How would population growth affect investment in the future? Asymmetric panel causality evidence for Africa.

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Abstract

Our generation is experiencing the greatest demographic transition and Africa is at the center of it. There is mounting concern over rising unemployment and depleting per capita income accruing there-from. We look at the issue in this paper from a long run perspective by examining the nature of the relationship between population growth and a plethora of investment indicators: public, private, foreign and domestic investments. Our findings reveal a long-run positive causal linkage from population growth to only public investment. But for domestic investment, permanent fluctuations in human capital affect changes in other forms of investments. For economic implications, sampled countries should take family planning and birth control policies seriously. Measures should be adopted such that, rising unemployment rate resulting from population growth be accommodated by private sector investments.

JEL Classification: C33; J00; O10; O40.

Keywords: Productivity; investment; human capital; asymmetric panel; causality; Africa.

1. Motivation

The emergence of Africa in the world as one of the continents with the highest demographic growth rate with the population projected to double by 2036 and represent 20% of the world by 2050(UN Worlds Population Prospects 2009) presents an important geo-economic concern to policy-makers, researchers and social scientists. The issue is even more

crucial with rising unemployment rate and soaring economic migration; enough logic to suppose, policy making should be tilted towards attracting investment in a bid to accommodate increasing human capital (work force). Therefore, investigating and understanding the effects of population growth on the continents investment dynamics could have quite paramount policy implications. It is an established consensus that, the three main things Africa needs are investment, investment and investment (Dangote Group, 2008; IMF Survey, 2009). Our modest contribution to literature will therefore consist of probing into long-term effects of growth in human capital (population growth) on four investment types, namely: foreign, domestic, public and private investments. The research outcome could be useful in economic policy; as sampled countries would gain conscience of future consequences of demographic changes on investments types (e.g. unemployment rate).

In a bid to push through our research agenda, we shall first test for stationary properties of univariate series at country level; then derive first-orderly integrated variables on which cointegration properties with productivity variables will be analyzed; depending on results obtained from cointegration tests, we shall investigate causality linkages by simple Granger(short-run) or Vector Error Correction Models(VECMs). Lastly, our discussion of policy implications will be preceded by empirical results. Meanwhile, a statement of our theoretical framework and a review of literature are imperative.

2. Literature review

2.1 The concern for population growth and need for investment in Africa.

There has been growing concern over Africa's population growth and corresponding rising unemployment rate. With the population projected to double by 2036, many proponents have it that, if stringent investment policies are not put in place, socio-economic issues related

to rising unemployment and decreasing per capita would increase the rate of clandestine and economic migration from the south to the north.

According to the World Bank, our generation is experiencing the greatest demographic change ever, with Africa at its center. From United Nations estimates, in the post colonial era (around 1970), there were two Europeans for every African. By the time those born in the 1970s go on retirement (2030) it is projected that, there would be two Africans for every European. These statistics make Africa the fastest growing continent with its population estimated to represent 20% of the world by 2050(UN Worlds Population Prospects 2009). Therefore the concern of knowing how this soaring population could be accomondated without bitter economic implications is quit paramount. In an attempt to find a solution to this growing concern, many analysts support the thesis that, the three most important things Africa needs are: investment, investment and investment.

Though private and foreign investments in Africa have surged over the past years, rising unemployment rates remain crucial. With structural adjustment policies imposed by the World Bank and International Monetary Fund requiring liberalization, privatization and meandering towards market based economies in the 1980s; we should expect foreign and private investments to increase with population growth at the expense of public investments. Foreign capital investments for example have surged from $15 billion in 2000 to $87 billion in 2007.

As concerns the need for investment, analysts seem to be seeing from the same angle. Dangote Group (2008) has emphasized that Africa needs investments not aid. It decried the rejection of products from African companies by multinationals and urged African companies to target inter-African trade. This pressing investment need is supported by a recent IMF Survey(April 2009) in which many analysts believe foreign donors should focus more on

investment avenues in Africa, than on aid. Development assistance and aid would improve per capita, but sustainable investment could benefit the continent more in the long run.

2.2 Literature on linkages between population growth and economic growth.

The link between population growth and economic growth has been a controversial agenda in the literature of economic development. While some proponents see population growth as an instigator of long-run growth, others express ambivalence over this relationship.

The contribution of population growth to economic development has been addressed by many studies. More recently, Azomahou and Mishra (2008) in revisiting the impact of age dynamics on economic growth through age-structured population for OECD and non OECD countries show that, between 1960 and 2000, said economies grew mostly due to the stock of human capital. In comparative terms, findings reveal non OECD countries are likely to enjoy higher growth than their OECD counterparts. Moreso, the age-dynamics side of the study reinforces the consensus that, age-structured population, especially the work force, is important in explaining differences in growth between OECD and non OECD countries. Much ealier, Hondroyiannis and Papapetrou(2005), in a study on the relationship between fertility and output in eight European countries using panel cointegration analysis, established that, in the long-run(based on data from 1960 through 1998) increase in output per capita would be associated with higher fertility. This confirms the thesis of proponents who acknowledge the current low fertility rate in Europe is having a toll on European economic growth.

Contrary to this well established positive link between birth rate and growth rate, the concern as to why many poor countries with high birth rates reflect low growth rates remains puzzling and has been explained through classical and modern theories. Malthusian and neo-Malthusian theories explain the relation between population growth and economic

development through depletion of per capita income. This is the direct consequence of population growth increasing faster than GDP growth.

Contrary to the abundance of 'demographic-change and growth' literature, studies that have exclusively focused on the relationship between investment and population growth are quite scanty. Unfortunately, we found none that directly addresses linkages between the two later set of indicators. We therefore infer that, since investment is exogenous to economic growth, studies dedicated to causality flow from demographic change to economic growth should be tantamount to those from population growth to investment. As we have pointed our earlier, though there is no established consensus on the direction of causality flowing from population growth to economic growth, the flow from development to population growth has a generally acceptable negative link.

