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

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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 corresponding rising unemployment and depleting per capita income. We examine the issues in this paper from a long-run perspective by assessing the relationships among population growth and a plethora of investment dynamics: public, private, foreign and domestic investments. Using asymmetric panels from 38 countries with data spanning from 1977 to 2007, 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 permanent changes in other forms of investments. Robustness checks on corresponding short-run Granger causality analysis and the long-run 'physical capital led investment' nexus are consistent with the predictions of economic theory. As a policy implication, population growth may strangle only public finances in the long-run. Hence, the need for measures that encourage family planning and create a conducive investment climate (and ease of doing business) for private and foreign investments. Seemingly, structural adjustments policies implemented by sampled countries may not have the desired investment effects in the distant future.

JEL Classification: C33; J00; O10; O40.
Keywords: Productivity; investment; human capital; asymmetric panel; causality; Africa.

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1. Introduction

The emergence of Africa in the world as one of the continents with the highest demographic growth rate with a 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 emigration (Tom, 2006; Asongu, 2012ab). This has reignited renewed interest in the problem of long-run investment opportunities. The continuous expansion of demography raises important policy questions[2], especially on the exhaustion of investment opportunities needed to accommodate rising unemployment owing to population surge (Seya 1989[3]; Adu-Nyako & Lele, 1991[4]; Shields et al., 2010). Socioeconomic unrests that have marked the African geopolitical landscape in recent years have been largely due to high unemployment rates (Sakbani, 2011; Mohammad, 2011). Economists in effect may no longer be thinking about the outer limits of capital accumulation and demand-side advantages of population growth. The unparalleled projection of population growth, coupled with the substantially documented investment needs of the African continent[5] raise important policy questions about the sources of future investment opportunities that would manage unemployment.

Beside the interesting policy relevance of this topic, in light of above facts and recent geopolitical climate in Africa, economists have learned to take awkward questions of Laymen in the street seriously: "What is it about additional people that make them a stimulus to investment? On what sort of investments shall our children depend-on for future

[2] A substantial bulk of African development literature has been consistent on the need for policies that target the management of population growth (Vaidyanathan, 1992; Meekers & van de Walk, 1992; Desai, 1992; Eshete, 1992; Hansen, 1992; Beghin, & Severyns, 1992; Johnston, 1992; Touré, 1992; Ohadike, 1992).

[3] Seya (1989, p.1) had advocated that, unchecked population growth may lead to serious social and economic burdens in developing countries in general and Africa in particular.

[4] Effectively dealing with population growth is one of the three priorities for an integrated strategy of poverty alleviation in Africa (p.1).

[5] Many recent studies in the African business literature have focused on factors determining investment (Rolfe & Woodward, 2004; Alagidede, 2008; Bartels et al., 2009; Tuomi , 2011; Kolstad & Wiig, 2011; Darley, 2012; Asongu, 2012c).

employment? Shall the government cope with the rising population?" These idle questions have recently exerted a substantial weight on the world's geopolitical and politico-economic landscapes[6].

In raising the issue of long-run employment opportunities, this paper has a twofold contribution to the African development literature. Firstly, the long-term focus of the analysis adequately calibrates the projected demographic issue in the distant future. Secondly, by assessing the connections between demographic changes and investment dynamics, we are able to provide the investment trends that policy makers need to focus-on to tackle potential long-term unemployment[7]. The distinction between public, private, foreign and domestic investment dynamics in the analysis addresses important questions on government (public versus private investment) and openness (foreign versus domestic investment) policies. The rest of the paper is organized as follows. Section 2 examines the literature on linkages among population growth, investment and economic growth. Data and methodology are discussed and presented respectively in Section 3. Empirical analysis is covered in Section 4. Section 5 concludes.

