IMF Working Papers 14/143

Africa Rising: Harnessing the Demographic Dividend

INTERNATIONAL MONETARY FUND

WP/14/143

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African Department

Africa Rising: Harnessing the Demographic Dividend

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August 2014

Abstract

Africa will account for 80 percent of the projected 4 billion increase in the global population by 2100. The accompanying increase in its working age population creates a window of opportunity, which if properly harnessed, can translate into higher growth and yield a demographic dividend. We quantify the potential demographic dividend based on the experience of other regions. The dividend will vary across countries, depending on such factors as the initial working age population as well as the speed and magnitude of demographic transition. It will be critical to ensure that the right supportive policies, including those fostering human capital accumulation and job creation, are in place to translate this opportunity into concrete economic growth.

JEL Classification Numbers: C23, J11, N17, O11

Keywords: Demographic Dividend, Economic Growth, Sub-Saharan Africa, Panel Estimates

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[1]We would like to thank the participants at the AFR Seminar held in September 2013. We also thank Paolo Mauro for comments which have vastly improved this paper and Roger Nord for general guidance. Fan Yang provided excellent research assistance.

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I. Introduction

Africa will account for 3.2 billion of the projected 4 billion increase in the global population by 2100 (Table 1). Its working age population[2] will increase by 2.1 billion over the same time frame, compared to a net global increase of 2 billion. With declining mortality and fertility, Africa's share of the working age population will increase from about 54 percent in 2010 to peak at about 64 percent in 2090. The rising share of Africa's working age population is increasing its productive potential at a time when most of the advanced economies face an ageing population. Africa's share of the global working age population is thus projected to increase from 12.6 percent in 2010 to over 41 percent by 2100. The magnitude of these demographic developments will be transformational for Africa and will also have major implications for the global economy.

Table 1. Africa Rising

	Total population (bn)			*Working age population (bn)*		
	2010	2100	Change	2010	2100	Change
World	6.9	10.9	4.0	4.5	6.5	2.0
Africa	1.0	4.2	3.2	0.6	2.7	2.1
Africa/World (percent)	14.9	38.5		12.6	41.2	

Source: IMF staff estimates based on UN World Population Database.

A demographic transition characterized by an increase in the working age population provides a country with a window of opportunity, which if properly tapped can generate a "demographic dividend" from higher growth. Indeed, this occurred in several countries in Asia and helped define the "Asian Miracle". While African demographic transitions exhibit significant differences, in part reflecting past episodes of famine and war, the continent's transition has important economic ramifications that can help define its economic potential and contribute to its emergence as a global player. However, two additional scenarios, albeit less positive, are also possible. In the less benign case, the window of opportunity passes by without any meaningful progress. In part, countries fail to put in place the policies to tap into the latent potential. In the worst case scenario, such a demographic transition could translate into an army of unemployed youth and significantly increase social risks and tensions.

Our study focuses on the demographic transition with a view to providing estimates of the potential magnitude of the dividend for Sub-Saharan Africa (SSA). We first develop a simple general equilibrium overlapping generations model to show the potential growth effects that theory would predict from the demographic transition. Turning to the data, our empirical model follows Bloom et al. (2010), but we introduce several methodological improvements. In particular, unlike Bloom et al. (2010) who use pooled OLS panel regressions, we introduce country and year fixed effects (FE) on the basis of the Hausmann test; and we use a wider range of panel estimation techniques to show that our results hold under various settings. Additionally, we emphasize the role of human capital in explaining regional differences in the magnitude of

[2] The working age population is defined as those aged between 15-64. The share of working age population is the working age population divided by the total population.

the demographic dividend; we investigate how the pace of transition and its magnitude matter for growth; and we consider whether any thresholds exist, as regard income and education levels, and how these matter for the dividend. To sum up, we also provide some initial estimates of the dividend that African countries can expect as a result of the transition.

We report five main findings:

- We confirm the unambiguous impact of demographic transitions on growth. A 1 percentage point change in the working age population increases real per capita GDP growth by 0.5 percentage point, with the range varying between 0 and 1.1 percentage points depending on the region. Our results are broadly similar to Bloom et al. (2010).
- Both the magnitude and speed of the demographic dividend depend on the country's initial level of the working age share and its rate of change, as well as the income level. The faster the increase in the working age share, the faster the accrual of the demographic dividends.
- Investment in human capital is critical to harnessing the demographic dividend. Countries with higher education levels benefit the most. We confirm the role of the demographic variables and the contribution of education in explaining the Asian miracle.
- Demographic factors contribute significantly to the dividend only up to a certain income level (around US$5,100 per capita). We suggest this is due to the fact that middle income countries' changing economic structures rely less on labor intensive strategies than at lower income levels. Our results also suggest that low income countries in Africa have the potential to benefit the most from the nascent demographic transition.
- The median African country with an initial per capita income level of around US$550 in 2010 can expect to benefit from a demographic dividend (beyond the growth that would occur with an unchanged demographic structure) of about US$1,350 by 2100. The resulting GDP per capita of US$3,865 is higher by about 56 percent compared with a scenario of an unchanged share of working age population.

Translating Africa's increased potential from the demographic transition into concrete dividends will require appropriate policies. A comparison between Asia and Latin America suggest that economic outcomes can differ significantly for broadly similar transitions. Asia's more favorable outcomes have been attributed to a stronger focus on human (education and health) and physical capital. An initial emphasis on labor-intensive export-led growth created employment opportunities and supported the transition into sectors with higher total factor productivity. Increased employment opportunities and higher labor participation rates, including for women, allowed Asia to maximize the benefits from the increase in labor force.

The paper is organized as follows. Section II reviews the literature. Section III reports stylized facts. Section IV presents a simple OLG model with varying demographics to motivate the discussion. Section V provides the estimation strategy. Section VI presents our estimates of potential demographic dividends. Section VII concludes.

II. A Brief Literature Review

There is an increasing recognition that beyond a population's[3] overall size, its age structure is of great economic significance (Williamson and Higgins, 2001; Bloom, Canning, and Sevilla, 2003). Most studies on this topic bring in the life cycle aspects in one form or another: an increase in the share of the working age population increases the labor supply and growth potential, thereby contributing to a demographic dividend. The increase in the working age population can be considered as the outcome of a mechanical process driven by declining mortality and fertility rates. The increase in working age population and resulting decline in dependency ratio causes an increase in output, savings, and investment (Lee, 2003; Galor, 2005). Such a demographic transition is often considered as a key driver of the Asian miracle (Bloom et al., 2000; Mason, 2001). The fact that the transition is yet to take place in Africa has also been provided as one of the reasons holding back growth in the region (Bloom and Sachs, 1998; Bloom et al., 2003).

Galor and Weil (2000) characterize the demographic transition as going through stages. Before the transition, population growth has a negative impact on economic growth. Once the transition is underway, higher life expectancy accelerates growth by favoring human capital accumulation and increasing total factor productivity[4]. The changing age structure favors savings, higher female labor force participation, and lower fertility rates (Bloom et al., 2009; Soares and Falcao, 2008). Additionally, with declines in child mortality, children come to be seen as "consumption" rather than "investment", and parents prefer fewer children, but place greater emphasis on the quality of education and health. This increases productivity (Rosenzweig, 1990; Soares, 2005).

