521. Data on Indian Ocean slave trade is obtained from Austen (1979) for the period before 1769, Martin and Ryan (1977) for the period 1770 to1799, and from Austen (1988) for the period 1800 to 1899. Data on Trans-Saharan slave trade comes from Austen (1992) and for Red Sea slave trade comes from Austen (1988). These figures are also listed in Nunn (2004) data appendix. Nunn also looks at several historical records to make a conjecture about the ethnicity and country of origin of these slaves. This is what he calls the 'ethnicity record.' Ethnicity record gives the information on ethnic and country origins of some of the slaves exported to the Americas and other parts during this period. Out of this slave sample, Nunn generates estimates of proportional representation of each country. He then distributes the sample from 'shipping records' to each country using these proportions. The information on the proportions is also available from his data appendix. We follow the same procedure and end up with a distribution which has a similar ordering as Nunn (2004). Nigeria comes out as the highest exporter of slaves. We have to reconstruct the data using the exact procedure as Nunn since his data is yet to be published.

Identifying good empirical proxies for each of these variables is certainly not the difficult part of the analysis. The difficulty however lies in sorting out the complex relationship between these variables and establishing causality. Anyone would hardly disagree that economic development is a complex phenomenon. Given the complex nature of this process, reverse causality and indirect effects are a real possibility.

Rather than malaria influencing development the causality may run the other way round. The rich economies can afford to invest in the research and development of drugs that cures or minimises the effect of malaria. They can also invest in public health programs to destroy mosquito habitat and wipe out malaria altogether.

Similar argument can be made about institutions. Rich nations have better institutions not because they have grown richer due to better institutions, but they can afford better institutions. Better institutions can also reduce malaria risk via better delivery of public health.

Indirect effect of slave export on development via institutions is also difficult to rule out. Frequent slave raids and the culture of violence may have damaged African institutions in the past and these institutions may have persisted over time.

The other additional problems are measurement error inherent in measuring a variable like slave export and unobserved country characteristics systematically influencing one of the explanatory variables.

Nunn (2004) assumes that the slaves exported from a particular port in Africa are coming from the country where the port is plus from the close neighbouring countries inland. This method always leaves a possibility of under-representation of slaves from inland (Nunn 2004). This under-sampling of slaves from the interior will lead to OLS estimates that are biased towards zero.[3]

It can also be the case that a country chooses slave trade and demonstrates extreme reliance on warfare and violence because of some unobserved characteristics inherent in its culture. If these characteristics are still persisting, then it is impossible to identify econometrically the partial effects of slave trade on its current level of development. The size of the estimates will

[3] This is formally known as attenuation bias.

be biased away from zero as the coefficient will account for the unobserved country effect plus the true effect of slave trade.

In order to minimise the effect of reverse causality, indirect effects, measurement error, and unobserved country characteristics on our coefficient estimates, we identify instruments for each of the suspected endogenous explanatory variables. An instrument is an exogenous source of variation which is correlated with the suspected explanatory variable but uncorrelated with the error term. This approach of estimation is formally known as the instrumental variable method.

Following Sachs (2003) we use malaria ecology as the instrument for malaria risk. This measure is ecologically based and built upon climatology and vector conditions on a country by country basis, and is therefore exogenous to public health interventions and economic conditions. Hence, it can serve as a valid instrument for malaria risk.

Institutions are instrumented by the largely accepted log settler mortality and log population density in 1500 instruments introduced by Acemoglu et al. (2001) and Rodrik et al. (2004).

Slave export is instrumented by the geography based measure distance from the coast. The rational behind using distance from the coast as an instrument is the following. It is expected that the higher the distance from the coast, the lower is the volume of slave exports. The obvious reason being the cost of capturing and transporting slaves to the coast increases with distance (Nunn 2004).