[6] "*The premises of the Arab Spring and hitherto unanswered questions about some of its dynamics could be traced to poverty; owing to unemployment and rising food prices. "We will take to the streets in demonstrations or we will steal," a 30-year old Egyptian woman in 2008 vented her anger as she stood outside a bakery. Riots and demonstrations linked to soaring consumer prices took place in over 30 countries between 2007-08. The Middle East encountered food riots in Egypt, Jordan, Morocco and Yemen. In Ivory Coast, thousands marched to the home of President then Laurent Gbagbo chanting: "you are going to kill us"," we are hungry", "life is too expensive" ...etc. Similar demonstrations followed in many other African countries, including , Cameroon, Senegal, Ethiopia, Burkina Faso, Mozambique, Mauritania and Guinea. In Latin America, violent clashes and demonstrations over rising food prices occurred in Guatemala, Peru, Nicaragua, Bolivia, Argentina, Mexico and the Haitian prime minister was even toppled following food riots. In Asia, people flooded the streets in Bangladesh, Cambodia, Thailand, India and the Philippines. Even North Korea surprisingly experienced an incident in which market women gathered to protest against restrictions on their ability to trade in food. The geopolitical landscape in the last couple of months has also revolved around the inability of some political regimes to implement concrete policies that ensure the livelihoods of their citizens. Tunisia, Egypt, Morocco, Senegal, Uganda, Zambia, Mauritania, Sudan, Western Sahara and most recently Nigeria are some countries that have witnessed major or minor unrests via techniques of civil resistance in sustained campaigns involving strikes, demonstrations, marches and rallies*" (Asongu, 2012d).

[7] It is an established consensus that, the three main things Africa needs are investment, investment and investment (Dangote Group, 2008; IMF Survey, 2009).

2. Population growth, investment and economic growth: theory and evidence

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 social unrests, brain drain and/or illegal migration.

According to the World Bank, our generation is experiencing the greatest demographic change ever, with Africa at its center. From the 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 quite paramount. In an attempt to find a solution to this growing concern, many analysts (directly or indirectly) are in support of the thesis that African needs other forms of investments owing to the failed privatization projects (Rolfe & Woodward, 2004; Alagidede, 2008; Bartels et al., 2009; Tuomi , 2011; Kolstad & Wiig, 2011; Darley, 2012; Asongu, 2012c). Dangote Group (2008) has emphasized that Africa needs investments not aid. It has 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[8]. Though private and foreign investments in Africa have surged over the past years[9], 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 investment.

A strand of current issues in African business has focused on the need to improve Africa's share of foreign direct investment (FDI). Rolfe & Woodward (2004) have examined the Zambian experience of attracting foreign investment through privatization. Findings have shown that, despite increased foreign-investment during the 1990s, the economy has stagnated. They conclude that, having sold-off its state assets, Zambia (like other sub-Saharan African (SSA)) countries must endeavor to attract investment through other channels. Much recently, Bartels et al. (2009) have assessed the reason SSA's FDI share has persistently averaged 1% of global flows and concluded that, FDI 'location decision' in SSA is influenced strongly by policy issues[10]. As a broad extension of this analysis, using microdata and firm interviews to explore the role of FDI drivers in South Africa, Tuomi (2011) has used a micro level analysis (which enables specification of the investment climate constraints) and has also found the impediments to investment to be centered around wrong-policy. A stance further confirmed by Kolstad & Wiig (2011) and Darley (2012) in their investigations of Chinese FDI in Africa and how to increase SSA's share of FDI respectively. Two insights relevant to the context of this paper could be drawn from the above literature: (1) the need for alternative

[8] The peril of foreign aid has been confirmed in recent African institutional (Asongu, 2012ef) and development (Asongu, 2012g) literature.

[9] Foreign capital investments for example have surged from $15 billion in 2000 to $87 billion in 2007.

[10] Motivated by the intuition that location decision and perceptions of investors are very instructive in policy making, they have analyzed a survey of perceptions, operations and motivations of 758 foreign investors in 10 SSA countries. Their results demonstrate that, the provision of transaction cost-reducing information on industries and markets on the one hand and utility services to investors on the other hand , before and after a firm's FDI decision are significant factors.

sources of employment (or investment) beside FDI and; (2) the important role of policy making bodies in determining investment flows.