Another strand of the literature characterizes demographic transitions as a window of opportunity to earn a demographic dividend (Carvalho and Wong, 1999; Pool, 2007), if good policies are in place (Bloom and Canning, 2000). Without proper policies, the increase in working age share may lead to rising unemployment and fuel economic and social risks (Bloom et al., 2003, 2007; Lorentzen et al., 2008). Some of the main policy variables considered in the literature include the quality of governmental institutions, labor market regulation, macroeconomic management, openness to trade and capital flows, and human capital. Efficiently channeling the savings from the demographic transition and preparing for an aging population by making good use of pension assets can also contribute to economic growth.

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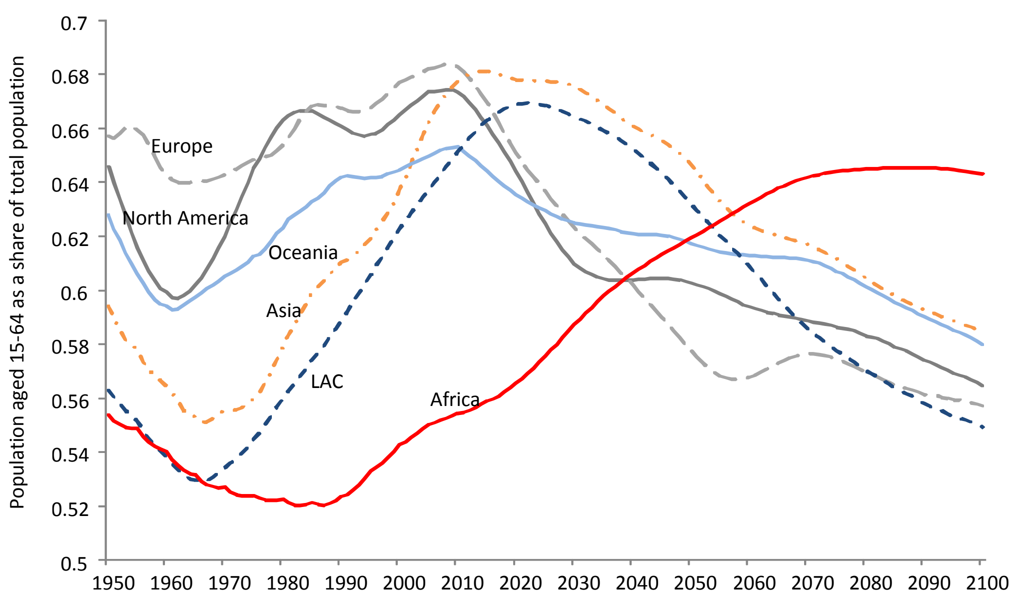
[3] While the Malthusian view provided a dismal prospect for countries with an increasing population due to pressures on limited resources, others (Kuznets, 1960; Simon, 1987) countered that countries with a growing population were better able to develop and exploit knowledge, thereby avoiding the poverty trap.

[4] Demographic transitions can also have international spillovers. Open economy models increasingly emphasize the role of international capital flows as a complement to changes in savings behavior and capital accumulation. Ageing countries with an excess capital can transfer resources to countries experiencing the demographic transition due to differentials in capital returns (Brooks, 2003).

III. Stylized Facts

Africa's demographic transition is atypical. Compared to other regions, Africa starts at a much lower base, the transition is longer, and the peak around 2090 is at a somewhat lower level than other regions. Figure 1 places Africa's demographic developments in a global context. Europe and North America had their transitions following the post world war baby boom. A similar transition started in other regions (Asia, Latin America, and Oceania) in the 1970s. Owing to the lag with which medical advances and family planning practices reached Africa, the transition there did not start until the mid-1980s. Additionally, the pace of Africa's transition is somewhat slower—about three generations compared to one generation for the other regions—and even at the peak, the share of the working age population is smaller than other regional peaks. On current trends, Africa is expected to have a higher share of working age population than North America and Europe in the next two decades, and the highest among all continents by 2060.

Figure 1. Global trends in working age population: 1950-2100

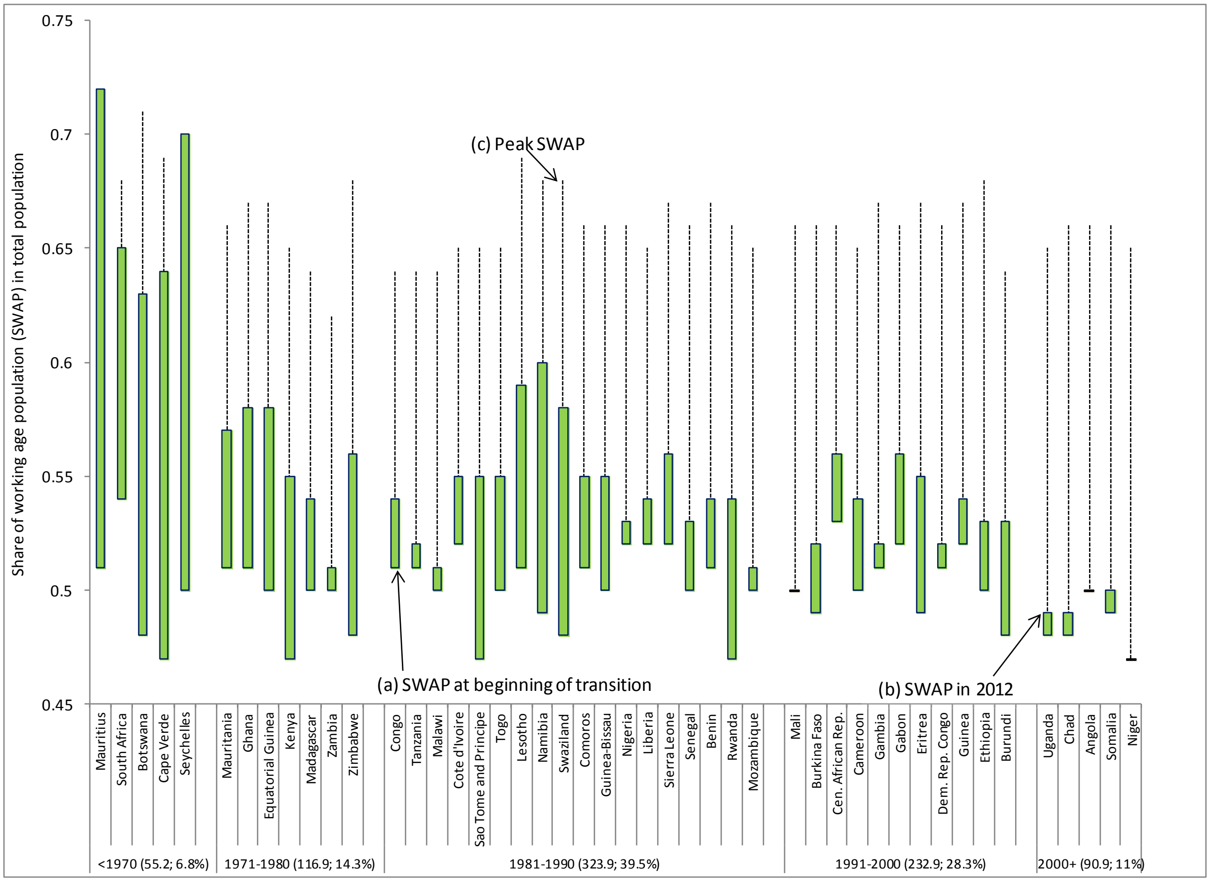


Source: IMF staff estimates based on UN World Population Database

At the same time, there is significant heterogeneity across the African economies in terms of when they started the transition and where they have reached relative to their peak (Figure 2). Figure 2 classifies the countries into five groups based on the decade when they started their transition. The main information can be summarized as:

- A first group (South Africa, Botswana, Cape Verde, Seychelles and Mauritius) has nearly completed the demographic transition, in a time frame similar to Asia and Latin America. Due to the fast decline in their mortality and fertility rates, the share of their working age population increased by nearly 20 percentage points, and these countries have completed over 80 percent of the transition. These countries have also experienced some of the highest growth in SSA during that time period, and graduated to middle income status.