In an instrumental variable estimation, endogenous explanatory variables are replaced by their predicted values from the first stage equations. The first stage equations are as follows.

$$\mathrm{MAL}_i = \mu + \delta \mathrm{ME}_i + \chi \mathrm{LSM}_i + \tau \mathrm{LPD}_i + \kappa \mathrm{DC}_i + \varepsilon_{\mathrm{MAL}_i} \qquad (2)$$

$$\mathrm{INS}_i = \varphi + \eta \mathrm{LSM}_i + \theta \mathrm{LPD}_i + \sigma \mathrm{ME}_i + \nu \mathrm{DC}_i + \varepsilon_{\mathrm{INS}_i} \qquad (3)$$

$$\text{SLVX}_i = \psi + \omega\text{DC}_i + \phi\text{ME}_i + \pi\text{LSM}_i + \upsilon\text{LPD}_i + \varepsilon_{\text{SLVX}_i} \qquad (4)$$

where ME_i, LSM_i, LPD_i, and DC_i refers to malaria ecology, log settler mortality, log population density in 1500, and distance from the coast respectively.

Equations (1) – (4) are at the core of the empirical results that we report in the next section. This is perhaps the simplest way that one can deal with so many complex issues econometrically.

3. Results and Robustness

Panel A of Table 2 reports estimates of the core specification. The first column of panel A reports the OLS estimate of the model. Malaria risk is the only statistically significant variable in this specification. Executive constraints and slave exports are statistically insignificant. One sample standard deviation reduction in malaria risk will result into approximately 1.6 fold increase in per capita income.

The second column of panel A reports the 2SLS estimate. The instruments used are malaria ecology, log settler mortality, log population density in 1500, and distance from the coast. Qualitatively the result remains the same as the OLS estimate. Malaria risk is the only statistically significant variable and executive constraints and slave exports are statistically insignificant. However, the magnitude of the coefficient on malaria risk increases. The impact of one standard deviation decline in malaria risk on per capita income now becomes 1.7 fold which is bigger than what is reported by the OLS estimate.

These results are indicative of the importance of malaria in Africa. Malaria dominates over the other factors when it comes to explaining economic development in Africa. The partial correlation coefficients reveal that malaria explains 26.3% of the variation in log per capita income in Africa. This however does not mean that the institutions story and the slave export story have no role. But the presence of malaria as an explanator eclipses the role of the other two stories.

The first stage regressions reported in panel B indicate that the chosen instruments are valid. The first column of panel B shows that malaria ecology is correlated with malaria risk. The second column shows that both log settler mortality and log population density in 1500 are negatively correlated with executive constraints. This makes them valid instruments for institutions.[4] Finally, the third column reports negative correlation between distance from the coast and log slave exports. It appears that log slave exports is also correlated with malaria ecology implying that high malaria incidence made the native African population vulnerable to be captured as slaves. Miller (1982) finds similar evidence in Portuguese traveller records, missionary and church documents. He argues that frequent epidemics of killer diseases like malaria, yellow fever caused massive depopulation in the agriculturally marginal zones of West-Central Africa and made the local population vulnerable to slave raids.

The core result is robust to the addition of other control variables in the specification. In Table 3 we report the coefficient estimates on malaria risk, executive constraint, and slave export when additional control variables are added. Panel A of the table shows that the malaria result remains unchanged even when we control for trade openness, religion, legal origin, and schooling. In Table 3A we also control for Sachs and Warner (1997) trade openness, ethnic fractionalisation, linguistic fractionalisation, religious fractionalisation, proportion of primary exports in 1970, and proportion of GDP from mining. The malaria result holds in all the cases.

[4] The direction of the correlation is also in conformity with previous studies by Acemoglu et al. (2001) and Rodrik et al. (2004).

The result also holds when we change the dependent variable to annualised growth rate in per capita income over the period 1960 – 2000 (see Table 3, panel A).[5]

In panel B of Table 3, we replace malaria with other measures of diseases. The first column in panel B shows what happens when we replace malaria with yellow fever. Yellow fever is the only statistically significant variable in this specification. The impact of one standard deviation reduction in yellow fever will be a 2.6 fold increase in per capita income. Dengue and AIDS comes out to be statistically insignificant indicating that they do not affect long-run development. Even though yellow fever is statistically significant, it only explains 4.5% of the variation in log per capita income.

