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Ibhagui, Oyakhilome

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Explaining Differences in Income Levels of Africa's Largest Economies – A Development Accounting Perspective

Oyakhilome Ibhagui

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Abstract

Drawing upon the experience of Africa's largest economies, this paper examines the phenomenon of income discrepancies in Africa and applies the combined methodologies of Development Accounting (DA) à la Caselli (2005) and Business Cycle Accounting (BCA) à la Chari, Kehoe and McGrattan (2007) in a standard neoclassical, small open economy model. Classified into 2 equal-numbered groups – G1 and G2 – based on output size and region of location, the economies comprise Sub-Saharan Africa's top 3 economies (G1: Nigeria, South Africa and Angola), and North Africa's top 3 economies (G2: Egypt, Algeria and Morocco). Distortions in production efficiency, labour and capital, collectively termed wedges, are calculated, and the extent, evolution and impact of the wedges are determined for the period 1990 to 2013. Empirical results show that although efficiency wedge plays an important role in explaining income differences, labour wedge and investment wedge are also important for understanding income differences in Africa and, by extension, bridging the gap.

Keywords: Business cycle accounting; efficiency, capital and labour markets distortions; development accounting; distortions; African economies.

JEL classification numbers: E13, N17, O11, O47, O55

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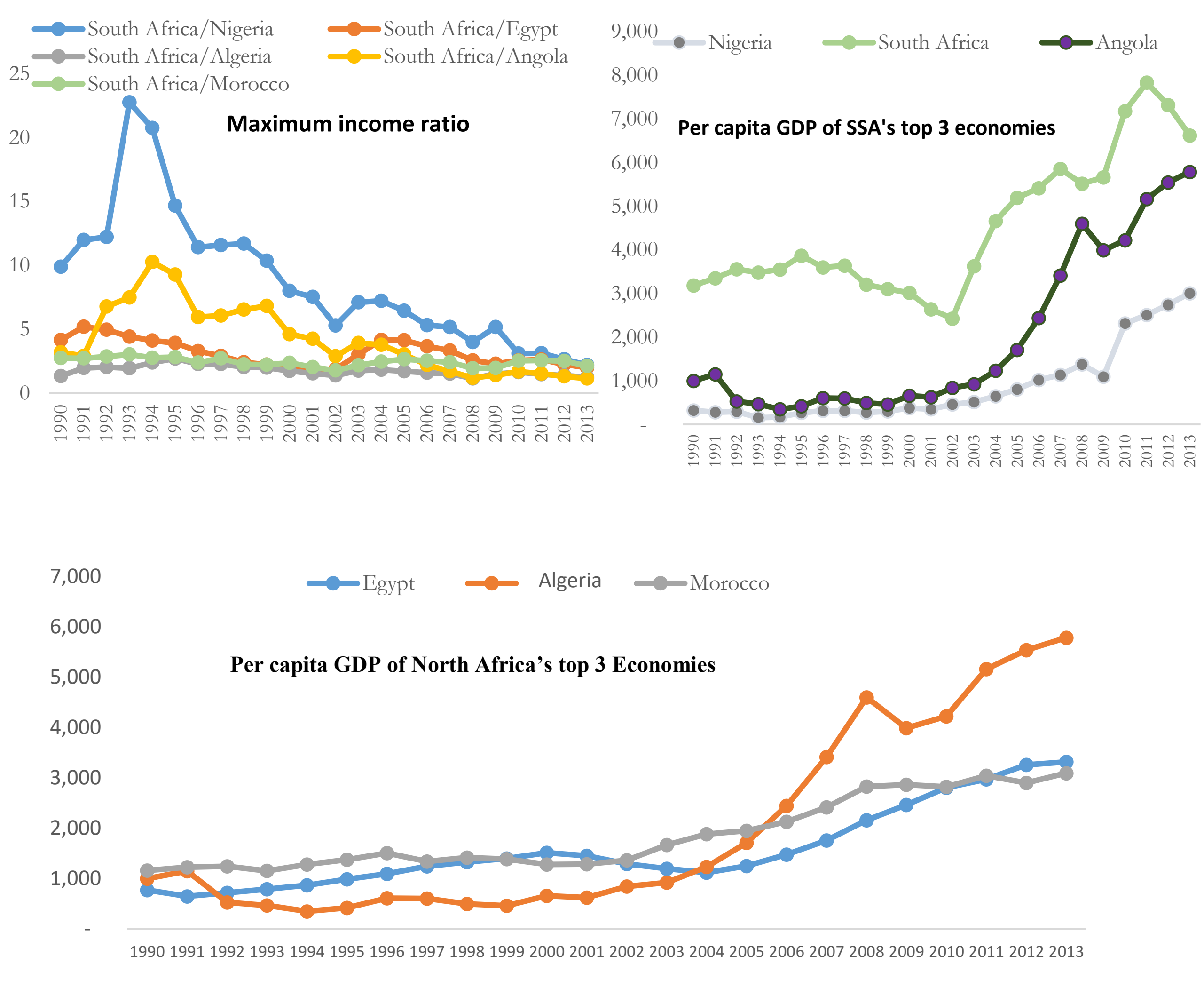
1. Introduction

Africa's top 6 economies share one thing in common – a considerable portion of their revenues are generated from the export of commodities. In Nigeria, receipts from crude oil constitute more than 90% of export income and generate over 70% of government revenue. Algeria's government revenue is 70% hydrocarbon income which represents over 95% of the country's export earnings. In a similar fashion, 80% of Angola's government revenue comes from crude oil sales, and crude oil makes up around 95% of the country's export income. South Africa, Egypt and Morocco all generate significant earnings from commodity exports which make up a sizeable proportion of their respective government revenues. Despite the similarity among these countries, significant differences in income levels still exist. Overall, this puts them on dissimilar levels of development.

Cross-country differences in per capita income are known to be high among Africa's top 6 economies. The observed maximum income ratio[1], a measure of cross-country differences, occurs between Nigeria and South Africa, reaching an all-time high of 23 in 1993 and averaging 8.73 between 1990 and 2013.