Figure 2. Evolution of shares of working age population in Sub-Saharan Africa

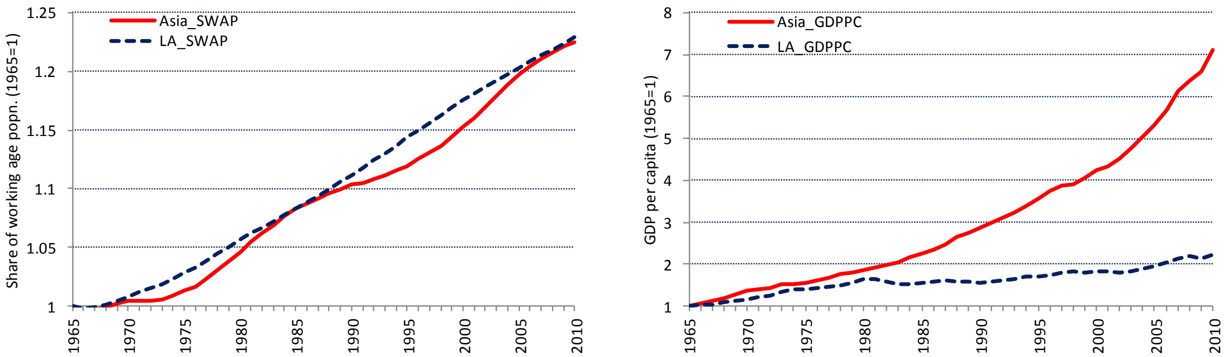


Source: IMF staff estimates based on UN World Population Database.
Notes: The decade refers to the period when the country started the transition. Numbers in bracket represent the group's population and its share of the sample's total of 819.6 million in 2010. (a) The base of the rectangle shows the SWAP at the beginning of the transition. For instance, Congo started its transition with a SWAP of about 51 percent. The transition is still in its infancy in cases where the rectangle is missing (Angola, Mali, Niger). (b) The top of the rectangle shows the country's SWAP in 2012. For instance, Uganda had a SWAP of 49 percent in 2012. (c) The end of the dotted line shows the SWAP for a country at its peak. For Swaziland, this is at 68 percent. For Mauritius and Seychelles, the SWAP is at its peak.

- The majority of the countries (29 out of 46), representing nearly 70 percent of the continent's 2010 population, embarked on the transition between 1981 and 2000. They are not expected to reach their peak before 2050. The share of their working age population would increase by an average of 16 percentage points. As of now they have only completed about 25 percent of their transition.
- Five countries, which represent 11 percent of the continent's 2010 population, have embarked on the transition on the transition after 2000.

The current level of economic development in the African economies undergoing the transitions comes closest to those of Asia and Latin America in the 1960s. However, Asia and Latin America went on to experience different economic outcomes, despite their transition paths being broadly similar (Figure 3).

Figure 3. Diverging experiences in Asia and Latin America: 1965-2010



Source: World Population Prospects (2013) and World Economic Outlook

Figure 3 shows the evolution of the share of working age population and GDP per capita between 1965 and 2010 in Asia and Latin America. The share of the working age population in both regions increased by over 20 percent. While Asia experienced a seven fold increase in its GDP per capita, the increase was only two fold in Latin America. There were however regional disparities within Asia. Countries like China, South Korea, and Singapore, experienced a big increase in real GDP per capita growth, though there was not much change in Philippines and Fiji. Latin America's experience was somewhat more homogenous, although growth was lower throughout. Some of the factors that have been put forward to explain Asia's more favorable economic outcomes have been attributed to stronger focus on human (education and health) and physical capital, higher labor participation rates, and an initial emphasis on labor intensive export-led growth that allowed to maximize the benefits from the increase in labor force and transition into sectors with higher TFP. In contrast, a weak policy environment and an inability to attract investment on a sufficient scale are considered as two factors that have hindered Latin America's ability to benefit from a demographic dividend.

IV. An Economic Model of Demographic Transitions

A. The model

To show some of the potential macroeconomic implications of the demographic changes through simulations, we develop a simple general equilibrium model in the spirit of Diamond (1965). The model presented here is for illustrative purposes and to motivate the discussions. Our empirical estimation procedure in the next section will allow for a more general structure.

The economy

Consider a standard two-period overlapping generations model with identical agents. Population grows at a constant rate n, such that there are $(1+n)$ more (young) workers than (old) retirees. At each time t, capital (k) and labor (l) are used to produce a homogeneous good (y).

Households

Each non-altruistic individual lives for two periods, providing one unit of labor inelastically when young, and living in retirement when old. The intertemporal utility-maximizing problem is taken to be additive and log-linear[5]. When young, the agents choose the levels of consumption and savings which maximize their utility; when old, they live off their savings. β is the discount factor applied to future consumption. Agents maximize utility by maximizing consumption $u(c_t, c_{t+1})$ subject to their lifetime budget constraints: $Max \{c_t, c_{t+1}, s_t\}\ u = ln\ c_t + \beta\ ln\ c_{t+1}$ subject to: $c_t = w_t - s_t$ and $c_{t+1} = R_{t+1} s_t$.

Firms

Identical firms competitively produce a homogeneous good using a Cobb Douglas production function: $Y = AK^{\alpha}L^{1-\alpha}$, where α is the share of capital in production. In intensive form (dividing by L), this production function reduces to: $y = A\ k^{\alpha}$.

Firms maximize profit by taking factor prices as given. The labor market clears such that labor demand equals labor supply. The economy is endowed with an initial capital stock $K_0 > 0$ and capital depreciates fully from one period to the next. Technology is assumed to be constant. The interest rate and wages are thus given by $R = A\ \alpha\ k^{\alpha-1}$ and $w = A\ (1-\alpha)\ k^{\alpha}$.

Competitive equilibrium

Given the objectives of the households and the firms, we can define a competitive equilibrium as a sequence of $\{K_t, c_t, c_{t+1}, R_t, w_t\}_{t=0}^{\infty}$, where $\{R_t, w_t\}_{t=0}^{\infty}$ are paid their marginal products, households maximize their consumption according to the Euler equation, and capital markets clear $(S_t=K_{t+1})$, while the economy's resource constraint $(y=ct+c_{t-1}/(1+n)+(1+n)k_{t+1})$ is always satisfied.

Given the above definition of competitive equilibrium, the intertemporal budget constraint of the individual is: $c_t + c_{t+1}/R_{t+1} = w_t$ and the Euler equation, which dictates the optimal allocation of consumption over the two periods of an agent's lifetime, is: $c_{t+1} = \beta\ R_{t+1}\ c_t$.