In Table 3A we also perform influential observation check using the DFITS formula and Cook's distance suggested by Belsley et al. (1980). The influential observations according to the first formula are Equatorial Guinea and Gabon; and according to the second formula are Equatorial Guinea, Gabon, and South Africa. Omitting these influential observations from the sample does not alter the malaria result.

The results discussed above show that malaria dominates over institutions and slave exports when it comes to explaining long-run economic performance of Africa. However, they do not tell us anything about the mechanism through which malaria may impact long term economic performance. In order to explore a bit more about the mechanism we adopt the following strategies. First, we look at the conditional correlation between national savings and malaria. We observe a strong negative relationship between the two. Second, we develop an overlapping generation model in which the household face a constant threat of death through malaria. There is also an adverse effect on their productivity from the disease. Here also we see a negative

[5] The growth rate is calculated using the formula $\frac{1}{40}\log\left(\frac{y_{2000}}{y_{1960}}\right)$.

relationship between malaria and savings and hence economic growth. This helps us to better explain the correlation between malaria and development in Africa.

3. Exploring the Mechanism through which Malaria Impacts Development

3.1 Malaria and its Impact on Savings

To estimate the impact of malaria on savings, we use the following model.

$$\left(\frac{S}{Y}\right)_i = \varsigma + \vartheta \text{MAL}_i + \rho \log y_i + \zeta_i \tag{5}$$

The results are reported in Table 4. In column 1 of Table 4 we start off with the unconditional correlation between malaria and savings rate. The relationship is negative and statistically significant when the model is estimated by OLS. A one standard deviation increase in malaria risk results into a 5.4 percentage point decline in the savings rate. Column 2 estimates the model using 2SLS. The effect remains unaltered in terms of direction and statistical significance. However, the magnitude of the effect declines to 4.2 percentage points, that is, 1.2 percentage points less than the OLS estimate. In column 3, we add log per capita income as a control. The result remains unaltered but the magnitude of the effect becomes bigger than what it was in column 2. A one standard deviation increase in malaria risk results into a 5.2 percentage point decline in the savings rate in this case. Estimating this model by 2SLS results into a reduction in the magnitude of the coefficient however it remains statistically significant and bears a negative sign. The magnitude of the impact coefficient in column 4 is 4.3 percentage point.

3.2 An Overlapping Generation Model with Mortality and Morbidity from Malaria

Let us consider a perfectly competitive decentralised economy with a single homogeneous good for both consumption and production. The households in this economy maximise their lifetime expected utility subject to an intertemporal budget constraint. A typical household comprises of both young and old members and each member of the household lives for only two periods. The young members work in the first period and retire in the second period when they are old, and then they die. The members also consume in both periods and the consumption in the second period is supported by their savings in the first period. Therefore at each point in time, members of only two generations are alive. There is also a positive probability that they die of malaria before they reach their old age. The probability of survival into the second period is exogenous to the model but depends inversely on unfavourable geography. Unfavourable geography is characterised by suitable temperature for mosquito breeding, mosquito species abundance, and the availability of malaria transmitting mosquito vector. In order to maintain simplicity of the structure, we assume away the possibility of bequests or any altruistic behaviour.

3.1 Households

The lifetime utility of a representative household of generation t can be expressed as follows.

$$U = u(c_1) + \phi u(c_2) \qquad (5)$$

Where c_1 and c_2 are the consumption of generation t when young and old respectively. We are also assuming that the household gets zero utility from death and u is concave and twice differentiable.

The survival probability ϕ of the representative household depends on the unfavourable geography vector, $\mathbf{\Gamma}$.[6]

$$\phi = \phi(\mathbf{\Gamma}) \in [0,1] \qquad (6)$$

$\mathbf{\Gamma}$ is exogenous to the model and shares an inverse relationship with ϕ. If $\mathbf{\Gamma}$ is too high then ϕ can be too low.

[6] One argument made by Chakraborty and Das (2005) in a recent paper is that the households can influence ϕ by investing in health. However, in this case we assume that increase in ϕ requires huge investment which is often beyond the scope of a private investor or a household. This is reasonably realistic because African malaria is predominantly geographic in nature and its reduction would require considerable public health intervention.