It is widely believed that, as income grows, families tend to prefer the quality of children to their quantity. Borrowing from Hasan (2010), per capita growth in China tends to lower population growth. He quotes the Becker hypothesis in supporting his findings: "…as per capita income increases, families turn to prefer quality over quantity of children. The resultant increase in the cost of bearing and rearing children would induce smaller family size and lead to decline in fertility" (page 360). Another explanation to this phenomenon could be seen from Pommeret and Smith (2005) who conclude that growth rates are negatively correlated with birth rates due to production volatility. Thus with development, productivity volatility affects the growth rate of an economy by altering both saving decisions and decisions to have children.

The contribution of this paper to literature could be captured from the following: (1) we analyze the direct linkage between investment and population growth from a productivity model, as literature is quite scanty on this relationship; (2)usage of a plethora of investment types provides a robust account on investment effects of population growth for the continent;

(3) analyses of panel stationary and cointegration properties are under both homogenous and heterogeneous assumptions; and (4) models based on VAR processes are specified by an appropriate optimal lag selection criterion for goodness of fit.

3. Model and theoretical framework

Starting with the aggregate investment production function:

$$I = AK^{\alpha}W^{\beta} \quad (1)$$

where **I** is the investment variable, **A** is total factor productivity, **K** is capital stock, and **W** is the labour composite, which is determined by the rate of population growth . We can re-write equation (1) in the natural log form in per capita terms as:

$$\log I = \theta + \alpha \log K + \beta \log W \quad (2)$$

In the investment production function, physical capital is measured by gross fixed capital formation and human capital by population growth rate. To take account of the panel nature of our study, we can hence re-reformulate equation (2) in per capita form for country **i** at time **t** as: $\log I_{it} = \alpha_{it} + \alpha \log k_{it} + \psi_{it} \log w_{it}$ (3).

There are several channels through which human capital could improve investment. An investor would consider the cost of labour as a production factor before a decision to invest in a given region. The cost of labour is determined by its availability. From common sense and to some extend economic theory (demand and supply), countries with high growth rates in working force would 'ceteris paribus' have low working wage. It follows that, growth in work force should lead to cheaper labour cost, more investment and consequently higher economic growth. Thus, as hypothetically specified in equation 3, there is a positive relationship between stated productivity factors and investment types. This theoretical lay-out is synonymous to the positive dependence of aggregate production (GDP) on mentioned productivity factors and is supported empirically by many an author (Azomahou & Mishra,

2008; Hondroyiannis and Papapetrou, 2005). Concerning short-run effects, we don't expect results to be significant because, we hypothetically assume population growth should impact investment dynamics only in the long-term.

4. Data and Econometric methodology

4.1 Data

We obtain data from African Development Indicators of the World Bank. The 30 year span (1977 to 2007) is based on information availability. Selected investment variables include: per capita Gross Foreign Direct Investment (*FDI*); per capita Gross Private Investment (*Private Ivt*); Gross Public Investment on GDP (*Public Ivt*); and Gross Domestic Investment on GDP (*GDI*). Factor productivity proxies are Gross Fixed Capital Formation (*GFCF*) for physical capital and Population growth rate (*pop*) for human capital. 38 countries make up initial database but are trimmed down subsequently due to constraints in the cointegration theory[1]. Therefore, in panel analyses, constituent countries of the panel-base differ as we move from one form of investment to another. Suffice to disclose that, since we are concerned with knowing how investment is affected in the distant future by population growth, the other factor productivity proxy (physical capital or fixed capital formation) serves as a control variable and concurrently aids in robustness checks(verification of physical capital led investment nexus).

4.2 Causality estimations

Based on the Engle-Granger methodology (1987), short run estimations and long run estimators will be derived by simple Granger causality and Vector Error Correction (VEC) models respectively.

[1] For long-run elasticities to be estimated for a given country, factor productivity proxies must be integrated in the first order and cointegrated with investment variables. While integration requires exhibition of unit root at level series (and therefore stationarity at first differenced series), cointegration necessitates showing that, permanent changes in factor productivity variables affect investment proxies and vice versa.

4.2.1 Short run estimations

Let us consider a basic bivariate finite-order VAR model. As shown by equations (4) and (5) below, short-run or simple granger causality is based on evaluating how respectively, past values of physical capital (k) and human capital(w) could help past values of FDI in better explaining present values of FDI. Within this framework, for comparative reasons, we choose to apply this model on first differenced series since the absence of unit root is a precondition for its application. Our resulting VAR Models are as follows:

$$\Delta FDI_{it} = \sum_{j=1}^{p} \lambda_{ij} \Delta FDI_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}^{'} \Delta k_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (4)$$

$$\Delta FDI_{it} = \sum_{j=1}^{p} \lambda_{ij} \Delta FDI_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}^{'} \Delta w_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (5)$$

$$\Delta k_{it} = \sum_{j=1}^{p} \lambda_{ij} \Delta k_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}^{'} \Delta FDI_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (6)$$

$$\Delta w_{it} = \sum_{j=1}^{p} \lambda_{ij} \Delta w_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}^{'} \Delta FDI_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (7)$$

Models we retain as theoretically relevant for our study are (4) and (5). Equations (6) and (7) shall therefore not be applied because, with respect to our hypothetical model, we seek only to evaluate the effects of factor productivity variables on investment proxies and not the other way round (see equation 2). The corresponding tests for zero restrictions in the VAR models would be captured by the F-statistics; which is the Wald statistics for the joint hypothesis that parameters of lagged values of either 'w' or 'k' equals zero. To put this point into perspective, the null hypothesis for equation (5) should stipulate: 'w' does not granger cause FDI. It might be interesting to note that, the statement "'w' granger causes FDI" does not imply, FDI is the effect of 'w'. Granger causality measures precedence and information

content, but does not itself indicate causality in the more common sense of the term. Optimal lag selection for goodness of fit is based on AIC (Khim, 2004).