Fig 1: Maximum income ratio (X/Y) and GDP per capita ($) by country



[1] Maximum income ratio equals maximum per capita GDP divided by other countries' per capita GDP. Here, South Africa has the highest or maximum per capita GDP, so we divide its per capita GDP by other countries' per capita GDP

Though the income gap appears to be less pronounced for some countries, especially in the earlier periods, the difference in income levels nonetheless remain evident. It is more noticeable within the regions beginning from the 2000s and no work that I am aware of has attempted to interpret, explain or investigate the sources of these differences from the perspective of development accounting using the neoclassical growth model. Given this void, the goal of this paper is to investigate the role of factor distortions in accounting for the observed cross-country income dispersion among Africa's top 6 economies. Specifically, I ask if productivity as well as distortions in labour and capital can explain cross-country income dispersion and dwindling maximum income ratio among Africa's top 6 economies.

The neoclassical growth theory is well-known in the growth literature and has been widely used to explain income differences and development across countries. In the context of development accounting, a neoclassical production function – usually a Cobb-Douglas type – is defined and used to decompose differences in countries' income levels into contributions stemming from 2 major production factors – labour and capital – as well as the productivity (efficiency) of these factors. Studies using methods of development accounting have produced important results regarding which of the three components accounts for the largest differences in countries' income levels. In an influential paper, Caselli (2005) uses the method of development accounting to conclude that income differences across countries are attributable to differences in productivity. More importantly, he finds that the greatest differences in living standards are observed in Africa. Given this finding, it would be interesting to study whether factor usage plays a vital role in explaining these differences. Are the differences due to differences in factor usage? If yes, what drives factor usage differences amongst African countries? In this paper, I employ the method of development accounting, Caselli (2005), and business cycle accounting, Charry, Kehoe and McGrattan (2007), to analyze the sources of cross-country income differences among Africa's top 6 largest economies. Business cycle accounting helps in computing wedges associated with factor input while development accounting specifies the factor input and efficiency as potential income determinants for each country.

In their seminal work, Chari, Kehoe and McGrattan (2007) find that intertemporal wedge did not play a prominent role in the US experience of the great depression or in the 1982 recession. They reach this conclusion by retaining one of the estimated wedges in the model simulations and comparing the results of the simulations with actual data. Meanwhile, Christiano and Davis (2006) fault their findings by identifying two major procedural issues with their work. First, the procedure employed to compute the intertemporal wedge has a strong impact on the simulated time series. Second, the fact that wedges are correlated, as documented in Curdia and Reis (2010), makes it difficult to identify the partial impact of any one individual distortion. On this premise, Christiano and Davis (2006) conclude that findings in Chari, Kehoe and McGrattan (2007) are not robust. These criticisms motivate the empirical method of wedge estimation as in Konya (2013) on which the current paper is built. The empirical method allows direct estimation of wedges and reduces the sensitivity of estimation to model uncertainty, making wedges less sensitive to the assumptions regarding unobserved stochastic process in the time series.

In his comprehensive work, Caselli (2005) computes efficiency wedge for representative countries across 6 continents – Europe, Asia, North America, Africa, South America and Australia and finds that distortions to efficiency or efficiency wedge, are the most important source of underdevelopment across the world. However, the empirical work focused less on Africa and provides little focused view on the labour and capital wedges that characterize the situation in Africa's largest economies. In addition, he finds that factor accumulation is important to understand output differences across European countries, but the analysis does not give the same attention to developing regions such as Africa, neither does it specifically accept or reject that factor accumulation is important for explaining income differences in Africa. This creates a gap in the literature that needs to be filled, especially given the differences in income levels observed across many African countries. To this end, I examine the role of factor inputs, i.e. labour and capital markets, in income differences in a much greater detail, with specific emphasis on Africa's top 6 economies and also analyze the distortions that generate different income outcomes for each factor usage across these countries.

The role of factor input in income differences has been investigated in many instances and is well known, but with varying conclusions. Gourinchas and Jeanne (2006), in their calibrated small open economy model, conclude that capital market liberalization, equivalent to a reduction in investment distortions, leads to significant output gains but cannot explain large cross-country income differences. Caselli and Feyrer (2007) find that returns from investing in capital is no higher in poor countries than in rich countries, and that reallocating capital across countries, so as to equate the marginal product of capital, leads to a negligible change in world output. Prescott (2004), Rogerson (2008) and Ohanian, Raffo and Rogerson (2008) all provide evidence that labour wedge explains cross-country differences in labour supply among various OECD countries, an explanation which can also account for observed differences in income levels but cannot be generalized to Africa. As with other studies in the literature, a major issue with the aforementioned studies is that they provide a broad and diverse perspective across rich and poor countries but neglected the possibility of heterogeneity even among poor or rich countries and do not seek to understand the possible outcome when the study is done across particular countries that are more contiguous, i.e. countries in different sub-regions that share the same continent. Moreover, their data sample excludes important African economies such as Nigeria and Angola which are among the economies that are included in the data analyzed in this paper. Furthermore, as far as the literature goes, labour and capital market wedges as potential sources of income differences across countries have not been analyzed in Africa, neither in the context of business cycle accounting nor growth and development. This paper builds on this premise and, as a goal, examines the role of factor distortions in income differences across Africa's top 6 economies.

The approach employed in this paper closely follows Konya (2013) and the standard business cycle accounting of Chari, Kehoe and McGrattan (2007) and assumes a small open economy model setting as in Otsu (2010). I use the standard neoclassical growth model to provide relationships on observed macroeconomic variables via the production function, labour market equilibrium, resource constraint and Euler equation of consumption and investment. I then fit these equations on macro data by computing wedges associated with efficiency, labour and capital. I employ original, non-filtered data to identify the distortions/wedges. The advantage of this approach, as documented in Konya (2013), is that it makes the exercise informative and provides not only the business cycle properties, but also the absolute levels of wedges. As a result, it becomes possible to perform cross-country comparisons of distortions as well as the time series changes within a country. In general, identifying wedges is not straightforward and requires a new set of assumptions. In particular, in the neoclassical framework, investment/capital market wedge is a function of an expectation operator, which implies the existence of forward looking, non-deterministic variables whose values have to be determined before desired wedge levels can be computed. Chari, Kehoe and McGrattan (2007) address this challenge by proposing a VAR representation structure for the wedges and then estimating the VAR parameters by the method of full information maximum likelihood. However, despite the elegance of their approach, Konya (2013) notes that the approach is much less appealing in instances where original, non-filtered data are used since model-based estimation would require a convincing model of not only the business-cycle components, but also the growth component, which may be difficult to obtain in the context of African economies. In addition, the approach requires strong assumptions for the unobserved wedge process.