The representative individual supplies one unit of labour inelastically when young and receives a wage income w. Therefore the budget constraint faced by this individual in period t is given by the following expression.

$$c_1 + s = w \tag{7}$$

Where s is the amount of grain saved in period t. The saved grain also grows at a rate r when planted. Therefore in period t+1the individual consumes the amount saved in period t plus the growth in the grains. So the consumption in the second period is as follows.

$$c_2 = Rs \text{ where } R = 1 + r \tag{8}$$

Using (8) one can rewrite the budget constraint as

$$c_1 + \frac{c_2}{R} = w \tag{9}$$

For analytical convenience we assume that

$$u(c) = \frac{c^{1-\sigma}}{1-\sigma}, \sigma \in (0,1) \tag{10}$$

Each households treat w and R as given and maximises their lifetime utility subject to the budget constraint. This yields the following Euler equation.

$$\frac{c_2}{c_1} = (\phi R)^{\frac{1}{\sigma}} \tag{11}$$

Also from the first order conditions we get

$$c_1 = \frac{w}{1 + \phi^{\frac{1}{\sigma}} R^{\frac{1}{\sigma}-1}} \;\&\; s = \frac{c_2}{R} = \frac{w\phi^{\frac{1}{\sigma}} R^{\frac{1}{\sigma}-1}}{1 + \phi^{\frac{1}{\sigma}} R^{\frac{1}{\sigma}-1}} \tag{12}$$

3.2 Production

Every period the economy produces a single good which can be consumed or invested. The output is produced using physical capital K and labour L. The production technology

$\theta F(K,L)$ is neoclassical in nature and satisfies the Inada conditions. The parameter θ is less than 1 and is indicative of the morbidity effects of malaria. Due to morbidity of labour the economy cannot operate at the frontier of its production technology. It always underperforms. θ is also negatively dependent on $\mathbf{\Gamma}$. If geography is too unfavourable then θ is extremely low.

Under these conditions, in competitive product and factor markets, the economy wide wage and interest rates are:

$$w = \theta[f(k) - kf'(k)] \text{ and } r = \theta f'(k) \qquad (13)$$

where $k = \frac{K}{L}$. For simplicity, we assume no depreciation of capital.

3.3 Dynamics

Aggregate savings in period t is used as aggregate capital stock for production in period t+1 in this economy. Assuming logarithmic preferences $(\sigma = 1)$ and Cobb-Douglas production technology, we get the dynamic equation of the economy as

$$k_{t+1} = \frac{\theta\phi(1-\alpha)}{(1+n)(1+\phi)} k_t^{\alpha} \qquad (14)$$

At steady state $k_{t+1} = k_t = k^*$ and therefore the steady state level of capital stock is given by the following:

$$k^* = \left[\frac{\theta\phi(1-\alpha)}{(1+n)(1+\phi)}\right]^{\frac{1}{1-\alpha}} \qquad (15)$$

From the above expression we can see that a low probability of survival (ϕ) into the second period and a low value of θ results into a low level of steady state capital stock. In other words, high mortality and morbidity due to unfavourable geography results into a steady state with very low level of capital stock. This certainly fits well with what we observe in the data. The strong correlation between malaria and the level of development in Africa may very well be due to low θ and low ϕ.

The only way to improve living standard in this economy in the long-run is to reduce mortality and morbidity.[7] In order to reduce mortality and morbidity, one has to reverse the trend of unfavourable geography.[8] The cost of this is prohibitively high for the household and far outweighs the benefit. Another obstacle is that the household cannot internalise the positive externalities of reversing unfavourable geography. In that situation one may argue that intervention by the state is perhaps the right thing to do, provided the state has necessary fiscal resources.

4. Concluding Remarks

In this paper we construct a regression model to estimate the historical contributions of malaria, colonial institutions, and slave trade in Africa's underdevelopment. The estimation result shows that malaria explains more than one fourth of the variation within Africa. The other explanators are statistically insignificant and are at the best weak in presence of malaria. The result is robust to the choice of additional control variables such as trade, religion, legal origin, schooling, trade policy, reliance on mining, reliance on primary products export, ethnic fractionalisation, religious fractionalisation, and linguistic fractionalisation. Replacing malaria with other diseases does not appear to have the same explanatory power as malaria. Yellow fever is the only other disease that comes out to be statistically significant. However, it only explains less than 5% of the variation in log per capita income.