2.2 Population growth, human capital investments and investment opportunities

This section will be discussed in three strands: the first analyzes the debate on the linkages among population growth, human capital and investment opportunities; the second examines the relationship between population growth and investment opportunities and; the third assesses the debate on linkages between population growth and economic development.

In the first strand, it is essential to investigate how the soaring population will be accommodated by future investment dynamics because among the striking regularities, it is evident in aggregate cross-country data (whether examined cross-sectionally or over-time) that, there are inverse associations between fertility rates and 'per capita incomes, indicators of human capital, schooling levels and survival rates'. As a general rule, high-income countries have been (and are) characterized by low fertility and high-levels of human capital (Rosenzweig, 1990). Indeed, those countries that have experienced high rates of per capita income growth have also experienced relatively rapid declines in fertility and increases in human capital levels[11]. Hence, it could be inferred that, declines in fertility and increases in human capital levels accompany economic development. Such aggregate linkages by themselves do not reveal very much about the determinants of economic growth and human capital investments. In fact, it has frequently been stated that the declining rate of population growth was one of the major contributing causes for the failure of the American economy to recover fully from depression in the 1930s (Rosenson, 1942). It is probably factual that, in a

[11] 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 & 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.

boom period of rapid expansion and increasing population, a sudden decrease in the rate of population growth would tend to make investors more cautious. Indeed, increasing rate of population growth might influence investors to be pessimistically inclined to feel that, such an increase will cause more absolute unemployment and economic hardship in a country, so that investment prospects are less profitable. On the other hand, with an increasing rate of population, expectations of entrepreneurs change so that they turn to believe certain investments to be profitable. As investors increase their optimism, investment and unemployment increases and decreases respectively.

There are several ways in which population growth might influence investment in the second strand (Sweezy, 1940): (1) through its effect on the propensity to consume; (2) through its effect on the competition of aggregate consumer demand; (3) by means of supply of labour and; (4) as an essential part of a certain broader phenomenon which in turn vitally affects investment. Firstly, a population containing a high proportion of dependents may be expected to have a relatively high propensity to consume. To a considerable extent, this factor cuts both ways (so far as population is concerned). Whereas a rapidly growing population has a high proportion of children, a stationary population has a high proportion of people beyond working age. However, from sociological and political standpoints, the two situations differ considerably. Undoubtedly, a high proportion of dependent in the older age group presents much more a problem for the public than a high proportion of children. Moreover, during the transition period from rapid growth to complete stability, the population goes through a point where the combined proportion of dependents is at a minimum. Secondly, the effect of population growth on the composition of total consumer demand is important for investment opportunity. In fact, a growing population of necessity directs a relatively large proportion of its expenditure towards commodities which require relatively heavy capital outlays for their production. Thirdly, so far we have been considering the effect of population growth on the

demand for commodities and therefore, indirectly on the outlets for investment seeking funds. More direct is the effect of population growth on the labour supply. Indeed, this is the aspect of the concern that has interested classical economists and the usual treatment stems directly from their work. Fourthly, the above points have been asking what the effects of population growth on investment and employment would be. From a wider perspective, the link between population growth and investment is an essential part of a certain broader phenomenon. It is scarcely possible to conceive this linkage as occurring in isolation because; they are intimately bound with other factors (like technological change and progress in health care).

The third strand on linkages between population growth and economic development has been an issue of much heated debate. While some proponents view positive demographic change as an instigator of long-run growth, others express ambivalence over this relationship. The contribution of population growth to economic development has been addressed in many studies. Azomahou & Mishra (2008) in revisiting the impact of age dynamics on economic growth through age-structured population for OECD[12] and non OECD countries have shown 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 earlier, Hondroyiannis & Papapetrou (2005), in a study on the relationship between fertility and output in eight European countries (using panel cointegration analysis) had 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 that, the current low fertility rate in Europe is having a toll on European economic growth. Contrary to this

[12] OECD: Organization for Economic Co-operation and Development.

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.