In view of this, this paper computes the wedge levels using a technique which does not depend on solving recursive representations. The method uses auxiliary data to measure forward-looking variables – that is, the non-deterministic variables within the expectation operator. The auxiliary data used to proxy forward-looking variables are taken as *a priori* public forecasts, where available. The forecasts come from the IMF and capture expected output and inflation. This method ensures I can compute all wedges from single equations, without fully solving any underlying stochastic model. Furthermore, I perform a development accounting exercise using the neoclassical growth model, with a Cobb-Douglas production function, to separate the distortions into components that represent labour and capital market inefficiencies. This introduces input distortions into the production function. By using data between 1990 and 2013 for Africa's top 6 economies – Nigeria, South Africa, Egypt, Algeria, Angola and Morocco – I perform two different comparisons. First, I form two distinct groups with the three Sub-Saharan African economies and the three North-African economies. Following this, I examine the possibility of heterogeneity in labour and capital market outcomes within each group, given that countries in each group are in a similar economic region. Second, I analyze how capital and labour market distortions explain income differences between Sub-Saharan and North African economies.

The main results suggest that all 6 African economies benefit much more and experience significant increases in per capita output if labour and capital wedges (distortions) are simultaneously reduced to their minimum levels. In such scenario, the gain is largest for Nigeria at 74% for per capita output and least for Algeria at 29% for per capita output. Across Africa, Sub-Saharan African economies record the most significant gains, on average, from a joint reduction in labour and capital wedges compared to North African economies. Turning to results from single wedge reduction, the most significant gain from labour wedge reduction is seen in Nigeria followed by South Africa and Egypt wherein output, hours worked, and capital increased by roughly 74%, 49% and 36% respectively. Angola and Morocco also record gains in output, hours worked and capital after a reduction in labour wedge, but the gains are quite modest at around 4% for Angola and 10% for Morocco, suggesting that Nigeria, South Africa and Egypt would benefit the most while Angola and Morocco would benefit the least from policies aimed at reducing or eliminating wedges. In summary, the paper argues that efficiency and investment distortions, as well as labour distortions, explain income differences in Sub-Saharan Africa and North Africa, and are also important for understanding income differences within both regions. In addition, observed labour and capital taxes are related to the measured wedges in some but not all countries, and the significant unexplained components remain.

While most studies on Africa's growth and development have focused on drivers of economic growth and development, in this paper, I focus more on explaining income differences across and within Africa's largest economies by comparing the experiences of Sub-Saharan and North African countries. I show that while improvements in productivity are crucial for bridging income gaps and differences in Africa's largest economies, eventual catch up or gap-closing, driven by catalyzed acceleration in low income countries and sustainable growth in high income countries, is often the handiwork of other factors, with reductions in capital and labour market wedges being an important channel. To the best of my knowledge, this paper presents a unique study in that the influences of wedges on the differences in income levels have not been analyzed in Africa in the context employed in this paper. The remainder of the paper is organized as follows. In Section 2, I describe the theoretical framework of the model. In Section 3, I describe the data, explain the empirical procedure and present the results. In Section 4, I provide some analyses and interpretation of the estimated wedges. In Section 5, I discuss how income and factor input behave with changes in the wedges. Section 6 concludes the paper.

2. Theoretical Framework – The Model

The general equilibrium model presented here and in other parts of the paper closely follows Konya (2013) in entirety and is based on the open-economy, one-sector neoclassical growth model populated by infinitely lived households that draw income from supplying labour, renting capital to firms, earning interests on bonds purchased and paying interests on bonds issued. The main input includes exogenous productivity growth, capital accumulation, endogenous labour supply and the possibility of issuing bonds at an exogenously determined world real interest rate.

2.1 Households

The representative household receives utility from consumption C_t and disutility supplying labour h_t. After drawing income from supplying labour, renting capital to firms and earning or paying interest on bonds, the representative household allocates the net income towards consumption and investment, where investment can be physical investment (capital stock) and/or financial investment (bonds). The representative household's lifetime utility function may be expressed as

$$\mathbb{E}_t \sum_{t=0}^{\infty} \beta^t N_t \left[\log \frac{C_t}{N_t} + \chi \log(1-h_t)\right], 0 < \beta < 1 \tag{1.0}$$

and the aggregate net income or liquid asset available to the household is

$$\aleph_t = \left(1-\tau_t^h\right) W_t N_t h_t s_t + \left(1-\delta+r_t^k\right) K_t + B_t + T_t \tag{1.1}$$

where $\mathbb{E}_t$ denotes the expectation operator conditional on information at time t, β is the discount factor and N_t is the population size, C_t/N_t denotes per capita consumption, h_t is the supply of labour hours per person, s_t is the amount of human capital per person, $\left(1-\tau_t^h\right) W_t N_t h_t s_t$ is the net income from supply of labour, $\left(1-\delta+r_t^k\right) K_t$ denotes the net value of capital after earning return and accounting for depreciation, B_t is the net bond holdings and T_t represents government transfers (i.e. stemming from lump-sum tax). The aggregate net income and liquid capital can either be consumed in the current period or invested in physical and/or financial capital in the next period. Thus, these activities are constrained by the aggregate net income available to the household. As a result, when household maximizes utility, the associated optimization problem is given by

$$\max_{\{c,h\}_{t=0}^{\infty}} \mathbb{E}_t \sum_{t=0}^{\infty} \beta^t N_t \left[\log \frac{C_t}{N_t} + \chi \log(1-h_t)\right] \tag{1.2}$$

subject to the budget constraint

$$C_t + \left(1+\tau_t^k\right) K_{t+1} + \frac{B_{t+1}}{(1+\tau_t^b)(1+r_t^*)} = \left(1-\tau_t^h\right) W_t N_t h_t s_t + \left(1-\delta+r_t^k\right) K_t + B_t + T_t \tag{1.3}$$

$$K_{t+1} = I_t + (1-\delta) K_t$$

where K_t denotes the capital stock, B_{t+1} next period bond holdings and r_t^* is the exogenous world real interest rate. The gross growth rate of population is constant and exogenously given by $n = N_t/N_{t-1}$. Human capital is also exogenously specified, which yields an effective labour supply given by $N_t h_t s_t$. I also include into the optimization wedges τ_t^h, r_t^k and τ_t^b, representing labour wedge, capital wedge and borrowing wedge respectively.