We also use a regression model showing strong and negative conditional correlation between malaria and savings and a two period overlapping generation model to explain the

[7] Technology can also be a source of long-run growth. But it is not modeled explicitly here.
[8] Reversing unfavourable geography is used synonymously as large investments in public health.

mechanism through which malaria impacts long-run development. The model shows that malaria impacts economic development through mortality and morbidity. High mortality rate induces households to save less for the second period of life. This hinders capital accumulation. Morbidity on the other hand reduces labour productivity and hence household income. This has a negative income effect on household savings and capital accumulation. In the face of high malaria incidence and death from malaria, the economy remains trapped in a low level equilibrium. The model predicts that the only way out of this is large scale investments in public health.

Finally, the obvious question for a policymaker who would like to improve the performance of the African economies is how much guidance these results provide for her? The answer is a reasonable amount when they are put into the right perspective. Economic history literature documents that malaria and other vector borne diseases such as yellow fever has always been a problem not only in Africa but also in other tropical regions of the globe (Spielman and D'Antonio (2001), Dias (1981)). However, the question remains why it has persisted for so long in Africa whereas some other tropical parts of the globe recovered from it.[9] The answer lies in a systematic and successful public health intervention which never took place in Africa. One of the possible reasons why it never took place in Africa is the thin fiscal resources of most of the African governments. In a situation of widespread poverty and underdevelopment, taxing the households in order generate more funds for public health intervention may not be an option as it will aggravate the situation. It will also create an environment of conflict and political instability.

[9] A good example of recovery is Singapore which was a high malaria risk country until recently. This was made possible by large scale investments by the government in health. Similar situation arose in Panama in 1904 when the US wanted to build the canal. The mortality rate of the workforce was extremely high from yellow fever. The project was completed with the help of a major public health intervention supported by the then US government (Spielman and D'Antonio 2001).

Therefore, the only feasible option is to create international donor generated funds in order to eradicate the disease.

Sachs (2005) argues in favour of a large scale development planning in Africa funded by the international donors to eradicate malaria from the continent. The root of his idea goes back to the ‘Big Push’ recommendations made in the 1950s and 1960s in development economics. These ideas are not free from their problems. As Easterly (2006) points out that a ‘Big Push’ style planning exercise is unable to solve the inherent incentive problems with its implementation. According to him micro level projects which take into account the incentive problems will perhaps work better. This however does not take into account the time costs of disbursing aid in a micro planning framework. Micro planning framework can be extremely slow to deliver and one can raise questions about long-term viability of such projects. Therefore, a more pragmatic approach has to be a mix of the two keeping in mind the needs of the local population. This also has to be accompanied by institutional reforms which are at the heart of the incentive problems.

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***Table 1.* Descriptive Statistics**

Variable	Number of obs.	Mean	Standard Deviation	Minimum	Maximum
Log GDP per capita in 2000 ($\log y_i$)	46	7.46	0.815	6.19	9.24
Malaria Risk (MAL_i)	49	0.81	0.353	0	1
Executive Constraints in 2000 (INS_i)	44	3.71	1.64	1	7
Log total slave exports per square km ($SLVX_i$)	42	-1.83	2.78	-9.21	1.66
Malaria Ecology (ME_i)	49	10.59	8.28	0	31.55
Log settler mortality (LSM_i)	35	5.47	1.14	2.74	7.99
Log population density in 1500 (LPD_i)	45	0.89	1.30	-1.97	4.61
Distance from the coast (DC_i)	46	502.13	374.27	35.29	1319.58

Notes: For a detailed discussion of the definition and source of these variables, see Data Appendix.