3. Data and Econometric methodology

3.1 Data

We examine a sample of 38 African countries with data from African Development Indicators of the World Bank for the period 1977 to 2007. The limitation to only 38 countries is based on constraints in data availability. Aggregate investment dynamics include: Foreign Direct Investment (*FDI*); Gross Private Investment (*Private Ivt*); Gross Public Investment (*Public Ivt*) and; Gross Domestic Investment (*GDI*). Factor productivity variables are: Gross Fixed Capital Formation (*GFCF*) for physical capital and Population growth rate (*pop*) for human capital. While the first five variables are in ratios of GDP, population growth is in annual growth rate. The thirty-eight countries making-up the initial dataset are subsequently trimmed-down due to constraints in the cointegration theory[13]. Hence, in the analysis, constituent countries of the panel-base differ as we move from one form of investment to another. The inclusion of physical capital (or fixed capital formation) in the analysis has a twofold justification: firstly, it serves as a control variable for robustness checks (in the

[13] 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 in level series (and therefore stationarity in first differenced series), cointegration necessitates showing that, permanent changes in factor productivity variables affect permanent variations in investment proxies and vice-versa.

verification of the 'capital led investment' nexus) and; secondly, it is in line with the mainstream aggregate production investment specification[14].

3.2 Methodology

The estimation strategy typically follows mainstream literature on testing the effects of monetary policy variables on output and prices (Starr, 2005; Nogueira, 2009). The technique involves units root and cointegration tests that assess the stationarity properties and long-term relationships (equilibriums) respectively. In these investigations, the Vector Error Correction Model (VECM) is applied for long-run effects while simple Granger causality is used for short-term effects. Whereas application of the former model requires that the variables exhibit unit roots in levels (and have a long-run relationship (cointegration)), the latter is applied on the condition that variables do not exhibit unit roots (or are stationary).

4. Causality estimations

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

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[14] Starting with the aggregate investment production function:

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

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 Eq. A in the natural log form in per capita terms as:

$$\log I = \theta + \alpha \log K + \beta \log W \quad \text{(B)}$$

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 Eq. B in per capita form for country **i** at time **t** as: $\log I_{it} = \alpha_{it} + \alpha \log k_{it} + \psi_{it} \log w_{it}$

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 Eq. (A), 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 & 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.

4.1 Short run estimations

Let us consider a basic bivariate finite-order vector autoregression (VAR) model. As shown in Eqs. (1) and (2) 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 explaining present values of FDI. While in mainstream literature the Granger causality model is applied on variables that are stationary (in levels for the most part), within the framework of this study, we are applying this test to all 'investment and capital' pairs in 'first difference' equations for three reasons: (1) ensure comparability; (2) consistency with application of the model to stationary variables and; (3) robustness checks in case we might have missed-out something in the unit root test specifications.

In light of the above, the resulting VAR models in first difference are the following:

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

$$\Delta FDI_{it} = \sum_{j=1}^{p} \lambda_{ij} \Delta FDI_{i,t-j} + \sum_{j=0}^{q} \delta_{ij}^{'} \Delta w_{i,t-j} + \mu_i + \varepsilon_{i,t} \quad (2)$$

The null hypothesis of Eq. (2) is the stance that, *population growth (human capital)* does not Granger cause *FDI*. A rejection of this null hypothesis is captured by the significant F-statistics; which is the Wald statistics for the joint hypothesis that estimated parameters of lagged values equal zero. Optimal lag selection for goodness of fit is consistent with the recommendations of Liew (2004)[15].

[15] "*The major findings in the current simulation study are previewed as follows. First, these criteria managed to pick up the correct lag length at least half of the time in small sample. Second, this performance increases substantially as sample size grows. Third, with relatively large sample (120 or more observations), HQC is found to outdo the rest in correctly identifying the true lag length. In contrast, AIC and FPE should be a better choice for smaller sample. Fourth, AIC and FPE are found to produce the least probability of under estimation among all criteria under study. Finally, the problem of over estimation, however, is negligible in all cases. The findings in this simulation study, besides providing formal groundwork supportive of the popular choice of AIC in previous empirical researches, may as well serve as useful guiding principles for future economic researches in the determination of autoregressive lag length"* (Liew, 2004, p. 2).