2.1.1 Optimality Conditions

The value function associated with the optimization problem can be written as

$$V(K_t, B_t, A_t) = \max_{\{h_t, B_{t+1}, K_{t+1}\}} \{U(C_t, h_t) + \beta \mathbb{E}_t[V(K_{t+1}, B_{t+1}, A_{t+1})|A_t]\} \quad (1.4)$$

Differentiating the right-hand side of the value function with respect to h_t gives

$$\frac{\partial U(C_t, h_t)}{\partial C_t}\frac{\partial C_t}{\partial h_t} + \frac{\partial U(C_t, h_t)}{\partial h_t} = 0$$

and since

$$U(C_t, h_t) = N_t\left[\log\frac{C_t}{N_t} + \chi\log(1 - h_t)\right]$$

then

$$\frac{\partial C_t}{\partial h_t} = (1 - \tau_t^h)W_t N_t s_t, \frac{\partial U(C_t, h_t)}{\partial C_t} = \frac{N_t}{C_t} \text{and} \frac{\partial U(C_t, h_t)}{\partial h_t} = -\frac{N_t\chi}{1 - h_t}.$$

Consequently, the first order condition characterizing labour supply is given as

$$\frac{\chi C_t}{1 - h_t} = N_t(1 - \tau_t^h)W_t s_t \quad (1.5)$$

Differentiating the right-hand side of the value function with respect to K_{t+1} gives

$$\frac{\partial U(C_t, h_t)}{\partial C_t}\frac{\partial C_t}{\partial K_{t+1}} + \beta \mathbb{E}_t\left[\frac{\partial V(K_{t+1}, A_{t+1})|A_t}{\partial K_{t+1}}\right] = 0,$$

where

$$\frac{\partial C_t}{\partial K_{t+1}} = -(1 + \tau_t^k)$$

Thus, the capital equation is given by

$$-(1 + \tau_t^k)\frac{\partial U(C_t, h_t)}{\partial C_t} + \beta \mathbb{E}_t\left[\frac{\partial V(K_{t+1}, A_{t+1})|A_t}{\partial K_{t+1}}\right] = 0$$

$$\Rightarrow \quad -(1 + \tau_t^k)\frac{N_t}{C_t} + \beta \mathbb{E}_t\left[\frac{\partial V(K_{t+1}, A_{t+1})|A_t}{\partial K_{t+1}}\right] = 0 \quad (1.6)$$

Differentiating the left-hand side of the value function with respect to K_t yield

$$\frac{\partial V(K_t, A_t)}{\partial K_t} = \frac{\partial U(C_t, h_t)}{\partial C_t}\frac{\partial C_t}{\partial K_t} = (1 - \delta + r_t^k)\frac{N_t}{C_t}$$

$$\frac{\partial V(K_{t+1}, A_{t+1})}{\partial K_{t+1}} = (1 - \delta + r_{t+1}^k)\frac{N_{t+1}}{C_{t+1}}$$

Plugging the envelope condition into the capital equation yields the Capita-Euler equation as follows

$$-\left(1+\tau_t^k\right)\frac{N_t}{C_t}+\beta\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\frac{N_{t+1}}{C_{t+1}}\right]=0$$

$$\Rightarrow\quad \left(1+\tau_t^k\right)\frac{N_t}{C_t}=\beta\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\frac{N_{t+1}}{C_{t+1}}\right] \tag{1.7}$$

Differentiating the right-hand side of the value function with respect to B_{t+1} gives

$$\frac{\partial U(C_t,h_t)}{\partial C_t}\frac{\partial C_t}{\partial B_{t+1}}+\beta\mathbb{E}_t\left[\frac{\partial V(K_{t+1},B_{t+1},A_{t+1})|A_t}{\partial B_{t+1}}\right]=0,$$

where

$$\frac{\partial C_t}{\partial B_{t+1}}=-\frac{1}{\left(1+\tau_t^b\right)(1+r_t^*)}\text{and}\frac{\partial U(C_t,h_t)}{\partial C_t}=\frac{N_t}{C_t}$$

Thus, the bond equation is thus given by

$$-\frac{N_t}{C_t}\frac{1}{\left(1+\tau_t^b\right)(1+r_t^*)}+\beta\mathbb{E}_t\left[\frac{\partial V(K_{t+1},B_{t+1},A_{t+1})|A_t}{\partial B_{t+1}}\right]=0 \tag{1.8}$$

Differentiating the left-hand side of the value function with respect to B_t yields

$$\frac{\partial V(K_t,B_t,A_t)}{\partial B_t}=\frac{\partial U(C_t,h_t)}{\partial C_t}\frac{\partial C_t}{\partial B_t}=\frac{N_t}{C_t}$$

$$\frac{\partial V(K_{t+1},B_{t+1},A_{t+1})}{\partial B_{t+1}}=\frac{N_{t+1}}{C_{t+1}}$$

Plugging the bond envelope condition into the bond equation yields the Bond-Euler equation as follows

$$-\frac{N_t}{C_t}\frac{1}{\left(1+\tau_t^b\right)(1+r_t^*)}+\beta\mathbb{E}_t\left[\frac{N_{t+1}}{C_{t+1}}\right]=0$$

$$\Rightarrow\quad \frac{N_t}{C_t}=\left(1+\tau_t^b\right)\beta(1+r_t^*)\mathbb{E}_t\left[\frac{N_{t+1}}{C_{t+1}}\right] \tag{1.9}$$

Thus, the optimality conditions linking the wedges are given by

$$\begin{cases}\dfrac{\chi C_t}{1-h_t}=N_t\left(1-\tau_t^h\right)W_t s_t\\ \left(1+\tau_t^k\right)\dfrac{N_t}{C_t}=\beta\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\dfrac{N_{t+1}}{C_{t+1}}\right]\\ \dfrac{N_t}{C_t}=\left(1+\tau_t^b\right)\beta(1+r_t^*)\mathbb{E}_t\left[\dfrac{N_{t+1}}{C_{t+1}}\right]\end{cases} \tag{2.0}$$

The three equations represent the intertemporal conditions describing labour supply, capital investment and purchase/sale of bonds. The second and third conditions are linked by a common factor N_{t+1}/C_{t+1} and, under certain conditions, can be combined to get the arbitrage condition that determines capital investment in a small open economy. The assumption is that the marginal product of capital, r_{t+1}^k, and the inverse of consumption growth, C_t/C_{t+1}, are independent, implying that conditional covariance between r_{t+1}^k and C_t/C_{t+1} is zero. So, $\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\frac{N_{t+1}}{C_{t+1}}\right]=\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\right]\mathbb{E}_t\left[\frac{N_{t+1}}{C_{t+1}}\right]$.