Table 2. **Malaria and African Development: Core Results**

Panel A: The Model		
$\log y_i = \lambda + \alpha \text{MAL}_i + \beta \text{INS}_i + \gamma \text{SLVX}_i + \varepsilon_i$		
Dependent Variable	**Log per Capita GDP in 2000**	
	OLS estimate obs= 37	2SLS estimate obs= 31
Malaria Risk (MAL_i)	-1.28*** (0.2832)	-1.52*** (0.5446)
Executive Constraints in 2000 (INS_i)	-0.11 (0.0714)	0.28 (0.2231)
Log total slave exports per square km (SLVX_i)	-0.05 (0.0404)	0.02 (0.0619)
R^2	0.3910	
Endogeneity test (p)		0.0335
Instruments		ME, LSM, LPD, DC

Panel B: The First Stage Regressions			
Dependent Variables	Malaria Risk (MAL_i) obs= 31	Executive Constraints in 2000 (INS_i) obs= 31	Log total slave exports per square km (SLVX_i) obs= 31
Malaria Ecology (ME_i)	0.01** (0.0051)	0.015 (0.0410)	0.19*** (0.0482)
Log Settler Mortality (LSM_i)	0.17*** (0.0543)	-0.21*** (0.0461)	0.27 (0. 3813)
Log Population Density in 1500 (LPD_i)	-0.033 (0.0443)	-0.46* (0.2651)	0.51* (0.3112)
Distance from the coast (DC_i)	9e-05 (0.0001)	-0.001 (0.0008)	-0.004*** (0.0009)
R^2	0.5036	0.4636	0.6057
F-stat	6.60	2.27	9.99

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Figures in the parentheses are the respective standard errors. The standard errors reported in the regressions are heteroskedasticity robust. All the regressions reported above are carried out with an intercept. The endogeneity test p-value indicates that we can reject the null of exogeneity at 5% level of significance.

***Table 3.* Malaria and African Development: Robustness Check (2SLS Estimates)**

Panel A: The Model $\log y_i = \lambda + \alpha \text{MAL}_i + \beta \text{INS}_i + \gamma \text{SLVX}_i + \xi \text{OTH CTRL}_i + \varepsilon_i$							
Dependent variable	**Log per Capita GDP in 2000**						**Growth in Per Capita GDP (1960 – 2000)**
	obs = 30	obs = 30	obs = 30	obs = 31	obs = 31	obs = 16	obs = 31
Malaria Risk (MAL_i)	-1.92*** (0.5532)	-1.78*** (0.4987)	-1.56*** (0.5249)	-1.55** (0.6186)	-1.55** (0.6186)	-1.85** (0.8478)	-0.03*** (0.0059)
Executive Constraints in 2000 (INS_i)	0.13 (0.1293)	0.26 (0.2276)	0.24 (0.1714)	0.299 (0.2357)	0.299 (0.2357)	0.05 (0.1268)	-0.001 (0.0026)
Log total slave exports per square km (SLVX_i)	0.03 (0.0507)	0.08 (0.0827)	0.03 (0.0629)	0.03 (0.0586)	0.03 (0.0586)	0.04 (0.0666)	0.001 (0.0008)
Additional Controls	Log trade share in 2000	Catholicism	Islam	Legal Origin (French)	Legal Origin (British)	Schooling in 2000	
Panel B: Robustness with Other Diseases							
Dependent variable	**Log per Capita GDP in 2000**						
	obs = 31	obs = 31	obs = 24				
Yellow Fever in 1996	-3.59*** (1.062)						
Average Dengue in 1975 – 1995		11.92 (21.25)					
AIDS			-0.11 (0.1464)				
Executive Constraints in 2000 (INS_i)	0.23 (0.2766)	-0.15 (1.201)	0.78 (1.491)				
Log total slave exports per square km (SLVX_i)	0.02 (0.0896)	-0.62 (1.003)	-0.31 (0.4427)				

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Figures in the parentheses are the respective standard errors. The instruments used are ME, LSM, LPD, and DC. The standard errors are heteroskedasticity robust. All the regressions reported above are carried out with an intercept.