4.2 Long run estimators

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

$$FDI_{it} = \beta k_{it} \quad (3)$$

$$FDI_{it} = \beta w_{it} \quad (4)$$

Resulting VECMs are the following:

$$\Delta FDI_{it} = \alpha(FDI_{i,t-1} - \beta k_{i,t-1}) + \varepsilon_{1,t} \quad (5)$$

$$\Delta k_{it} = \alpha'(k_{i,t-1} - \beta FDI_{i,t-1}) + \varepsilon_{2,t} \quad (6)$$

$$\Delta FDI_{it} = \alpha''(FDI_{i,t-1} - \beta w_{i,t-1}) + \varepsilon_{3,t} \quad (7)$$

$$\Delta w_{it} = \alpha'''(w_{i,t-1} - \beta FDI_{i,t-1}) + \varepsilon_{4,t} \quad (8)$$

Eqs. (5) and (6) reflect short-term adjustments to the cointegration relation of Eq. (3) while Eqs. (7) and (8) mirror the adjustments to Eq. (4). 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. Hence, 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 FDI and physical capital respectively (Eqs. 5 and 6). We shall replicate the same models (3 and 4) for the other investment types. The same deterministic trend assumptions used for cointegration tests will be applied and goodness of fit in model specification will be based on the AIC[16] (Liew, 2004).

[16] Akaike Information Criterion.

4.3 Derivation of integrated variables from country-specific unit root tests

4.3.1 Country-specific unit root tests

In order to use the cointegration theory, we first test for stationarity properties at country levels. In doing so, we correct for serial correlations using the standard Augmented Dickey Fuller (ADF)[17] test. We do not elaborate on the mechanics of the unit root test because it is widely applied and constitutes only an exploratory analysis of the study. Optimal lag selection for goodness of fit in model specification is still in line with the recommendations of Liew (2004). Tables 1-2 below present the unit root test results. Country-specific variables with stationarity properties that are consistent with the cointegration theory are presented in bold. The choice of these countries depends on specific selection criteria; outlined in Section 4.3.2 below.

[17] Dickey & Fuller (1979).

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 with the AIC. 'c' and 'ct': 'constant' and 'constant and trend' respectively. n.a: not applicable; n.s.a: not specifically applicable due to issues in degrees of freedom.

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 with the AIC. 'c' and 'ct': 'constant' and 'constant and trend' respectively. n.a: not applicable; n.s.a: not specifically applicable due to issues in degrees of freedom.

4.3.2 Derivation of first orderly integrated variables and asymmetric panels

Based on the country-specific unit root tests results, the choice of countries (in bold in Tables 1-2) that will constitute asymmetric investment panels is guided by the following criteria:

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

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

In light of the above, the following asymmetric panels presented in Table 3 below are derived.

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

Asymmetric Panels					
Investment dynamics				Productivity factors	
Panel A	Panel B	Panel C	Panel D	Panel E	Panel F
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

Notes: FDI: Foreign Direct Investment. Ivt: Investment. Pop: population. GFCF: Gross Fixed Capital Formation. Rep: Republic. Afri: Africa.

4.4 Panel unit root tests

For every 'investment dynamic and productivity factor' pair, we assess evidence of stationarity using two types of first generational panel unit root tests. Like in the country-specific unit root tests, when the variables exhibit unit roots in levels, we proceed to test for

stationarity in their first differences. Employment of the VECM requires that the variables have a unit root (or are non stationary) in level series. There are two main types of panel unit root tests: first generational (that supposes cross-sectional independence) and the second generational (based on cross-sectional dependence). A precondition for the use of the latter generational test is a cross-sectional dependence test which is applicable only if the number of cross-sections (N) in the panel is greater than the number of periods in the cross-sections (T). Given that we have 31 periods (T) and less than 11 cross-sections (N), we are compelled to focus on the first generational type. Accordingly, both the Levin, Lin & Chu (LLC, 2002) and Im, Pesaran & Shin (IPS, 2003) tests are applied. Whereas the former is a homogenous oriented panel unit root test (common unit as null hypothesis), the latter is a heterogeneous based test (individual unit roots as null hypotheses). When the results are different, IPS (2003) takes precedence over LLC (2002) in decision making because, in accordance with Maddala & Wu (1999), the alternative hypothesis of LLC (2002) is too strong. Consistent with Liew (2004), goodness of fit (or optimal lag selection) is ensured by the Hannan-Quinn Information Criterion (HQC) and the Akaike Information Criterion (AIC) for the LLC (2002) and IPS (2003) tests respectively.