4.2.2 Long run estimators

For long run causality, let's consider foreign direct investment (FDI), physical capital (k), and human capital (w), with no lagged difference, such that:

$$FDI_{it} = \beta k_{it} \tag{8}$$

$$FDI_{it} = \beta w_{it} \tag{9}$$

Resulting VECMs are the following:

$$\Delta FDI_{it} = \alpha(FDI_{i,t-1} - \beta k_{i,t-1}) + \varepsilon_{1,t} \tag{10}$$

$$\Delta k_{it} = \alpha'(k_{i,t-1} - \beta FDI_{i,t-1}) + \varepsilon_{2,t} \tag{11}$$

$$\Delta FDI_{it} = \alpha''(FDI_{i,t-1} - \beta w_{i,t-1}) + \varepsilon_{3,t} \tag{12}$$

$$\Delta w_{it} = \alpha'''(w_{i,t-1} - \beta FDI_{i,t-1}) + \varepsilon_{4,t} \tag{13}$$

Like in the case of short-run causality, for long-run elasticities, only models (10) and (12) should be of interest to us. The right hand terms are the 'error correction terms' (ECTs). At equilibrium, the value of this term is zero. When the ECT is non-zero, it implies FDI and 'k' or 'w' have deviated from the long run equilibrium; the ECT helps each variable to adjust and partially restore the equation relation. The speeds of these adjustments are measured by **α** and **α''** for physical capital and human capital respectively. We shall replicate the same models (10 and 12) for all three remaining investment types and maintain the same deterministic trend assumptions used for cointegration tests. Goodness of fit in model specification would be based on the AIC (Khim, 2004).

4.3 Derivation of integrated variables from country specific unit root tests

4.3.1 Country specific unit root tests

In our quest to apply the cointegration theory, we shall first endeavour to test for stationary properties at country level. In doing so, we correct for serial correlations using Augmented Dickey Fuller (ADF) test. We do not elaborate on the mechanics of the unit root test because it is widely applied and constitutes only an exploratory venture of our study. However, as we have pointed-out earlier, what is imperative to note in the specification of the VAR process is that, optimal lag selection for goodness of fit is based on Akaike Information Criterion (AIC). Our choice of this criterion is guided by Khim (2004), who demonstrate that, when observations are less than 60, the AIC and Final Prediction Error (FPE) are best at specifying optimal lags. Unit root test results are presented on tables 1 and 2. Variables of countries whose stationary properties match expectations of the cointegration theory are seen in bold and could be retained as first orderly integrated for our analysis depending on a given selection criteria (see *4.3.2*)

Table 1: ADF Statistics for country specific unit root tests (1977-2007)