***Table 3A.* Additional Robustness Check (2SLS Estimates)**

The Model $\log y_i = \lambda + \alpha \text{MAL}_i + \beta \text{INS}_i + \gamma \text{SLVX}_i + \xi \text{OTH CTRL}_i + \varepsilon_i$								
Dependent variable	**Log per Capita GDP in 2000**							
	obs = 31	obs = 31	obs = 30	obs = 31	obs = 27	obs = 31	DFITS obs = 30	Cook's Distance obs = 29
Malaria Risk (MAL_i)	-1.54*** (0.5686)	-1.54* (0.8971)	-1.63** (0.7434)	-1.51** (0.6543)	-1.88*** (0.2459)	-1.76*** (0.4258)	-1.49*** (0.4113)	-1.31** (0.5547)
Executive Constraints in 2000 (INS_i)	0.28 (0.2066)	0.28 (0.3383)	0.31 (0.2530)	0.32 (0.2675)	0.13 (0.1478)	0.07 (0.1327)	0.16 (0.1225)	0.02 (0.3103)
Log total slave exports per square km (SLVX_i)	0.028 (0.0648)	0.018 (0.0661)	0.028 (0.0714)	0.014 (0.0721)	.022 (0.0345)	0.047 (0.0461)	0.012 (0.0459)	0.037 (0.0692)
Additional Controls	SWOPEN	Ethnic Fractionalisation	Linguistic Fractionalisation	Religious Fractionalisation	Primary Exports in 1970	Mining	--	--
Omitted Influential Outliers	--	--	--	--	--	--	GNQ, GAB	GNQ, GAB, ZAF

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Figures in the parentheses are the respective standard errors. The standard errors are heteroskedasticity robust. All the regressions reported above are carried out with an intercept. Influential observations are omitted using the following standard rules. In column 8, omit if $DFITS_i > 2\sqrt{\frac{k}{n}}$ (Belsley et al. 1980) and in column 9, omit if $Cooksd_i > \frac{4}{n}$ (Belsley et al. 1980) is used. Here n is the number of observation and k is the number of independent variables including the intercept.

Table 4. **Malaria and National Savings**

The Model $\left(\frac{S}{Y}\right)_i = \varsigma + \vartheta \text{MAL}_i + \rho \log y_i + \zeta_i$				
Dependent Variable	**Gross Savings as percentage of GDP in 2000** $\left(\frac{S}{Y}\right)$			
	OLS Estimate obs = 45	2SLS Estimate obs = 45	OLS Estimate obs = 42	2SLS Estimate obs = 42
Malaria Risk (MAL_i)	-15.21*** (3.674)	-11.86*** (5.208)	-14.85*** (3.869)	-12.25** (5.48)
Log per Capita GDP in 2000 ($\log y_i$)			2.81 (2.032)	3.17 (1.966)
R^2	0.2989		0.3318	
F-Stat	17.14	5.59	7.85	3.72
P-value	0.0002	0.0278	0.0014	0.033
Instruments		ME		ME

Notes: ***, ** and * indicates significance level of 1%, 5% and 10% respectively against a two sided alternative. Figures in the parentheses are the respective standard errors. The instruments used is ME for Malaria Risk. The standard errors are heteroskedasticity robust. All the regressions reported above are carried out with an intercept.

Data Appendix

Variable name	Description	Source
Log Per Capita GDP in 2000 ($\log y_i$)	Natural log of real GDP per capita in 2000. Real GDP figures are measured in US $ in current prices and the figures are PPP converted. For Botswana, Mauritania and Namibia we use 1999 values as an approximation. For Central African Republic I use 1998 values. For Angola, Zaire, and Sudan I use log per capita GDP (PPP adjusted and measured in current US$) from World Development Indicator (WDI).	Penn World Table (PWT) 6.1 Heston et al. (2002)
Growth in Per Capita GDP in (1960-2000)	Calculated using the formula $\hat{y}_{i2000} \equiv \frac{1}{40}(y_{i2000} - y_{i1960})$ for 46 African countries.	Penn World Table (PWT) 6.1 Heston et al. (2002)
Executive Constraints in 2000 (INS_i)	A seven category scale, 1 to 7, with a higher score indicating more constraint.	Polity IV dataset
Malaria Risk (MAL_i)	Percentage of the population at risk of malaria transmission in 1994.	Centre for International Development (CID), Geography Datasets, Harvard University
Log total slave exports per square km ($SLVX_i$)	This is natural log of the normalised estimate of total number of slaves exported from Africa during the period 1400-1899. The number of slave exports are normalised by the country size. The figure includes the Atlantic slave exports, the Indian ocean slave exports, the Trans Saharan slave exports, and the Red sea slave exports. I use Nunn (2004)'s methodology outlined in its data appendix to back out the numbers. The other sources that I have used following Nunn (2004) is Elbl (1997); Eltis et al. (1999); Austen (1979); Austen (1988); and Austen (1992). I have divided each of these numbers by the corresponding country size measured in km^2. The country size data is from CID geography dataset.	Nunn (2004)
Log Settler Mortality (LSM_i)	Natural log of estimated European Settler Mortality Rate in colonies and settlements	Acemoglu et al. (2001)
Log population Density in 1500 (LPD_i)	Log of total population divided by total arable land in 1500 A.D. Source: McEvedy and Jones (1978) as cited in Acemoglu, et al. (2002).	McEvedy and Jones (1978)