Table 4: Panel unit root tests

Panel A

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

Panel B

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

Panel C

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

Panel D

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 of 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. Invt: Investment. GDI: Gross Domestic Investment. LLC: Levin, Lin & Chu (2002). IPS: Im, Pesaran & Shin (2003).

From Table 4 above, it could be observed that, but for factor-domestic investment (Panel D) which significantly has variables void of unit root in level series (with GDI significant under both deterministic assumptions), the other three factor-investment variable-

panels are first orderly integrated. According to the Engle & Granger (1987) theorem, when variables are integrated, a linear combination among them could be stationary (cointegration).

4.5 Panel cointegration tests

According to the cointegration theory, two or more variables that exhibit unit root in levels may have a linear combination in a long-run (or equilibrium). In other words, we examine whether permanent long-run movements of factor productivity indicators affect permanent long-run investment dynamics. To achieve this, we examine the presence of cointegration among integrated variables with the 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 heterogeneous, the latter (Kao, 1999) is homogenous-based. Implementation of both tests is compatible with our earlier application of both homogenous (LLC) and heterogeneous (IPS) panel unit root tests. The same deterministic trend components used in integration tests are applied. Contrary to mainstream literature in which cointegration relations are based on multivariate statistics (Gries et al., 2009), to avoid misspecifications in causality estimations, we present both trivariate and bivariates tests but base our decisions on the latter. Optimal lag selection for goodness of fit is by the AIC.

Table 5: Bivariate and trivariate panel cointegration tests

Panel A

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 B

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 C

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 D

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 by the AIC. N/A (n.a): Not Applicable. . PP: Phillips-Perron. ADF: Augmented Dickey Fuller.

Table 5 above reports the findings of the cointegration tests. There is evidence of cointegration between factor productivity variables and three investment indicators (foreign, private and public investments). It is interesting to note that, the domestic investment variable and factor productivity variables were not overwhelmingly integrated due to the presence of level stationarity in a key variable (domestic investment). Hence, while domestic investment

and factor productivity variables (which have not been objects of any cointegration tests) will only be subject to short-run causality analysis, the other 'investment-factor productivity' pairs will be object of both short-term and long-run causality analysis.

4.6 Panel causality analysis

Table 6 below presents the results of the causality analysis. While the VECM is specified in level equations, Granger causality is in first difference representation. Optimal lag selection for goodness of fit in the VAR models is ensured by the AIC with three maximum lags. The F-statistics is for the joint significance of lagged values of independent variables. The Error Correction Terms (ECTs) represent short-run adjustments to the cointegration (long-run) relationships. Note should be taken of the fact that, physical capital is used as a control variable for robustness check in order to control for the 'physical capital-led investment hypothesis (nexus)'.

Table 6: Empirical results of panel causality analysis

Asymmetric panels	Goodness of fit in VAR models		Prime concern		Robustness checks	
			Labour led **Investment**		**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.

4.6 Discussion of results, policy implications, caveats and future directions

From the cointegration results, it could be observed that but for domestic investment; there are long-term equilibriums between population growth and other forms of investments. This implies permanent demographic changes affect permanent changes in investment dynamics and vice-versa. However, the correlation does not imply causation. A detailed analysis of short-run dynamics corresponding to the long-run equilibriums (cointegrating relationships) reveal a significant positive causal linkage from population growth to only public investment. This positive sign of the ECT is not unexpected. A broader 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 as a transmission channel to economic growth, then this result is consistent with the population-growth led economic-growth nexus (Hondroyiannis & Papapetrou, 2005; Azomahou & Mishra, 2008).