Countries	Foreign Investment				Private Investment				Public Investment			
	Level		First difference		Level		First difference		Level		First difference	
	c	ct	c	ct	c	ct	c	ct	c	ct	c	ct
Algeria	-2.992*	-13.13***	n.a	n.a	-2.501	-3.190	-2.956*	-2.881	-1.777	-1.722	-3.716***	-3.708**
Benin	-4.806***	-5.956****	n.a	n.a	**-0.900**	**-2.553**	**-3.814****	**-3.838****	-3.690**	-3.647*	n.a	n.a
Botswana	-2.248	-3.547*	-7.304***	-7.171***	-2.583	-3.022	-3.336**	-3.410*	-3.128**	-2.069	-4.336**	-6.079***
Burundi	-4.417***	-4.305**	n.a	n.a	-2.058	-2.071	-5.711***	-5.590***	-1.853	-2.751	-6.145***	-6.005***
Cameroon	-2.403	-2.402	-10.66***	-10.44***	-5.180***	-4.311***	n.a	n.a	-2.177	-3.007	-3.088**	-3.035
CAR	-1.049	-10.39***	-4.223***	-3.894**	-4.222***	-4.124**	n.a	n.a	-3.464**	-3.930**	-6.938***	-7.195***
Chad	-3.702**	-3.308	-3.171**	-2.717	-1.612	-2.545	-2.695*	-2.528	-2.073	-2.340	-4.316***	-4.802***
Côte d'Iv.	**-2.133**	**-2.661**	**-7.098*****	**-6.970*****	**-2.328**	**-2.256**	**-9.711*****	**-4.365****	**-1.554**	**-2.008**	**-4.955*****	**-4.949*****
Congo R.	**-0.995**	**-2.079**	**-4.660*****	**-3.639***	**-1.748**	**-1.229**	**-8.228*****	**-8.494*****	**-3.324****	**-3.264**	**-3.281****	**-3.416***
Egypt	-2.062	-0.858	-3.385**	-3.555*	-2.594	-2.515	-3.056**	-3.021	-1.186	-4.171**	-5.739***	-5.584***
Burkina F.	-7.635***	-8.338***	n.a	n.a	-1.712	-3.022	-4.802***	-4.638***	-1.475	-2.443	-5.919***	-5.814***
Gabon	-2.721*	-2.651	-7.243***	-7.198***	-1.983	-2.889	-2.800*	-2.778	-4.625***	-4.566***	-4.625***	-4.566***
Gambia	**0.319**	**-1.888**	**-13.361*****	**-14.000*****	**-2.064**	**-2.457**	**-5.060*****	**-4.938*****	**-2.877***	**-3.129**	**-4.660*****	**-4.515*****
Ghana	**-0.593**	**-3.096**	**-4.776*****	**-4.920*****	**0.755**	**-4.865*****	**-5.705*****	**-5.817*****	**-2.364**	**-2.330**	**-3.498****	**-3.353***
Guinea	-2.849*	-2.826	-3.801**	-3.726*	-1.801	-1.707	-4.392***	-4.348***	-0.576	-3.438*	-6.727***	-7.292***
Kenya	-3.966***	-4.701***	n.a	n.a	-1.314	-1.356	-5.578***	-5.762***	-1.653	-1.541	-4.276***	-4.251**
Lesotho	-3.119**	-3.198	-6.795***	-6.697***	-1.279	-1.125	-4.190***	-4.385***	-2.052	-2.386	-4.038***	-3.837**
Madagascar	-0.990	-5.213***	-5.053***	-4.906***	2.056	0.336	-6.365***	-3.985**	-3.245**	-3.573*	-3.861***	-3.732**
Malawi	-3.424**	-3.992**	n.a	n.a	**-2.014**	**-1.946**	**-5.941*****	**-5.832*****	**-2.570**	**-1.980**	**-4.908*****	**-5.806*****
Mali	-2.813*	-3.646**	n.a	n.a	-3.742**	-4.841***	n.a	n.a	-2.649*	-4.355**	n.a	n.a
Morocco	-1.434	-8.603***	-15.199***	-14.922***	0.116	-2.320	-5.022***	-3.875**	-3.817***	-2.959	-4.956***	-5.706***
Mozambique	-1.924	-2.610	-4.535***	-4.469**	-1.833	-1.553	-10.486***	-5.564***	-3.034**	-3.288*	n.a	n.a
Mauritania	-5.683***	-4.794***	n.a	n.a	-0.970	-3.269	-3.309*	-3.542	-6.762***	-0.261	-3.444**	-5.162**
Mauritius	-4.188***	-4.414***	n.a	n.a	-2.866*	-2.898	-2.969**	-2.890	-1.758	-1.485	-5.223***	-5.525***
Namibia	-2.836*	-4.079**	n.a	n.a	-1.616	-3.869**	-6.721***	-6.651***	-3.784***	-2.956	-7.717***	-8.387***
Niger	-3.577**	-3.468*	n.a	n.a	0.153	-1.056	-4.371***	-5.146***	-4.232***	-3.347*	n.a	n.a
Rwanda	-0.721	0.281	n.s.a	n.s.a	-1.006	-1.843	-3.741**	-3.635*	-1.871	-2.323	-4.951***	-4.991***
South Africa	-4.072***	-4.210**	n.a	n.a	**-3.233****	**-1.215**	**-4.555*****	**-5.331*****	-3.401**	-8.925***	n.a	n.a
Senegal	-1.771	-5.327***	-10.147***	-10.042***	-2.394	-3.358*	-6.470***	-6.367***	2.193	0.471	-6.622***	-7.693***
Seychelles	1.173	-0.584	-1.721	-2.221	-2.627	-2.862	-5.399***	-5.324***	-4.070***	-3.752**	n.a	n.a
Sierra Leone	-4.986***	-5.432***	n.a	n.a	-2.146	-1.253	-7.489***	-8.351***	-3.457**	-3.403*	n.a	n.a
Sudan	-0.836	-1.999	-2.515	-3.193	**-2.471**	**-3.074**	**-5.591*****	**-5.461*****	**-1.052**	**0.267**	**-3.515****	**-4.469*****
Swaziland	-3.953***	-3.932**	n.a	n.a	**-1.882**	**-4.716*****	**-5.570*****	**-5.739*****	**-3.237****	**-2.996**	**-10.754*****	**-10.734*****
Togo	-3.275**	-3.206	-10.037***	-11.202***	-1.356	-2.764	-5.607***	-5.556***	-3.688**	-4.169**	n.a	n.a
Tunisia	-3.638**	-4.201**	n.a	n.a	-5.087***	-4.992***	n.a	n.a	**-1.952**	**-1.650**	**-3.872*****	**-3.810****
Uganda	0.745	-1.647	-5.071***	-5.564***	-0.430	-3.607*	-6.531***	-6.354***	-3.537**	-3.585*	n.a	n.a
Zambia	**-1.646**	**-4.351****	**-5.833*****	**-5.627*****	-0.799	-1.606	-1.674	-1.922	**-1.576**	**-1.389**	**-3.872****	**-3.697***
Zimbabwe	-2.124	-2.381	-6.413***	-4.171***	-2.862*	-2.986	-5.288***	-5.098***	-3.448**	-3.547*	n.a	n.a

*, **, *** denote significance at 10%, 5% and 1% respectively. Maximum lag is 3 and optimal lags are chosen via AIC. 'c' and 'ct': 'constant' and 'constant and trend' ;respectively. n.a: not applicable; n.s.a: not specifically applicable.

Table 2: ADF Statistics for country specific unit root tests continued (1977-2007)