Variable name	Description	Source
Malaria Ecology (ME_i)	Malaria Ecology (ME) pop-weighted, Sept 2003 version. This variable provides an instrument for malaria risk that controls for the fact that causation may run not only from malaria to income but also from income to malaria. The basic formula for ME includes temperature, species abundance, and vector type (the type of mosquito). The underlying index is measured on a highly disaggregated sub-national level, and then is averaged for the entire country. Because ME is built upon climatological and vector conditions on a country-by-country basis, it is exogenous to public health interventions and economic conditions.	Kiszewski et al. (2004)
Distance from the coast (DC_i)	Mean distance to nearest coastline measured in kilometres.	Centre for International Development, Geography Datasets
Catholicism	Identifies the percentage of population of each country being Catholic in 1980.	LaPorta et al. (1999)
Islam	Identifies the percentage of population of each country being Muslim in 1980.	LaPorta et al. (1999)
Log of Trade Share in 2000	Natural log of Trade share calculated by taking log values of figure obtained by dividing volume of trade with GDP	WDI Online, The World Bank Group
Legal Origin (British)	Legal origin of the Company Law or Commercial Code of each country. The English Common Law dummy.	LaPorta et al. (1999)
Legal Origin (French)	Legal origin of the Company Law or Commercial Code of each country. The French Civil Law dummy.	LaPorta et al. (1999)
Total Years of Schooling in 2000	Average schooling years in the total population in 2000.	Barro and Lee (2000)
Yellow Fever Risk in 1996	Percentage of population living in areas with yellow fever (% country area), 1996; calculated in equal area cylindrical projection.	Centre for International Development, Geography Datasets, Harvard University
Average Dengue in 1975 – 1995	Percentage of population living in areas with dengue fever (Percentage country area), 1975 to 1995. Calculated in equal-area cylindrical projection. WHO. 1995. "Key Issues in Dengue Vector Control Toward the Operationalization of a Global Strategy." Geneva: WHO. Page 4.	Centre for International Development, Geography Datasets, Harvard University
AIDS	Number of AIDS incidents per 100,000 people.	United Nations Statistics Division, 2001
Ethnic Fractionalisation	Probability that two randomly selected individuals from a population belongs to different ethnic groups.	Alesina et al. (2003)

Variable name	Description	Source
Linguistic Fractionalisation	Probability that two randomly selected individuals from a population belongs to different language groups.	Alesina et al. (2003)
Religious Fractionalisation	Probability that two randomly selected individuals from a population belongs to different religious groups.	Alesina et al. (2003)
SWOPEN	The proportion of years that a country is open to trade during 1965-90, by the criteria defined by Sachs and Warner (1995).	Sachs and Warner (1995)
Primary Export in 1970	Share of exports of primary products in GNP in 1970.	Sachs and Warner (1997)
Mining	Fraction of GDP in Mining	Hall and Jones (1999)
Gross Savings as percentage of GDP $\left(\frac{S}{Y}\right)$	This is gross national savings as a percentage of GDP in 2001.	WDI Online, The World Bank Group