Under this assumption, the second optimality condition becomes

$$\left(1+\tau_t^k\right)\frac{N_t}{C_t}=\beta\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\right]\mathbb{E}_t\left[\frac{N_{t+1}}{C_{t+1}}\right]$$

and combining with the third optimality condition yields

$$\left(1+\tau_t^k\right)\left(1+\tau_t^b\right)\left(1+r_t^*\right)=\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\right] \quad (2.1)$$

The above equation shows that two sources of investment are possible –investment in capital stock, which yields a next period return of r_{t+1}^k, and purchase of bonds at the world financial market that offers a predetermined real interest rate of r_t^*. Accordingly, the investment wedge or capital distortions must be a combination of wedges or distortions emanating from these sources of investment. Thus, $(1+\tau_t^i)\,(1+r_t^*)=\mathbb{E}_t\left[\left(1-\delta+r_{t+1}^k\right)\right]$, where $1+\tau_t^i=\left(1+\tau_t^k\right)\left(1+\tau_t^b\right)$ is the (total) investment wedge – a combination of wedges emanating from the two investing activities. The investment wedge summarizes distortions in capital accumulation for a small open economy. Similar to a closed economy, the decision to accelerate or decelerate consumption in the next period is connected to the deterministic investment decision in the current period, but the connection is provided by the exogenous world interest rate as the economy is open and participation in the world financial market is unrestricted. In this paper, my sole concentration is on the production side. As a result, I would focus on the investment wedge as a measure of distortion affecting capital accumulation – a factor of production.

2.2 Firms and Production Technologies

There is a representative firm that rents labour and capital from households on a competitive factor markets and uses these factor inputs to produce homogenous goods used for consumption and investment. Production has the standard Cobb-Douglas technology of the functional form

$$Y_t=A_tK_t^{\alpha}(\Gamma_tN_th_ts_t)^{1-\alpha} \quad (2.2)$$

where Y_t is the output, $A_t$is the efficiency wedge and Γ_t is a deterministic labour-augmenting productivity process which ensures that household supply of labour becomes more productive or innovative as the state of technology improves and this is achieved by augmenting their labour. The labour-augmenting productivity process Γ_t grows at a constant rate $\gamma=1+\varphi$ such that

$$\Gamma_t=(1+\varphi)\Gamma_{t-1}\quad=(1+\varphi)^t\Gamma_0=\gamma^t\Gamma_0$$

Firms are perfectly competitive on both goods and factor (labour and capital) markets and thus seek to optimize profit. The profit function is given by $\pi_t=Y_t-W_tN_th_ts_t-r_t^kK_t$ and firms optimize profit by choosing the appropriate amount of labour and capital which solves the optimization problem

$$\max_{\{h_t,\ K_t\}}\pi_t=Y_t-W_tN_th_ts_t-r_t^kK_t$$

subject to

$$Y_t=A_tK_t^{\alpha}(\Gamma_tN_th_ts_t)^{1-\alpha}$$

which reduces to

$$\max_{\{h_t,K_t\}}\pi_t=A_tK_t^{\alpha}(\Gamma_tN_th_ts_t)^{1-\alpha}\quad-W_tN_th_ts_t-r_t^kK_t$$

2.2.1 Firms Optimality Conditions

a. Price of labour - W_t

$$\frac{\partial \pi_t}{\partial h_t} = A_t K_t^{\alpha}(1-\alpha)(\Gamma_t N_t h_t s_t)^{-\alpha}\Gamma_t N_t s_t - W_t N_t s_t$$

$$= A_t K_t^{\alpha}(\Gamma_t N_t h_t s_t)^{1-\alpha}\frac{(1-\alpha)}{h_t} - W_t N_t s_t$$

$$= Y_t \frac{(1-\alpha)}{h_t} - W_t N_t s_t = 0$$

$$\Rightarrow \quad W_t = Y_t \frac{(1-\alpha)}{N_t s_t h_t}$$

b. Price of capital - r_t^k

$$\frac{\partial \pi_t}{\partial K_t} = \alpha A_t K_t^{\alpha-1}(\Gamma_t N_t h_t s_t)^{1-\alpha} - r_t^k$$

$$= \frac{\alpha}{K_t} A_t K_t^{\alpha}(\Gamma_t N_t h_t s_t)^{1-\alpha} - r_t^k$$

$$= \frac{\alpha}{K_t} Y_t - r_t^k = 0$$

$$\Rightarrow \quad r_t^k = \frac{\alpha}{K_t} Y_t$$

Competitive equilibrium with labour and capital market distortions

A competitive equilibrium is a sequence of prices and wedges$\{W_t, r_t^k, r_t^*, \tau_t^h, \tau_t^i\}^{\infty}{}_{t=0}$ and quantities$\{C_t, h_t, K_{t+1}, i_t, B_t\}^{\infty}{}_{t=0}$ such that

i. Household optimizes utility given K_0 and $\{W_t, r_t^k, r_t^*, \tau_t^h, \tau_t^i\}^{\infty}{}_{t=0}$
ii. Firms maximizes profit given (W_t, r_t^k) for each $t \geq 0$
iii. Markets clear for each $t \geq 0$
iv. Resource constraint holds for each $t \geq 0$

2.3 The Wedges

Whatever distorts an equilibrating system and causes it to deviate is termed a wedge. In this paper, we consider three different wedges – efficiency wedge, labour wedge and investment wedge. The efficiency wedge relates to how distortions in efficiency or total factor productivity influence the optimal utilization of the limited input or factors of production, relating changes in input to output. Essentially, it is a wedge between changes in input and output and captures the disturbances in production efficiency which manifest themselves as total factor productivity. The labour wedge, on the other hand, is a distortion in the labour market which manifests itself as disturbances in the labour market and can shift or alter wage level, with a resulting impact on labour availability and consequently output and income level. These disturbances in the labour market can manifest themselves as taxes, consequently altering wage, although they need not be taxes.