Countries	Domestic Investment				Physical Capital				Human Capital(Population growth)			
	Level		First difference		Level		First difference		Level		First difference	
	c	ct	c	ct	c	ct	c	ct	c	ct	c	ct
Algeria	-2.853*	-1.465	-2.901*	-6.147***	-2.624	-2.100	-5.992***	-6.502***	-1.632	-1.825	-1.960	-2.123
Benin	-3.406**	-3.549*	n.a	n.a	**-0.717**	**-8.603*** **	**-8.045*** **	**-7.778*** **	**-2.097**	**-1.344**	**-8.902*** **	**-9.263*** **
Botswana	-2.574	-2.745	-3.820***	-3.853**	-2.888*	-3.550*	n.a	n.a	-0.539	-2.806	-1.763	-1.494
Burundi	-1.390	-2.703	-7.960***	-7.813***	-1.747	-1.941	-6.800***	-6.687***	-3.580**	-3.681**	n.a	n.a
Cameroon	-2.231	-1.670	-6.562***	-6.797***	-4.582***	-3.918**	n.a	n.a	2.257	-0.558	-1.089	-2.448
CAR	-3.458**	-3.552*	n.a	n.a	-3.774***	-3.772**	n.a	n.a	-1.119	-2.339	-2.514	-3.093
Chad	-1.557	-3.646**	-4.374***	-4.340**	-1.641	-3.094	-3.893***	-3.801**	-1.072	0.594	-0.015	-0.760
Côte d'Iv.	**-1.831**	**-1.479**	**-4.469*** **	**-4.746*** **	**-1.786**	**-1.467**	**-5.279*** **	**-5.810*** **	**-1.166**	**-4.242** **	**-3.326** **	**-3.098**
Congo R.	**-2.626***	**-2.931**	**-4.527*** **	**-4.436*** **	**-2.607**	**-3.058**	**-4.552*** **	**-4.471*** **	**-1.131**	**-1.214**	**-2.813***	**-2.882**
Egypt	-1.577	-3.397*	-4.159***	-4.080**	-2.112	-3.309*	-5.121***	-4.995***	-1.567	-3.334*	-2.155	-1.737
Burkina F.	-2.607	-2.591	-6.795***	-6.659***	-2.440	-2.540	-7.057***	-6.987***	-1.916	0.279	-1.268	-2.452
Gabon	-4.679***	-5.192***	n.a	n.a	-3.604**	-4.003**	n.a	n.a	-1.755	-2.397	-1.461	-0.971
Gambia	-6.293***	-6.443***	n.a	n.a	**-2.970***	**-2.951**	**-4.710*** **	**-5.053*** **	**-1.143**	**-1.553**	**-1.063**	**-6.523*** **
Ghana	**0.693**	**-2.689**	**-6.230*** **	**-6.482*** **	**0.518**	**-4.130** **	**-5.783*** **	**-5.936*** **	**0.689**	**-7.314*** **	**-4.253*** **	**-13.654*** **
Guinea	-1.089	-2.281	-4.313***	-4.529***	-1.099	-2.429	-4.427***	-4.576***	-2.126	-2.591	-1.858	-1.834
Kenya	-2.951*	-4.360***	n.a	n.a	-4.559***	-4.264**	n.a	n.a	-1.286	-3.203	-2.379	-2.347
Lesotho	-1.418	-1.062	-5.029***	-5.079***	-1.358	-0.959	-5.260***	-5.012***	0.247	-2.079	-1.439	-1.615
Madagascar	-0.666	-1.844	-6.443***	-6.589***	-0.175	-1.294	-4.984***	-5.086***	-2.804*	-1.276	-1.420	-2.755
Malawi	**-2.743***	**-2.721**	**-7.796*** **	**-8.042*** **	**-2.353**	**-2.173**	**-6.527*** **	**-6.812*** **	**-1.506**	**-2.249**	**-3.115** **	**-3.083**
Mali	-1.727	-3.703**	-8.364***	-8.225***	-1.755	-3.714**	-8.390***	-8.256***	-1.425	-4.472***	-2.688*	-2.515
Morocco	-2.197	-2.636	-6.075***	-4.151**	-2.414	-2.845	-5.605***	-3.953**	9.587	17.212	6.654	-1.825
Mozambique	-2.632*	-2.994	-4.386***	-4.814***	-2.632*	-2.994	-4.386***	-4.814***	-2.199	-2.247	-2.074	-1.976
Mauritania	-1.798	-1.725	-8.590***	-8.442***	-4.263***	-4.263**	n.a	n.a	-3.352**	-0.473	0.722	1.593
Mauritius	-3.148**	-3.078	-2.572	-2.499	-3.964***	-4.241**	n.a	n.a	-2.106	-2.215	-5.884***	-5.787***
Namibia	-3.792***	-3.797**	n.a	n.a	-2.748*	-3.426*	n.a	n.a	-2.247	-2.351	-1.532	-1.050
Niger	-3.687**	-1.413	-2.927*	-3.957**	-1.011	-2.356	-3.214**	-4.414***	-1.786	1.899	0.707	0.138
Rwanda	-0.843	-1.908	-9.900***	-10.020***	-1.551	-2.661	-5.820	-6.028***	-2.588	-2.565	-2.479	-2.425
South Africa	**-1.838**	**-1.486**	**-4.575*** **	**-4.814*** **	**-1.545**	**-0.106**	**-3.000** **	**-3.665** **	**-0.780**	**-2.345**	**-3.921*** **	**-4.218** **
Senegal	-0.531	-1.005	-6.304***	-6.651***	-0.934	-2.539	-6.392***	-6.316***	-1.544	-3.545*	-2.427	-2.277
Seychelles	-3.149**	-3.003	-7.251***	-7.308***	-3.135**	-2.985	-7.066***	-7.132***	-5.342***	-5.282***	n.a	n.a
Sierra Leone	-2.127	-1.534	-8.211***	-9.493***	-1.738	-1.628	-8.488***	-9.725***	-2.472	-2.335	-2.380	-2.424
Sudan	**-1.201**	**-3.519***	**-5.354*** **	**-4.802*** **	**-1.478**	**-1.779**	**-5.843*** **	**-5.873*** **	**-1.686**	**-2.757**	**-2.758***	**-2.813**
Swaziland	**-3.978*** **	**-2.327**	**-5.158*** **	**-5.353*** **	**-2.999** **	**-2.337**	**-5.143*** **	**-4.751*** **	**0.105**	**-2.112**	**-1.506**	**-9.394*** **
Togo	-2.172	-2.227	-6.221***	-6.728***	-3.531**	-3.238*	n.a	n.a	-2.367	-3.489*	-2.521	-2.461
Tunisia	**-2.402**	**-4.300** **	**-5.484*** **	**-5.354*** **	**-2.379**	**-2.936**	**-3.847*** **	**-3.797** **	**-0.958**	**-4.634*** **	**-5.188*** **	**-5.083*** **
Uganda	-0.160	-4.807***	-6.668***	-6.541***	-0.819	-3.649**	-4.977***	-4.866***	-2.961*	-3.015	-1.804	-1.834
Zambia	**-2.827***	**-1.636**	**-4.750*** **	**-6.064*** **	**-1.222**	**-2.265**	**-5.203*** **	**-5.980*** **	**1.468**	**-1.659**	**-10.479*** **	**-11.040*** **
Zimbabwe	-2.347	-2.318	-5.426***	-5.378***	-3.385**	-3.358*	n.a	n.a	-2.016	-0.994	-4.318***	-0.505