The optimal consumption and savings of the agents can then be expressed as: $c_t = w_t/(1+\beta)$, $c_{t+1} = \beta\ R_{t+1}\ w_t/(1+\beta)$, and $s_t = \beta\ w_t/(1+\beta)$.

Given that the savings of the young is converted into capital in the next period, the steady state capital to labor ratio can then be expressed as: $k^*= [\beta(1-\alpha)/(1+\beta)(1+n)]\hat{}[1/(1-\alpha)]$.

It thus follows that an increase in n leads to a decrease in k^*. This in turn will also lead to an increase in the interest rate, while causing wages to fall. We focus on the effects of the demographic changes on output in the simulations.

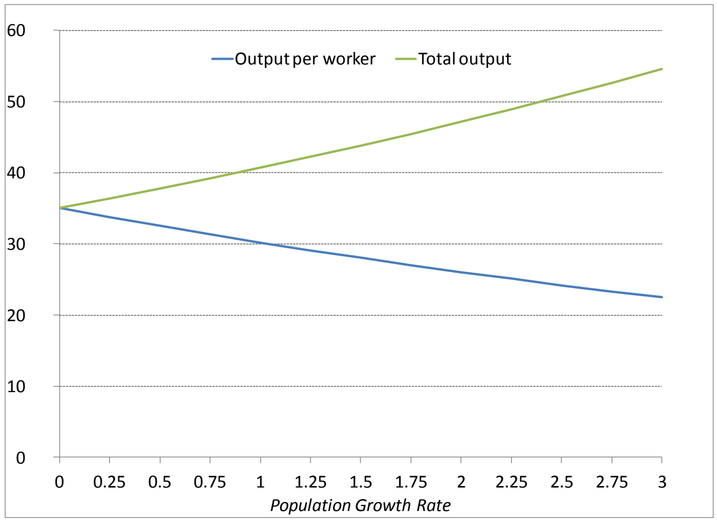
B. Calibration

We calibrate the model to generate an interest rate of around 5 percent per annum (in line with actual data). We assume one period to equal 30 years and for capital to depreciate fully during that period. In line with de la Croix and Michel (2002), we assume an initial population growth

[5] The choices of the utility and production functions are driven by the ease of analytical tractability and model predictability. In particular, the two period OLG model with Cobb Douglas technology and log preferences exhibits a unique and globally stable capital to labor ratio k^* for all $k > 0$.

rate of 2.5 percent per annum and a quarterly discount rate of 0.99; we set the share of capital in the production function to 1/3. The effects of different population growth rates[6] on aggregate and per worker output are shown in Figure 4.

Figure 4. Population growth and output



An increase in the population growth rate increases the labor force. Other things equal, this leads to a fall in capital per worker, which causes output per worker to fall. However, because of the overall increase in the labor force, aggregate output in the economy increases. The focus of the next section is to turn to the data and study these effects in a richer empirical framework.

V. Empirical Estimates of Demographic Dividends

A. Methodology

We initially follow Bloom et al. (2010) and begin by writing output per capita (Y/N) as a combination of output per worker (Y/WA) and the share of workers in the economy (WA/N):

$$\frac{Y}{N} = \frac{Y}{WA}\frac{WA}{N} \quad (1)$$

We can further define $y = log\frac{Y}{N}, z = log\frac{Y}{WA}, w = log\frac{WA}{N}$, and differentiate equation (1) to get:

$$\dot{y} = \dot{z} + \dot{w} \quad (2)$$

The growth rate of income per capita can thus be decomposed into growth of income per worker and the growth of the working age share, assuming a constant participation rate[7]. The growth rate of income per worker ($\dot{z}$) further depends on the initial level of income per worker (denoted as

[6] Annual population growth rates of 1, 2, and 3 percent are consistent with population increases of 35 percent, 81 percent, and 143 percent, respectively, over 30 years.

[7] Bloom et al. (2010) included the participation rate in the accounting identity but concluded that it was impossible to put the effect of the participation rate into empirical tests. They suggest that the poor quality of the participation rate data could lead to unreasonable results (Bloom and Canning, 2003).

z_0) and its deviation from the steady-state level of income per worker (denoted as z^*). By letting ρ be the convergence speed, the growth rate of income per worker can be expressed as follows:

$$\dot{z} = \rho(z^* - z_0) \tag{3}$$

Since the initial level of income per capita, $y_0 = w_0 + z_0$, we have:

$$\dot{y} = \rho(z^* + w_0 - y_0) + \dot{w} \tag{4}$$

As z^* is determined by a set of variables at the initial level (X_0), Eq (4) can be rewritten as:

$$\dot{y} = \rho(\beta' X_0 + w_0 - y_0) + \dot{w} \tag{5}$$

Eq (5) motivates our empirical model. To explain the growth rate of real GDP per capita, we include the initial level of the working age share ($w_0 \equiv WAS$), its growth during the period ($\dot{w} \equiv \Delta$WAS), the initial GDP level (z_0), and the set of growth determinants at the beginning of the period (X_0). We construct a panel of 172 countries that allows us to investigate the impact of demographic developments on growth. Given the slow dynamic nature of demographic data, we use 5 yearly data over the period 1960 to 2010. These are sourced from the World Development Indicators (2012).

We specify our initial empirical model as:

$$y_{it} = \alpha + \beta_0 Log(WAS)_{it} + \beta_1 \Delta WAS_{it} + \beta' X_{it} + c_i + \theta_t + \varepsilon_{it} \tag{6}$$

where i is the country index and t is the period index. c_i is country specific effect while θ_t is a period dummy for time fixed effect. Among the two demographic variables, $Log(WAS)_{it}$ is the initial working age share, while ΔWAS_{it} is the growth of working age share over the 5-year period *t.* To avoid potential endogeneity problems, $log(WAS)_{it}$ is taken from one year before each 5-year period. X_{it} is a vector of variables that affect the long-run equilibrium. These include the initial GDP level (to control for convergence), trade openness (ratio of trade over GDP), investment[8] (investment over GDP), and sectoral transformation (share of agriculture in GDP) among others. All control variables[9], except sectoral change, are taken from one year before each 5-year period to ensure that they are predetermined. They will be referred as initial values.

We then depart from Bloom et al. (2010) in three ways. First, we do not include institutional quality (bureaucratic quality) as this unnecessarily curtails the sample size. Second, education level as proxied through years of schooling is highly correlated with income levels. Instead, we use dummy variables to categorize countries by education levels.

We adopt a general to specific approach whereby we gradually drop variables that are not significant and finally include only significant variables. We also undertake sensitivity tests to check the robustness of our results. Bloom et al. (2010) used a pooled OLS (POLS). A random effect (RE) estimator is more efficient than POLS when there is a country-specific effect.

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[8] The capital stock, such as the initial capital stock per capita (PWT 8.0), has a high correlation with initial GDP and may lead to biased results due to multicollinearity.

[9] The summary statistics are provided in Appendix Table 1.

However, given that both the RE and POLS lead to biased estimates when country-specific is correlated with the explanatory variables, we apply the fixed effect (FE) on the basis of the Hausmann test. We also include time period dummies in all model specifications to control for common shocks across all countries within the sample. To account for the possibility that ΔWAS is influenced by economic growth rate during one period, we also apply system GMM estimator as a robustness check.