Finally, the investment wedge constitutes distortions in the capital/investment market. In this paper, the distortions come from two sources –physical capital accumulation and purchase of fixed income asset, i.e., bonds in the world financial market, since the economy being considered is a small open type. So, the investment wedge is a non-linear combination of wedges or distortions emanating from these sources. Unlike the efficiency wedge and labour wedge, the investment wedge is not directly observable as it is nondeterministic and contains expectation which have to be structurally estimated. In arriving at an estimate for the expectation, I deviate from the usual structural estimation method of investment wedge that estimates a stochastic process for the VAR as in Charry, Kehoe and McGrattan (2007) but instead employ the purely empirical technique proposed by Konya (2013).

Expressions for the three wedges are obtained by combining the household and firm optimality conditions. In this case, the wedges are written as functions of terms which are completely deterministic and observable except for the investment wedge which contains a combination of terms that are observation but not deterministic due to the presence of an expectation. Thus, eliminating w_t and r_t^k between household and firm optimality conditions and solving for A_t from the Cobb Douglas technology relating input to output yield expressions for the labour, investment and efficiency wedges as

$$1-\tau_t^h=\frac{\chi C_t}{(1-\alpha)Y_t}\frac{h_t}{(1-h_t)} \tag{2.3}$$

$$1+\tau_t^i=\frac{1}{1+r_t^*}\left[\mathbb{E}_t\left(\alpha\frac{Y_{t+1}}{K_{t+1}}+1-\delta\right)\right] \tag{2.4}$$

$$A_t=\frac{Y_t}{[K_t^\alpha((1+\gamma)^t\Gamma_0 N_t h_t s_t)^{1-\alpha}]} \tag{2.5}$$

These expressions provide clear interpretation of the three wedges. The labour wedge is determined by hours worked and the consumption-output ratio. The efficiency wedge is country-specific and may contain productivity shocks, productivity growth, market-power induced profitability and also fluctuations in capacity utilization of physical capital since it captures how the input factors, labour and capital, are efficiently utilized. Unlike the labour and efficiency wedges which can be computed in a straightforward manner, computing the investment wedge requires data samples on expected variables which are normally not deterministic ex ante. Here, I employ the empirical technique proposed by Konya (2013) which uses publicly available forecasts to measure the non-deterministic forward-looking variables where they are available and uses actual data realizations in instances where the publicly available forecasts are not available after having shown that the measured investment wedge is not sensitive to the use or forecast or actual data.

3. Empirical Analysis

This section describes relevant data and implements the methodology highlighted above on the data to obtain empirical results. It begins by describing relevant data and computing the wedges associated with factor input and usage. The factor inputs are measures of labour and capital while factor usage is the efficiency or total factor productivity. In this set up, efficient investment decisions are consistent with consumption smoothing and consumption growth is linked to investment via the exogenous world interest rate. Also, the borrowing wedge τ_t^b well captures distortions in consumption. However, empirical analysis provided in this section is specific in that it focuses on the production side, not the consumption side and thus relies on the above investment wedge as an appropriate measure of distortions affecting capital accumulation, a factor input.

3.1 Data and Variables

Data used in this analysis comes from the World Bank, International Monetary Fund (IMF), Penn World Tables and Laborsta. The data sample is gathered from these sources for 6 countries for periods 1990 – 2013 as dictated by data availability. The data contains real per capita GDP in constant dollars, consumption and investment as a fraction of output, and total population size. As documented in Konya (2013), the advantages of using variables measured in international prices include 1) they can be directly compared across countries and 2) differences in relative prices can be easily controlled. Despite these advantages, however, Deaton and Heston (2010) identify problems associated with such data, including challenges involving performing country comparisons across different regions, analyzing countries having different consumption and production structures and measuring government services and housing. Since countries considered in this paper share similar characteristics, major one being that they are Africa's most advanced economies, the data challenges and problems mentioned above are much likely to be well mitigated.

Hours worked data come from Laborsta. Where such data are unavailable, I assume that the work ethic or labour law in a country with unavailable data is largely a reflection of labour laws obtainable in countries from which independence was gotten. I then proxy the missing data using corresponding data from these countries. For each country in this paper, I assume there are 6 work days in a week and 16 hours of work per day. This yields a weekly time endowment of 6.16=96 hours/week which is at variance with other studies which assume 7 work days per week and 16-hour work per day for some European countries, the reason being that African countries usually set aside a day for full religious activities and thus work is either severely restricted or prohibited on this day. After computing the weekly time endowment, I take the average weekly hours as given and divide by 96 (the weekly time endowment), giving values between 0 and 1. These values represent h_t, interpreted as the fraction of hours worked of available work hours per week.

Following Caselli (2005) and Konya (2013), I compute human capital s_t for the active workforce (age groups 15 – 64) as the weighted sum of school years, where the weight is the employment rate associated with each level of education, using the relation

$$s_t = \sum_{i=1}^{3} \vartheta_i \, e^{\varphi(\sigma_i)} \tag{2.6}$$

where ϑ_i is the rate of employment associated with category i, with i being the level of educational attainment. In this paper, I consider three categories of educational attainment according to the UNESCO ISCED 1997 classification system which partitions educational attainment into 3 segments: upper-level secondary (ISCED 0-2), upper secondary and post-secondary non-tertiary (ISCED 3-4) and tertiary (ISCED 5-6).Average schooling years σ_i in each category i varies across countries and are given below

Table 1: Educational attainment

	ISCED 0 - 2	ISCED 3 - 4	ISCED 5 - 6
Nigeria	9	13	16
South Africa	10	14	16
Egypt	11	14	17
Algeria	12	15	16
Angola	10	13	15
Morocco	9	14	16