*, **, *** denote significance at 10%, 5% and 1% respectively. Maximum lag is 3 and optimal lags are chosen via AIC. 'c' and 'ct': 'constant' and 'constant and trend' ;respectively. n.a: not applicable; n.s .a: not specifically applica

4.3.2 Derivation of first orderly integrated variables and asymmetric panels

From specific country unit root tests results, the choice of countries (in bold on tables 1 and 2) that would constitute asymmetric investment panels will be guided by the following criteria:

-both factor productivity variables (human and physical capital) must exhibit unit root at level series and be first orderly integrated (first differenced stationary);

-at least one investment proxy must also be non stationary at level series and stationary at first differenced series.

Applying above selection process to all countries resulted in the derivation of six variable panels below (see table 3).

Table 3: Derivation of countries with first orderly integrated variables: I (1)

Asymmetric Panels					
Investment dynamics				Productivity factors	
Panel 1	Panel 2	Panel 3	Panel 4	Panel 5	Panel 6
FDI	Private Ivt	Public Ivt	Domestic Ivt.	Labour(Pop)	Capital(GFCF)
	-Benin			-Benin	-Benin
-Ivory Coast	-Ivory Coast	- Ivory Coast	-Ivory Coast	-Ivory Coast	-Ivory Coast
-Congo Rep.	-Congo Rep.	-Congo Rep.	-Congo Rep.	-Congo Rep.	-Congo Rep.
-Gambia	-Gambia	-Gambia		-Gambia	-Gambia
-Ghana	-Ghana	-Ghana	-Ghana	-Ghana	-Ghana
	-Malawi	-Malawi	-Malawi	-Malawi	-Malawi
	-South Afri.		-South Afri.	-South Afri.	-South Afri.
	-Sudan	-Sudan	-Sudan	-Sudan	-Sudan
	-Swaziland	-Swaziland	-Swaziland	-Swaziland	-Swaziland
		-Tunisia	-Tunisia	-Tunisia	-Tunisia
-Zambia		-Zambia	-Zambia	-Zambia	-Zambia

Source (authors synthesis)

4.4 Panel unit root tests

Bearing in mind the means of our research agenda is the use of a parametric method for data analysis, we start with correcting for serial correlations by testing the stationary

properties of our series. In event, a series is not integrated at level: not I(0); we test for the presence of first order stationarity(first differenced absence of unit root): I(1). Integration indicates stationarity and shows a model that assumes a particular functional distribution could be applied for estimation. While the short-run granger causality model is applied when there is absence of serial unit roots, the long-run granger version (VECM) presupposes at least a first order integration (unit root at level and none at first differenced).

There are two main types of panel unit roots test: first generational that assume cross sectional independence and second generational based on cross sectional dependence. A precondition to the application of the later test is a cross sectional dependence test which is possible only and only if the numbers of cross sections (N) in a panel are higher than the number of periods in country time series (T). Consequently we limit ourselves to the first generational type. Within this category, among panel unit roots tests mostly applied in the literature of macro economic variables are, Levin, Lin and Chu (LLC-2002) and Im, Pesaran and Shin (IPS-2003). While the former is homogenous and founded on the presence of a common unit root (null hypothesis), the later is heterogeneous and based on the existence of individual unit roots. Within the framework of this research, we shall apply both tests, but base our decisions entirely on the IPS-test in event of a conflict of interest because, borrowing from Maddala and Wu (1999), the alternative hypothesis of the LLC test is too powerful. Goodness of fit is ensured by AIC with 3 maximum lags. Results are presented on table 4 below.

Table 4: Panel Unit Root Test

Panel 1

Unit root tests for factor-foreign investment productivity

Deterministic components		LLC tests for homogenous panel			IPS tests for heterogeneous panel		
		FDI	Labour	Capital	FDI	Labour	Capital
Level	c	1.616	1.866	0.155	1.257	2.783	-0.304
	ct	0.019	3.318	-1.355*	-1.644*	-2.752***	-1.618*
First difference	c	-12.552***	-11.474***	-8.412***	-13.385***	-6.898***	-8.896***
	ct	-11.130***	-13.721***	-8.210***	-11.880***	-13.353***	-8.673***

Number cross sections involved are **five** :Ivory Coast, Congo Republic, The Gambia, Ghana and Zambia

Panel 2

Unit root tests for factor-private investment productivity

Deterministic components		LLC tests for homogenous panel			IPS tests for heterogeneous panel		
		Private Ivt.	Labour	Capital	Private Ivt.	Labour	Capital
Level	c	-2.722***	1.230	-0.201	-0.855	1.519	-0.926
	ct	-2.528***	4.309	-2.764***	-1.828**	-2.341***	-2.825***
First difference	c	-2.722***	-11.476***	-10.336***	-14.598***	-6.535***	-12.872***
	ct	-2.528***	-14.828***	-8.263***	-11.455***	-13.519***	-11.859***

Number cross sections involved are **nine** :Benin, Ivory Coast, Congo Republic, The Gambia, Ghana, Malawi, South Africa, Sudan and Swaziland

Panel 3

Unit root tests for factor-public investment productivity

Deterministic components		LLC tests for homogenous panel			IPS tests for heterogeneous panel		
		Public Invt.	Labour	Capital	Public invt.	Labour	Capital
Level	c	-1.297*	2.312	-1.207	-2.518***	2.702	-1.383*
	ct	0.996	4.449	-1.763**	0.353	-3.314***	-1.457*
First difference	c	-11.917***	-11.508***	-11.360***	-10.752***	-7.500***	-12.293***
	ct	-9.757***	-15.006***	-9.446***	-9.628***	-14.449***	-11.375***