B. Initial Results

The findings are shown in Table 2 and the results are broadly in line with the literature. The initial results are summarized in column 1. The two demographic factors, the initial size of the working age group and the change in working age share, have positive impacts on growth and are significant at the 1 percent level. It suggests that having a large working age population increases the economy's productive capacity from the outset. At the same time, a fast growing working age population further speeds up the growth process. A 1 percentage point change in the working age population increases real per capita GDP growth by 0.5 percentage point, with the range varying between 0 and 1.1 percentage points depending on the region[10]. The initial GDP per capita has the expected negative sign in line with the conditional convergence effect: more developed economies have a lower growth rate so that less developed economies catch up. A shift away from the agriculture sector leads to a higher growth rate.[11] We initially include the initial ratio of investment over GDP, but this variable is eventually dropped as part of the general-to-specific approach.

To deal with potential endogeneity problems, especially for the sectoral change in agriculture and ΔWAS, we apply system GMM estimator in column (2). We assume the sectoral change in agriculture and ΔWAS to be endogenous and the remaining explanatory variables to be predetermined. The results are largely in line with the FE estimates. They pass the Arellano-Bond test and the Sargan/Hansen test of over-identification, indicating that the model specification is appropriate. Both the initial WAS level and ΔWAS remain positive and significant at 1 percent level. The estimates from system GMM, while close to the estimates from FE, are slightly higher. Given that GMM could lead to the problem of too many instruments when there are many explanatory variables[12], we maintain the FE results as our baseline.

Given the perceived importance of human capital in harnessing the demographic dividend, we include an education level dummy in column (3). Countries are categorized in two groups: education level below the mean, and otherwise. The overall results remain unchanged, but the

[10] The results by region are presented in Appendix Table 2.

[11] Using the change in the agriculture sector may lead to endogeneity problem. We also tried the ratio of agricultural output over GDP in one year before each 5-year period and the results do not change. We follow Bloom et al. (2010) and use the change rather than initial level.

[12] According to Roodman (2009), having many instruments can overfit endogenous variables, fail to expunge their endogenous components, and bias the resulting coefficient estimates.

importance of human capital is magnified. While both groups of countries benefit from a demographic dividend, countries with higher education benefit twice as much.

Table 2. Baseline results for 5-year growth

	(1)	(2)	(3)
Average 5yr growth rate of real GDP per capita			
	FE	SYS GMM	FE
Log Initial GDP per capita	-5.22***	-0.60***	-5.25***
	(-6.33)	(-4.11)	(-6.38)
Trade Openness	0.02***	0.00	0.02***
	(2.90)	(1.47)	(2.84)
Sectoral Change (Agr)	-0.16***	-0.42***	-0.16***
	(-3.30)	(-3.08)	(-3.31)
Log(WAS)	12.57***	14.05***	11.47***
	(3.37)	(6.97)	(2.96)
Δ WAS	0.53***	0.76***	0.30*
	(3.75)	(3.37)	(1.73)
Δ WAS * High education			0.31*
			(1.65)
Constant	-10.59	-52.46***	-5.77
	(-0.74)	(-7.07)	(-0.38)
Observations	1,100	1,100	1,100
Number of countries	172	172	172
Time FE	Yes	Yes	Yes
R-squared	0.29		0.30
Adjusted R-squared	0.28		0.29
AR(1) pval		0.00	
AR(2) pval		0.14	
Hansen J df		86	
Hansen J pval		0.35	
Nr. Instruments		101	

Notes: Two-step system-GMM estimator is used in Column (2). Time dummies are treated as exogenous. ΔWAS and sectoral change (Agr) are treated as endogenous while the remaining explanatory variables are treated as exogenous. For endogenous variables, two periods lags were used as instruments in the first-difference equations and their once lagged first-differences were used in the levels equation. The full set of instruments are used. Robust standard errors are corrected for small-sample bias using Windmeijer's (2005) approach and reported in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

We have thus far improved the econometric model of Bloom et al. (2010) while confirming their findings that both the initial working age share and the change in the working age share matter for growth. In particular, both a high and fast growing working age share contribute significantly to growth. Additionally, we have shown that the magnitude of the dividend is contingent upon investment in human capital. We ran the same set of regressions for 1-year and 10-year growth periods. The results are consistent with our findings in Table 2.

C. Regional Differences and the Role of Human Capital

As highlighted earlier, the demographic transitions and their impact across continents vary. While most of the other regions are already ageing, or peaking, Africa's transition is at a nascent stage. Here, we consider the results by region, focusing particularly on when the regions started their expansionary phase and their investment in human capital. For sample size purposes, we group Europe and North America, and Asia and Oceania. These regions went through their transitions over broadly the same periods and the magnitude was more or less similar.

Table 3 summarizes the magnitude of demographic dividends by regions. We run regression (3) from Table 2 for the various regions using the mean education level dummy in [4]-[7], and use quartiles in [8]-[11] to further focus on education levels. The distribution for the categorization is based on the sample as a whole. The main findings suggest an unambiguous demographic dividend for Asia and Europe. Asia's economic miracle was significantly attributable to making the most of the demographic transition. Including the quartiles for Asia reveals that the magnitude of the dividend rises as years of schooling increase. In particular, the dividend is highest for countries in the top quartile. The fact that the first and third quartiles are not significant could suggest the presence of some threshold effects. Shifting from the first to the second quartile could benefit economies by supporting a transition from low level agriculture to higher productivity manufacturing. Similarly, a shift to the fourth quartile could support the emergence of a high productivity services sector. Latin America's coefficients confirm our earlier suggestion that the region did not fully harness the demographic dividend.

Table 3. Demographic dividends by regions

	Using mean education level dummy				Using quartile dummies			
	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]
Average 5yr growth rate of real GDP per capita	Asia 1965-2010	Europe 1965-2005	LA 1965-2010	SSA 1985-2010	Asia 1965-2010	Europe 1965-2005	LA 1965-2010	SSA 1985-2010
Log Initial GDP per capita	-6.14***	-13.04***	-7.17***	-8.19***	-3.47**	-13.54***	-6.66***	-9.39***
	(-3.04)	(-9.84)	(-5.39)	(-3.05)	(-2.09)	(-6.41)	(-3.49)	(-3.15)
Trade Openness	0.01	0.01	0.02	0.03	0.01	0.01	0.00	-0.01
	(0.54)	(1.26)	(1.31)	(1.41)	(0.52)	(0.98)	(0.05)	(-0.83)
Sectoral Change (Agr)	-0.27***	0.32***	0.02	-0.16**	-0.29***	0.29***	0.03	-0.11*
	(-2.84)	(4.64)	(0.24)	(-2.34)	(-3.99)	(3.34)	(0.39)	(-1.94)
Log(WAS)	17.94**	41.35***	1.99	-50.22**	12.12*	31.58***	0.75	-14.99
	(2.29)	(4.47)	(0.26)	(-2.67)	(1.71)	(3.66)	(0.09)	(-0.95)
Δ WAS	0.64**	0.77***	-0.08	-0.67**	-0.05	0.49**	-0.63	-1.03***
	(2.41)	(3.15)	(-0.17)	(-2.04)	(-0.11)	(2.15)	(-0.77)	(-3.06)
Δ WAS*High Education	0.23	0.30	-0.17	1.72*				
	(0.65)	(1.22)	(-0.39)	(1.74)				
Δ WAS*Q2 (25%-50%)					0.85*	-0.04	-0.03	1.44***
					(1.71)	(-0.09)	(-0.03)	(4.69)
Δ WAS*Q3(50%-75%)					0.28	0.65	-0.07	0.97
					(0.59)	(1.45)	(-0.08)	(0.98)
Δ WAS*Q4 (75%-100%)					2.22**	0.36	1.33	1.10
					(2.62)	(0.84)	(1.25)	(0.93)
Constant	-24.23	-46.80	51.36*	245.39***	-18.13	-5.31	53.70	117.29*
	(-0.76)	(-1.13)	(1.90)	(3.10)	(-0.67)	(-0.14)	(1.69)	(1.75)
Observations	287	226	204	173	239	207	157	134
Number of countries	53	39	31	39	41	33	23	29
R-squared	0.41	0.75	0.35	0.51	0.46	0.72	0.43	0.60
Adjusted R-squared	0.38	0.74	0.30	0.48	0.42	0.69	0.35	0.55