Granger causality flowing from population growth to foreign investment in the short-run is in line with the predictions of economic theory. An increase in population has the tendency to induce positive expectations from entrepreneurs as they turn to believe certain investments will be profitable; either by means of higher demand for commodities or cheap labour supply. With this optimism, investment and unemployment correspondingly increases and decreases respectively. This optimism is merely relative to foreign investment. It is also interesting to broadly infer that, the overwhelming absence of Granger causality flowing from population to other forms of investment is also consistent with the predictions of economic theory which stipulate that, population growth affects economic growth only in the long-run. This inference is based on the assumption that, the other investment dynamics are exogenous to economic prosperity.

The robustness checks have aimed to assess the causal link flowing from physical capital to aggregate investment dynamics. The interest of this side of analysis is to control for

the ‘physical-capital led investment’ nexus. From a short-run perspective, but for the significance of the relationship with domestic investment, other insignificant results were expected. Regarding adjustments to the long-run equilibrium, but for public investment (that is significant with an unexpected negative sign), the remaining ECTs (short-run dynamics) are significantly positive. This is sound empirical justification of or robustness to the ‘physical-capital’ led investment nexus.

One important finding of this work worth emphasizing 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 the public investments necessary to accommodate the 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) should be accommodated with the corresponding private sector investments. In other words, governments would still play a crucial role in economic investment in a distant future if measures are not taken to either: (1) address existing trends of rising demographic change or; (2) encourage a positive investment climate and ease of doing business that will provide incentives for private and foreign investments.

As observed in the literature section, 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 expected a significant positive long-run causality to flow 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. Moreover, public spending would still play a great role in economic investments in the future. Consequently, from a population growth standpoint, it could be inferred that, structural adjustments policies implemented by sampled countries may not have the desired investment effects in the long-term.

To the best of our knowledge, the absence of literature dedicated to examining the bearing of demographic change on investment dynamics makes our results less comparable. However our findings are broadly consistent with the need for other forms of investments documented in the African business literature (Rolfe & Woodward, 2004; Alagidede, 2008; Bartels et al., 2009; Tuomi , 2011; Kolstad & Wiig, 2011; Darley, 2012; Asongu, 2012c). In this paper, we have only considered demographic determinants of investment. But in the real world, investment is endogenous to a complex set of variables. From a wider perspective, the link between population growth and investment is an essential part of a certain broader phenomenon. It is scarcely possible to conceive this linkage as occurring in isolation because; they are intimately bound with other factors (like technological change and progress in health care). Hence, it would be interesting to replicate the analysis in a multivariate VAR context. Another interesting future research direction could be to assess whether the findings apply to country-specific cases. Moreover, another future research direction could entail analyzing the human capital factor in productivity 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 insights into this phenomenon. Measuring skills would be quit challenging, so we recommend Lall (1990) for a unique opportunity to provide first-hand account by building a proxy using school attainments at the primary and secondary levels or any other proxy in future analysis.

5. Conclusion

Our generation is experiencing the greatest demographic transition and Africa is at the center of it. There is mounting concern over corresponding rising unemployment and depleting per capita income. We have examined the issues in this paper from a long-run perspective by assessing the relationships among population growth and a plethora of investment dynamics: public, private, foreign and domestic investments. Using asymmetric panels from 38 countries with data spanning from 1977 to 2007, our findings have revealed a long-run positive causal linkage from population growth to only public investment. But for domestic investment, permanent fluctuations in human capital affect permanent changes in other forms of investments. Robustness checks on corresponding short-run Granger causality analysis and the long-run 'physical capital led investment' nexus have been consistent with the predictions of economic theory. As a policy implication, population growth may strangle only public finances in the long-run. Hence, the need for measures that encourage family planning and create a conducive investment climate (and ease of doing business) for private and foreign investments. Seemingly, structural adjustments policies implemented by sampled countries may not have the desired investment effects in the distant future.

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