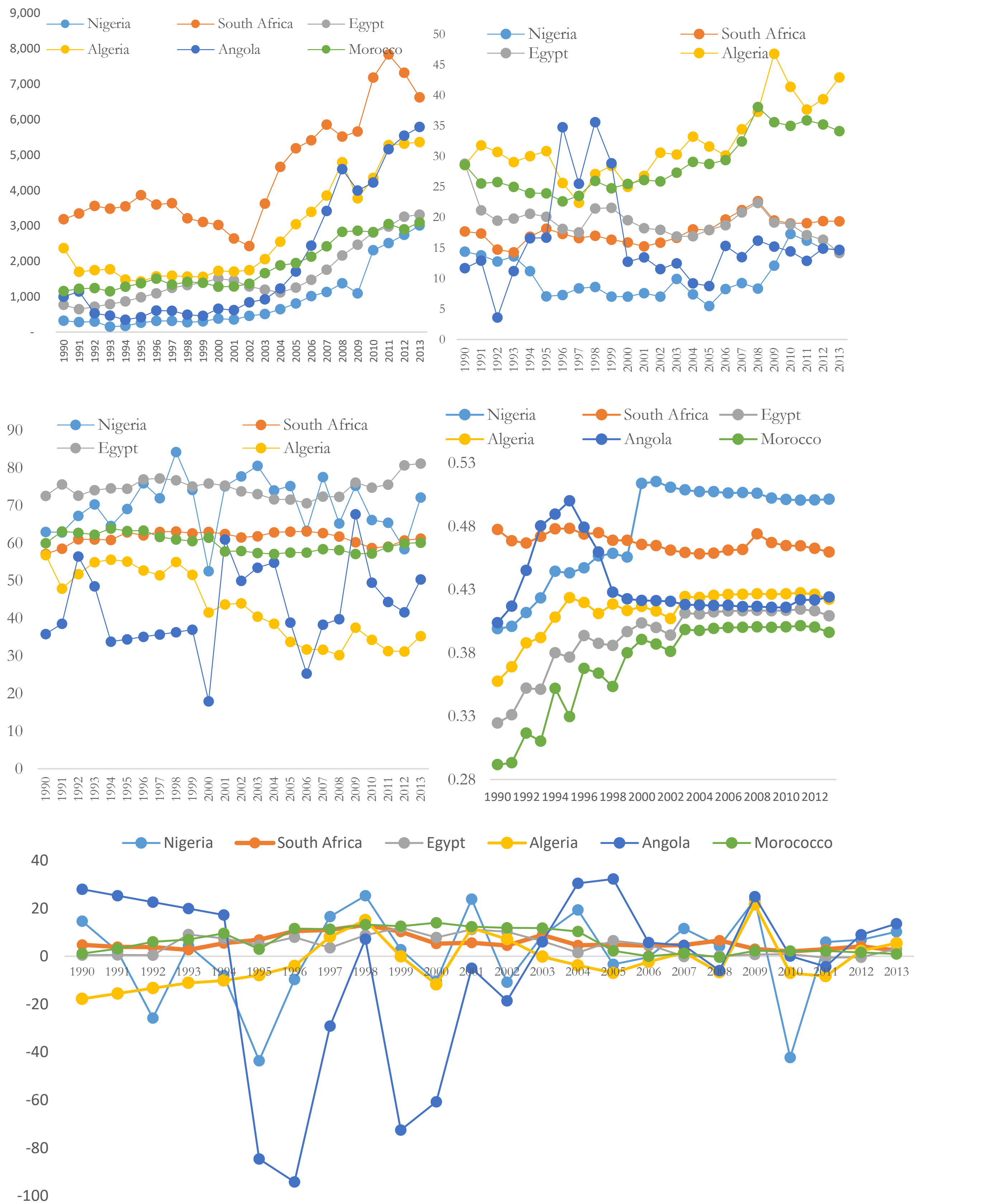
Source: Countries education system websites and author's own estimation

The function $\varphi(\sigma_i)$converts the number of schooling years into human capital. Caselli (2005) identifies $\varphi(\sigma_i)$ as a piecewise linear function defined as

$$\varphi(\sigma_i) = \begin{cases} 0.134\,.\,\sigma_i \ \text{ if } \sigma_i \leq 4 \\ 0.134\,.\,4 + 0.101\,.\,(\,\sigma_i - 4) \ \text{ if } 4 < \ \sigma_i \leq 8 \\ 0.134\,.\,4 + 0.101\,.\,4 + 0.068\,(\,\sigma_i - 8) \text{ if } \ \sigma_i > 8 \end{cases} \tag{2.7}$$

This definition implies the associated slopes, or returns to years of schooling, are 0.134, 0.101 and 0.068 when schooling years are 4 years and above, between 4 and 8 years and above 8 years respectively. Together with the employment rate for each group, these values are substituted into the above expression for s_t to obtain the aggregate human capital associated with all considered categories. Employment rate data for age groups 15-64 are obtained from the World Bank. Actual employment rates for each educational category are not available, so I use the assumption that higher human capital/educational attainment attracts higher employment prospect and hence higher employment rates for each country. The data variables are graphed. Figures below illustrate stylized facts about Africa's 6 largest economies in the sample period 1990-2013. Specifically, they show the evolution of per capita GDP, per capita investment, per capita consumption, labour hours and computed human capital.

Fig. 2: Cross country evolution of per capita GDP, investment, consumption labour hours and human capital



3.2 Calibration

Here, I calibrate the set of parameters$\{\alpha, \delta, \gamma, \chi\}$ which are then used to obtain the wedges. These parameters are assumed to be invariant across countries. It is important to note that for a small open economy, the opportunity cost of investing is the world real interest rate. Moreover, the wedges do not depend on the discount factor β. Consequently, the discount factor is not required for computing the wedges. To calibrate γ, the common long-run productivity growth parameter, I follow Konya (2013) and compute the average growth rate of US real per capita GDP between 1990 and 2013. This yields γ=0.036 or a gross growth $(1+\gamma) = 1.036$. Any productivity growth above this rate for a country is captured by the efficiency wedge. The reason for using US data is that the parameters are assumed to be technology parameters common across the countries under consideration and the US is taken as the standard for technology which determines the common technology frontier available to these countries.

The capital elasticity of production $\alpha = 0.33$, which measures the responsiveness of production levels to changes in capital, is calibrated using the US aggregate capital share estimate as in Valentinyi and Herrendorf (2008) and, following Caselli (2005), this value is assumed to be common across countries. Meanwhile, the calibrated depreciation rate from the capital accumulation equation in steady state is taken as $\delta = 0.04$. This value is taken as the same for all the economies considered. Finally, the importance of leisure in utility,χ, is computed from the labour steady state equation which is given by

$$\chi = \left(1-\bar{\tau}_t^h\right)\frac{(1-\alpha)}{\frac{\bar{C}}{\bar{Y}}}\frac{\left(1-\bar{h}\right)}{\bar{h}} \tag{2.8}$$

where $\bar{C}/\bar{Y} = 0.6$ is the steady state consumption-output ratio taken as the pooled sample average of South Africa, Angola and Algeria. To compute χ, I assume that in a steady state with a zero labour wedge, hours worked, estimated as the fraction of total hours worked weighted by the highest employment rate, is $\bar{h} = 0.20$. Plugging into the labour steady state equation gives $\chi = 4.44$.