Notes: ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively. All regressions include time fixed effects. Column [8]-[11] include quartile dummies for years of schooling.

The results for Africa are equally interesting in view of the relatively early stage of the transition and the fact that Africa's average years of schooling of 5.4 years in 2010 is still below that of Europe and North America in 1960. For Africa, countries at lower levels of education have had a decline in growth following the increase in their working age population. This is consistent with the results in the theoretical section and may suggest the existence of a Malthusian phase during which population growth has an adverse impact on growth. However, countries that have invested in education, have been able to reverse this effect and benefit from a positive dividend. Countries that move from the first to the second quartile benefit from a net positive dividend.

These results are not seen for the other quartiles, probably a reflection that most SSA countries do not yet fit in those categories in terms of education levels.

The regional results have two significant implications. First, they confirm that for similar demographic transitions, the final economic outcomes can differ significantly. Second, they underscore the role of policies in ensuring the translation of potential growth into actual dividends.

D. Robustness Checks

We now investigate whether there is a threshold effect for the demographic variables on growth, i.e., whether the contribution of demographic factors to growth is reduced when GDP per capita exceeds a certain level. While there is no ambiguity as regards the contribution of demographic factors at lower levels of development, convergence implies that the marginal contribution might decline over time. To test whether there is a threshold for demographic variables, we first included the interactive terms between the two demographic variables and log initial GDP per capita to the set of controls in Column (1) of Table 2. The results are shown in Column (1) of Table 4.

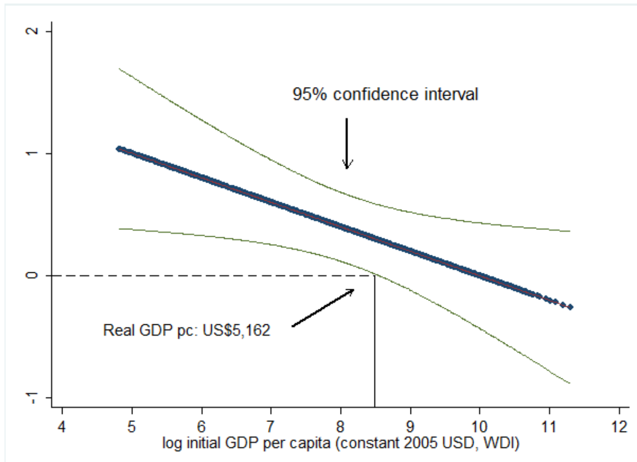
Table 4. Demographic dividends and threshold effects

Average 5 year growth rate of real GDP per capita	(1) Full Sample	(4) >=med (GDPpc)	(5) <med (GDPpc)	(6) >=TPoint (GDPpc)	(7) <TPoint (GDPpc)
Log Initial GDP per capita	13.53	-6.73***	-4.55***	-6.84***	-4.94***
	(1.60)	(-5.53)	(-3.91)	(-4.74)	(-4.60)
Trade Openness	0.02***	0.01*	0.03**	0.01*	0.03**
	(2.73)	(1.87)	(2.24)	(1.90)	(2.50)
Sectoral Change (Agr)	-0.16***	0.04	-0.16***	0.00	-0.17***
	(-3.29)	(0.30)	(-3.31)	(0.01)	(-3.51)
Log(WAS)	48.28***	10.20**	11.28**	-0.01	10.08**
	(3.04)	(2.11)	(1.99)	(-0.00)	(2.03)
Δ WAS	2.01***	0.05	0.67***	0.05	0.63***
	(2.67)	(0.32)	(2.64)	(0.23)	(3.10)
Log(WAS)*Log Initial GDP per capita	-4.59**				
	(-2.22)				
Δ WAS*Log Initial GDP per capita	-0.20**				
	(-2.22)				
Constant	-155.59**	20.36	-14.87	65.95*	-5.66
	(-2.42)	(0.86)	(-0.73)	(2.00)	(-0.32)
Observations	1,100	509	591	334	766
R-squared	0.30	0.30	0.29	0.30	0.31
Number of countries	172	97	104	64	128
Time FE	Yes	Yes	Yes	Yes	Yes
Adjusted R-squared	0.29	0.284	0.277	0.273	0.298

Notes: Robust t-statistics in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively.

The estimation results confirm our hypothesis. While the demographic factors remain positive and significant, the interactive term is negative, implying that once the economy reaches a certain level of development, the contribution of demographic factors to growth declines. Figure 5 shows the relationship between ΔWAS and initial GDP per capita. The blue lines show the marginal effect on average 5-year growth rate of a 1 percentage point increase in the share of working age population at different levels of initial real GDP per capita. When GDP per capita reaches around US$ 5,162, the contribution of the demographic variables to growth is no longer significant. We posit that this result is driven by the changing structure of middle income countries, where the reliance on labor intensive strategies is somewhat less and the convergence effects dominate.

Figure 5. Demographic dividend and development level



Source: Authors' calculations.

VI. Estimates of Demographic Dividends for Sub-Saharan Africa

In this section, we estimate the demographic dividend that Sub-Saharan Africa could potentially reap over the period 2010 to 2100. The demographic dividend is defined as the difference between the GDP per capita without the demographic transition and the GDP per capita with demographic transition. We take year 2010 as the starting year and consider two potential scenarios: (i) where the share of working age population remains constant at 50 percent, and (ii) where the share of working age population rises as predicted by the UN's median scenario. Due to data coverage and robustness of the results, we choose the coefficient estimates shown in column (1) of Table 1 to compute the average 5-year growth rate. The initial GDP per capita level and trade openness are taken from year 2010 while sectoral change from agriculture is assumed to be zero due to lack of information and projection on this variable. In other words, we assume there will not be much further shift from the agriculture sector to the non-agriculture sector. To the extent the pace of structural transformation is accelerated and the economy moves away from agriculture, GDP could increase by a faster pace with a resulting slowdown in the demographic dividend as the economy reaches a certain income threshold.

Figures 6 (a) and (b) show the expected evolution of the share of working age population in SSA and the estimated demographic dividends for the median country with an initial per capita income level of about US$560. The share of working age population is projected to peak at 65 percent in 2090. While GDP per capita is expected to peak at around US$2,475 in the baseline, factoring in demographic developments causes GDP per capita to rise to US$3,865 by 2100. The demographic dividend of about US$1,350 implies that per capita GDP is higher by nearly 56 percent. One however needs to note that the demographic dividend initially accrues at a low pace and only takes off in the second half of the century. Appendix 2 provides country specific estimates, although uncertainty is much greater for these.