Number cross sections involved are **nine** :Ivory Coast, Congo Republic, The Gambia, Ghana, Malawi, Sudan, Swaziland, Tunisia and Zambia

Panel 4

Unit root tests for factor-domestic investment productivity

Deterministic components		LLC tests for homogenous panel			IPS tests for heterogeneous panel		
		GDI	Labour	Capital	GDI	Labour	Capital
Level	c	-2.364***	2.191	-1.573*	-1.920**	2.873	-0.842
	ct	-2.485***	7.005	-1.1350	-1.500*	-3.596***	-0.347
First difference	c	-2.364***	-13.551***	-10.768***	-12.635***	-8.524***	-11.654***
	ct	-1.752**	-14.724***	-9.114***	-11.866***	-13.646***	-10.826***

Number cross sections involved are **nine** :Ivory Coast, Congo Republic, Ghana, Malawi, South Africa, Sudan, Swaziland, Tunisia and Zambia

*, **, *** denote significance at 10%, 5% and 1% respectively. Maximum lag is 3 and optimal lags are chosen via HQC for LLC test and AIC for IPS test. 'c' and 'ct': 'constant' and 'constant and trend' ;respectively.

From table 1, it could be discerned that, but for factor-domestic investment which significantly has variables void of unit root at level series, the other three factor-investment

variable-panels are first orderly integrated. When variables are integrated, a linear combination of them could be stationary (cointegration).

4.5 Panel cointegration tests

According to the cointegration theory, two or more series that exhibit unit root may have a linear combination in a long-run equilibrium. In other words, we quest to examine whether permanent long-run movements of factor productivity affect long-run investment dynamics. To achieve this, we test integrated variables for cointegration with Engle-Granger based Pedroni and Kao tests. Borrowing from Camarero & Tamarit (2002), the advantage of applying these two tests is that, while the former (Pedroni; 1999) is heterogenous, the later (Kao; 1999) is homogenous based. Implementation of both tests is compatible with our earlier application of both homogenous (LLC) and heterogeneous (IPS) in unit root tests. The same deterministic trend components used in integration tests are applied. Contrary to mainstream literature where cointegration relations are based on trivariate statistics (Gries et al, 2009), to avoid misspecifications in causality estimations, we present both trivariate and bivariates tests but base our decisions on the later. Optimal lag selection for goodness of fit is by AIC. Our main findings reveal some evidence of a cointegration relationship between factor productivity variables and three investment proxies (foreign, private and public investments). Suffice here to mention that, the domestic investment variable and factor productivity variables were not overwhelmingly integrated due to the presence of level stationarity in key variables. Therefore, with respect to the cointegration theory, domestic investment is sidelined and can be used only for short-run causality. Long-run equilibrium results are summarized on table 5 below.

Table 5: Bivariate and trivariate panel cointegration tests

Panel 1

Cointegration tests for factor-foreign investment productivity

	FDI, Labour, Capital		FDI, Labour		FDI, Capital	
Deterministic trend specifications	c	ct	c	ct	c	ct
Engle-Granger based Pedroni test for heterogeneous panel						
-Panel PP Statistics	-1.003	-1.410*	-2.500***	-3.388***	-0.278	-2.198**
-Panel ADF Statistics	-2.233**	-2.701***	-3.008***	-3.268***	-1.021	-3.335***
-Group PP Statistics	-0.754	-1.976**	-1.706**	-2.927***	0.943	-2.345***
-Group ADF Statistics	-2.112**	-3.223***	-1.716**	-2.559***	-0.479	-2.425***
Engle-Granger based Kao test for homogenous panel						
-ADF t statistics	1.916**	n.a	2.031**	n.a	3.125***	n.a

Panel 2

Cointegration tests for factor-private investment productivity

	Private I, Labour, Capital		Private I, Labour		Private I, Capital	
Deterministic trend specifications	c	ct	c	ct	c	ct
Engle-Granger based Pedroni test for heterogeneous panel						
-Panel PP Statistics	-2.799***	-2.861***	-1.380*	-1.273	-3.729***	-1.873**
-Panel ADF Statistics	-2.854***	-2.475***	-1.953**	-3.008***	-3.850***	-3.245***
-Group PP Statistics	-3.277***	-3.028***	-1.750**	-2.393***	-3.966***	-2.210**
-Group ADF Statistics	-3.754***	-2.678***	-2.337***	-4.031***	-4.978***	-2.348***
Engle-Granger based Kao test for homogenous panel						
-ADF t statistics	-4.399***	n.a	0.327	n.a	-4.366***	n.a

Panel 3

Cointegration tests for factor-public investment productivity

	Public I, Labour, Capital		Public I, Labour		Public I, Capital	
Deterministic trend specifications	c	ct	c	ct	c	ct
Engle-Granger based Pedroni test for heterogeneous panel						
-Panel PP Statistics	-1.530*	-1.347*	1.481	-0.844	-1.347*	-2.031**
-Panel ADF Statistics	-2.670**	-3.231***	0.771	-3.147***	-1.506*	-3.164***
-Group PP Statistics	-1.575*	-3.331***	2.891	0.323	-0.808	-3.320***
-Group ADF Statistics	-3.738***	-4.426***	2.127	-12.24***	-1.718**	-3.841***
Engle-Granger based Kao test for homogenous panel						
-ADF t statistics	-1.971**	n.a	-4.147***	n.a	-2.066**	n.a

Panel 4

Cointegration tests for factor-domestic investment productivity

N/A due to presence of level stationarity in key variables

*, **, *** denote significance at 10%, 5% and 1% respectively. Maximum lag is 3 and optimal lags are chosen via AIC. N/A (n.a): Not Applicable.