Figure 6 (a). GDP growth in median SSA country

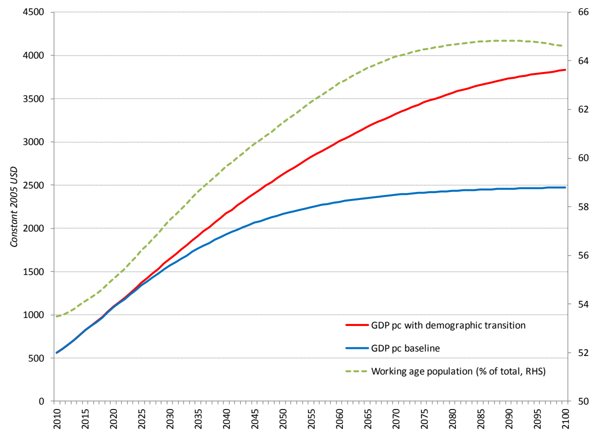
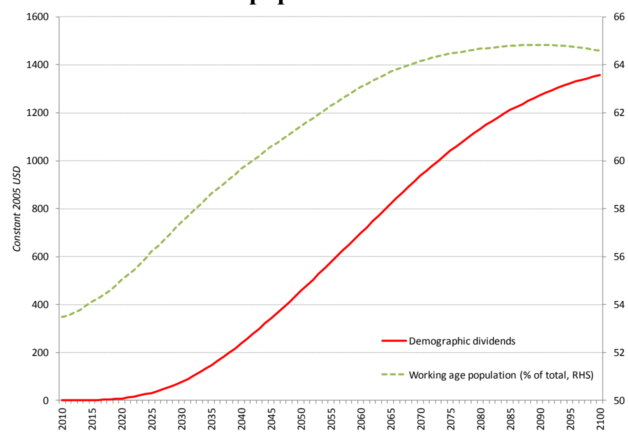


Figure 6 (b). Demographic dividend and working age population



Source: Authors' calculations.

VII. Conclusions

Much has been said and written about Africa's growth potential. The projected increase in Africa's working age population during this century represents a window of opportunity, which if properly tapped can be transformational. Our study confirms that growth can be substantially higher and low income countries stand to benefit the most from this transition given that the magnitude of the dividend declines as economies mature. While the transition represents an opportunity, it can also create potential social risks if it is not managed properly, particularly if the economy does not create jobs on a sufficient scale to absorb those joining the labor market.

Our results regarding the significant interaction between the human capital and the magnitude of the demographic dividend suggest that improving and increasing access to education is critical to improve the productivity of workers and support a transition to higher valued added sectors. Additionally, we have also shown that structural transformation fostering a shift away from agriculture is also conducive to harnessing the demographic dividend. As such policies that remove impediments to private sector development and enable labor intensive manufacturing could help position Africa to make the most of its resources.

Appendix Table 1. Summary statistics

Variable	Obs	Mean	S.D.	Min	Max	Source
Average 5-year growth rate of real GDP per capita	1489	1.43	3.26	-22.56	26.90	WDI (2012)
Log Initial GDP per capita	1493	7.89	1.61	3.91	11.75	WDI (2012)
Ratio of Investment to GDP	1438	0.11	0.11	-0.23	1.16	PWT 8.0
Trade Openness	1395	76.03	48.86	1.08	429.95	WDI (2012)
Years of Schooling	1420	5.61	3.03	0.04	12.91	Barro and Lee (2013)
Bureaucratic quality	659	2.13	1.21	0.00	4.00	ICRG (2012)
Sectoral Change (Agriculture)	1211	-1.31	4.45	-43.13	26.22	WDI (2012)
Life Expectancy	1904	61.88	11.70	30.31	81.98	WDI (2012)
Working age share	1908	57.91	6.54	45.27	79.14	WDI (2012) and UN
Change in working age share	1908	0.60	1.44	-6.27	7.81	WDI (2012) and UN

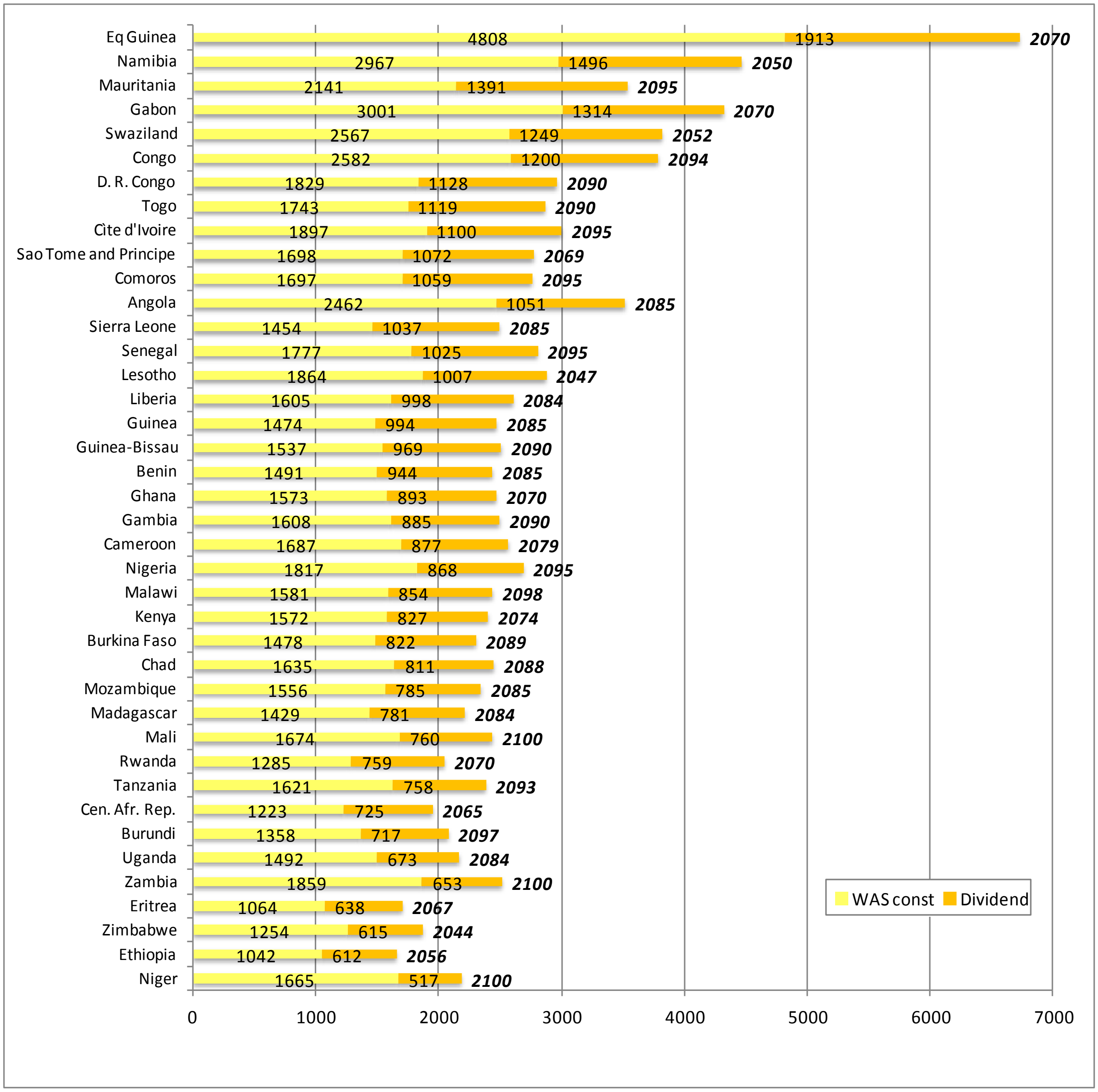
Source: Authors' calculations.

Appendix Table 2. Demographic dividend by regions

	(1)	(2)	(3)	(4)
Region	Asia	Europe	Latin America	SSA
Period	1965-2010	1965-2005	1965-2010	1985-2010
Log Initial GDP per capita	-6.14***	-13.06***	-7.15***	-6.02**
	(-3.02)	(-9.87)	(-5.38)	(-2.49)
Trade Openness	0.01	0.01	0.02	0.03
	(0.58)	(1.26)	(1.36)	(1.40)
Sectoral Change (Agr)	-0.27***	0.33***	0.02	-0.18**
	(-2.84)	(4.64)	(0.21)	(-2.33)
Log(WAS)	19.19**	41.39***	1.52	-34.27**
	(2.56)	(4.50)	(0.21)	(-2.32)
Δ WAS	0.81***	1.04***	-0.25	0.02
	(3.11)	(3.81)	(-1.19)	(0.08)
Constant	-31.66	-46.80	52.08**	176.34***
	(-1.11)	(-1.13)	(2.07)	(3.31)
Observations	287	226	204	197
R-squared	0.41	0.75	0.35	0.46
Number of countries	53	39	31	44
Adjusted R-squared	0.39	0.74	0.31	0.44

Note: Robust t-statistics in parentheses. ***, ** and * denote significance at the 1%, 5%, and 10% levels, respectively. All regressions include time fixed effects.
Source: Authors' calculations.

Appendix Figure 1. Country specific demographic dividends in peak year



Source: Authors' calculations.
Note: Projected dividend for countries at their peak based on baseline WAS of 50 percent in 2010. Countries are ranked by the size of the demographic dividend per capita in their peak year (shown at the end).

References

Barro, Robert, and Jong-Wha Lee (2013), "A New Data Set of Educational Attainment in the World, 1950-2010." *Journal of Development Economics*, 104, 184-198.

Bloom David E., and J. D. Sachs (1998). "Geography, Demography, and Economic Growth in Africa," *Brookings Papers on Economic Activity*, 2, 207–295.

Bloom, David E., and Canning, D. (2000). "The Health and Wealth of Nations," *Science*, 287, 1207–1209.

Bloom, David E., and David Canning, and Pia N. Malaney (2000). "Population Dynamics and Economic Growth in Asia," *Population and Development Review*, 26, 257-290.

Bloom, David E., and David Canning (2003). "Contraception and the Celtic tiger". *The Economic and Social Review*, 34, 229–247.

Bloom, David E., David Canning and Jaypee Sevilla (2003). "The Demographic Dividend: A New Perspective on the Economic Consequences of Population Change", *RAND*.

Bloom, David E., David Canning, Gunther Fink, and Jocelyn Finlay (2007). "Realizing the Demographic Dividend: Is Africa any different?", *PGDA Working Paper* No. 23.

Bloom, David E., David Canning, Guenther Fink and Jocelyn E. Finlay (2009). "Fertility, Female Labor Force Participation, and the Demographic Dividend," Journal of Economic Growth, 14(2), 79-101.

Bloom, David E., David Canning, Linlin Hu, Yuanli Liu, Ajay Mahal, Winnie Yip (2010). "The contribution of population health and demographic change to economic growth in China and India", *Journal of Comparative Economics,* 38, 17–33

Brooks, R. (2003), "Population Aging and Global Capital Flows in a Parallel Universe," *IMF Staff Papers*, 50 (2), 200-221.

De Carvalho, J., and L. Wong (1999). "Demographic and Socioeconomic Implications of Rapid Fertility Decline in Brazil: A Window of Opportunity," in Reproductive Change in India and Brazil, 208-240, eds. by Martine, G., Das Gupta, M. and L., Chen. Oxford: Oxford University Press.

De la Croix, D., and Michel, P., (2002). *A Theory of Economic Growth: Dynamics and Policy in Overlapping Generations*. Cambridge University Press, Cambridge

Diamond, Peter (1965), "National Debt in a Neoclassical Growth Model", *American Economic Review*, 55(5), 1126-1150.

Galor, O. (2005). "From Stagnation to Growth: Unified Growth Theory," in Handbook of Economic Growth, eds. by P. Aghion, and S. Durlauf, Chapter 4, Elsevier Science B.V., Amsterdam.

Galor, O., and D. N. Weil (2000). "Population, Technology and Growth: From the Malthusian Regime to the Demographic Transition," *American Economic Review*, 110, 806-828.

Kuznets, S. (1960). "Population Change and Aggregate Output," NBER Chapters, in: *Demographic and Economic Change in Developed Countries*, pages 324-351 National Bureau of Economic Research, Inc.

Lee, R. (2003). "The Demographic Transition: Three Centuries of Fundamental Change," *Journal of Economic Perspectives*, 17(4), 167-190.

Lorentzen, P., and J. McMillan, and R. Wacziarg (2008). "Death and development," *Journal of Economic Growth*, 13(2), 81-124.

Mason, Andrew (2001). "Population, Capital, and Labor," in *Population Change and Economic Development in East Asia: Challenges Met, Opportunities Seized*, eds. by Mason A., Chapter 8, Stanford: Stanford University Press.

Pool, I. (2007). "Demographic Dividends: Determinants of Development or Merely Windows of Opportunity," *Ageing Horizons*, 7, 28-35.

Roodman, D. (2009). "How to do xtabond2: An introduction to difference and system GMM in Stata," *Stata Journal*, StataCorp LP, 9(1), 86-136.

Rosenzweig, Mark R. (1990). "Population Growth and Human Capital Investments: Theory and Evidence," *Journal of Political Economy*, 98(5), 38-70.

Simon, B. (1987). "Systematization and Segmentation in Education: the Case of England," in *The Rise of the Modern Educational System*, eds. by Muller, D., Ringer, F., and Simon, B. Cambridge University Press, Cambridge, MA.

Soares, R. R. (2005). "Mortality Reductions, Educational Attainment, and Fertility Choice," *American Economic Review*, 95(3), 580-601.

Soares, Rodrigo R., and Bruno L. S. Falcao (2008). "The Demographic Transition and the Sexual Division of Labor," *Journal of Political Economy*, 116(6), 1058-1104.

Williamson, J.G., and M. Higgins (2001). "The Accumulation and Demography Connection in East Asia," in Population Change and Economic Development in East Asia: Challenges Met, Opportunities Seized, eds. by Mason A., Chapter 5, Stanford: Stanford University Press.

Windmeijer, F. (2005). "A finite sample correction for the variance of linear efficient two-step GMM estimators," *Journal of Econometrics*, 126(1), 25-51.