4.6 Panel causality analysis

With respect to the Granger representation theorem, above unit roots and cointegration results imply the validity of an error correction representation of human capital and investment types from a dynamic modeling set up. Where we find absence of integration and cointegration, like in the case of domestic investment, we analyze this relationship by simple

Granger causality, with variables at first difference. Optimal lag selection for goodness of fit in the VAR models is ensured by the AIC with three maximum lags. Table 4 provides F-statistics for the joint significance of lagged values of independent variables. It also shows the Error Correction Terms (ECTs) representing short-run dynamics of the cointegration (long run) relationship. Note should be taken of the fact that, based on our hypothetical model (see equation 2); physical capital is used as the control variable for robustness check in a bid to control for 'physical capital led investment hypothesis (nexus)'.

Table 6: Empirical results of panel causality analysis

Asymmetric panels	Goodness of fit in VAR models		Prime concern **Labour** led **Investment**		Robustness check **Capital** led **Investment**	
	1st dif.	Level	Short run (1st dif.)	Long run(level)	Short run (1st dif.)	Long run(level)
	Max(AIC)	Max(AIC):CE	F-Stats[a]	ECT(t-stats) º	F-Stats[a]	ECT(t-stats) º
Foreign Investment	3(3)/ 3(3)	3(1):1/ 3(3):1	3.021**	0.0001 (1.565)	0.521	**0.225*** (2.983)**
Private Investment	3(3)/3(3)	3(3):1/3(1) :1	1.793	-0.002 (-1.187)	0.350	**0.253*** (4.573)**
Public Investment	3(3)/3(3)	3(2):1/3(1) :1	1.332	**0.003*** (5.228)**	1.467	**-0.230*** (-3.723)**
Domestic Investment	3(3)/3(3)	n.a	0.436	s.l	**2.673****	s.l

[a] (F-Stats) F-statistics (Wald statistics) test the significance of lagged values of the endogenous variables. ° (ECT/t-stats) Error Correction term and t-ratios. Asterisks indicate the following levels of significance:***, 1%;**; 5% and *; 10%. Maximum lag is 3 and optimal lags are chosen via AIC. s.l and n.a indicate "stationary at level" and "not applicable" respectively. 1st dif: First difference. Max: Maximun. CE: Cointegrating Equation. VAR: Vector Auto Regression.

5. Discussion of results

From cointegration results, it could be observed that, but for domestic investment, there is long-term equilibrium between population growth and other forms of investments. This implies permanent demographic changes affect investment types and vice-versa. However, the correlation doesn't imply causation, so detailed analyses of short-run dynamics accruing from long-run equilibrium (cointegrating relationship) reveal a significant positive causal linkage from population growth to only public investment. The positive sign of the error correction term for the significant relation is also not unexpected (see equation 1). A detailed interpretation of the long-term elasticity follows: a 1% change in population growth

will lead to 0.3% change in per capita public investment. If public investment is considered a transmission channel to economic growth, then this result concords with the population-growth led economic-growth nexus (Hondroyiannis and Papapetrou, 2005; Azomahou & Mishra, 2008).

Regarding simple granger causality, the insignificance of F-statistics was also not unforeseen. In defining short-run expectations from our hypothetical models, we earlier stated that, from economic theory and to some extend common sense, population growth should not affect investment in the short run because it a long-term economic factor.

For robustness check, as presented in our initial model of investment productivity (see equation 2), we have also investigated the causal link from physical capital (fixed capital formation) to investment types. The wisdom of this side of analysis is to control for physical-capital led investment nexus. From a short-run perspective, but for significance of the relationship with domestic investment, other insignificant results were expected. Regarding adjustments for long equilibrium, but for public investment that is significant with an unexpected negative sign, all ECTs (short run dynamics) are significantly positive. This is sound empirical justification of the 'physical-capital led investment-productivity nexus' in our hypothetical model.

One important finding of this work is that, in the long run, population growth would only deplete public finance through increasing public investments. Therefore, demographic policies in sampled countries should be focused towards family planning and birth control. These would ensure that human capital variations through demographic change grow concurrently with investment necessary to capture rising unemployment. A corollary to this implication invites the speeding up of the privatization process in sampled countries; so that, increasing long-term unemployment arising from population growth be accommodated by the private sector. In other words, governments shall still play a crucial role in economic

investment in a distant future if measures are not taken to address this rising demographic change.

As we have earlier explained, with structural adjustment policies of liberalization, privatization and meandering towards market-based-economies imposed by the World Bank and International Monetary Fund on most sampled African countries, we should have expected significant positive long-run causality flows from population growth to foreign and private investments on the one hand, and less positive correlations with public investments on the other hand. This implies much still has to be done to attract foreign and private investors. Also, public spending would still play a great role in economic investments. Consequently, one could infer, structural adjustments policies implemented by sampled countries have not had the desired investment effects.

6. Conclusion

This paper empirically examines the nature of stationarity, cointegration and Granger causality from population growth to four investment types. From an initial broad database of thirty-eight African countries, we have narrowed down our dataset to four asymmetric panels based on first-order integration of key productivity indicators. Using both homogenous and heterogeneous panel unit root and cointegration tests, we provided evidence of long run equilibrium between population growth and three main types of investments (foreign, public and private). Short-run or simple Granger causality from human capital to investment are not unexpectedly found to be insignificant. Long-run elasticities have the right signs for the most part and are only significant for causality flowing from population growth to public investment. A logical policy implication is for sampled countries to watch their population growths which could strangle pubic finances in the long-term. Another implication is for

governments of sampled countries to adopt austerity measures that reduce public spending and increase private and foreign investments.

For future research, the human capital factor in productivity could be analyzed from an age-dynamic perspective, so that a better account of investment-factor productivity with respect to age-structured work force is brought to light. Our analysis is entirely limited to the quantity of labour force. However, we believe a parallel analysis based on the quality of labour force with parameters like health and type of secondary education; amongst others, could provide more insight into this phenomenon.

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