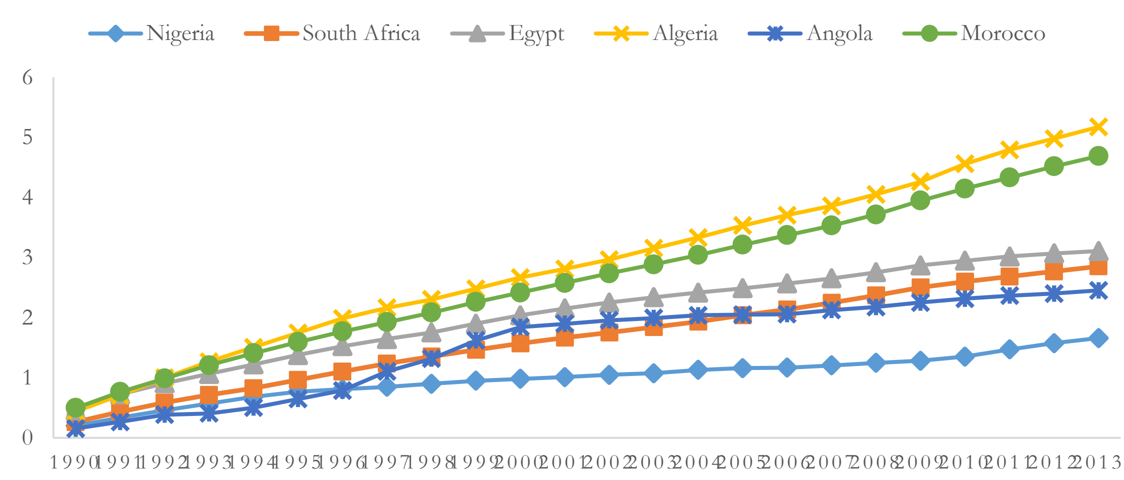
3.3 Capital Stock

The capital accumulation equation, which relates current aggregate capital stock, depreciation rate and current investment to future aggregate capital stock, is given by $K_{t+1} = (1-\delta)K_t + I_t$. The aggregate capital stock data for countries under consideration are not readily available, so I use the Perpetual Inventory Method (PIM). Using the PIM requires an initial capital stock K_0 which is largely unavailable, although data samples on the investment time series for the countries analyzed are available within the period of analysis. In order to address the unavailability of K_0 in the baseline estimations, I follow Caselli (2005) and assume that the initial capital stock K_0 grows at a steady state growth rate, which equals $n\gamma$, to give the next period's capital stock. Under this assumption, $K_1 = n\gamma K_0$ and $K_1 = (1-\delta)K_0 + I_0$, which essentially follows that

$$K_0 = \frac{I_0}{n\gamma - 1 + \delta} \tag{2.9}$$

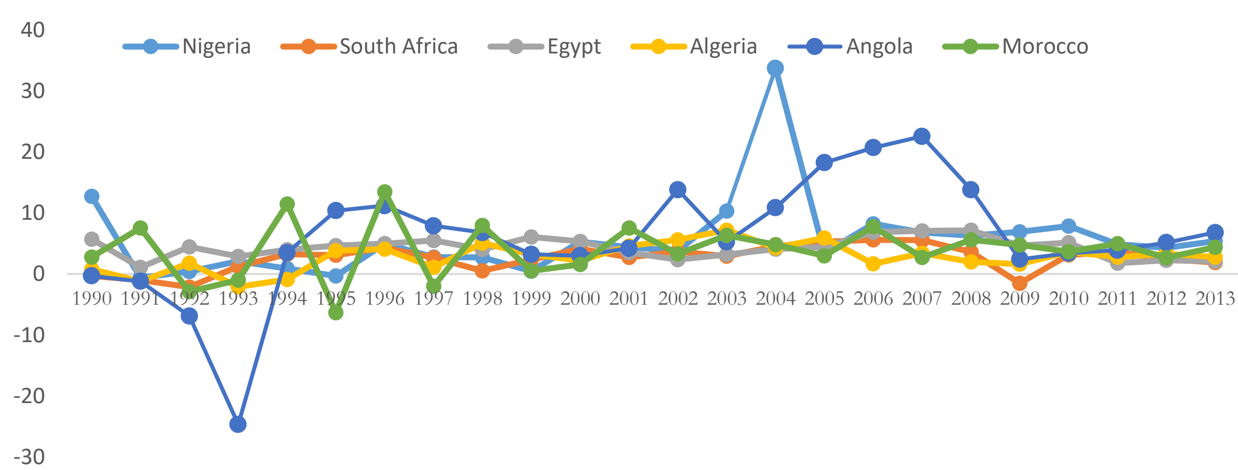
The capital-output ratios generated for the six countries using this assumption are shown in the figure below.

Fig. 3: Capita-output ratio per country across time



The capital-output ratio, which is between 0.2 and 4.7 for the six countries throughout the sample period, shows an increasing trend which implies that for all of the African countries considered, capital-output ratio enjoyed a largely steady increase between 1990 – 2013, an indication of a steady investment in capital stock as these countries on average enjoyed a steady increase in output over the period under consideration, with Nigeria, South Africa, Egypt, Algeria, Angola and Morocco enjoying average output growth rates of 5.75%, 2.57%, 4.30%, 2.78%, 6.01% and 3.94% respectively. Worthy of note is the fact that the capital-output ratios of the Sub-Saharan Africa's top economies – Nigeria, South Africa and Angola – form a convergence and are at variance with those of North Africa's top economies – Egypt, Algeria and Angola

Fig. 4: Year on year output growth (%) per country over time



3.4 The efficiency wedge

The efficiency wedge is obtained from the Solow residual associated with the Cobb-Douglas technology. Thus, to compute the efficiency wedge, I first derive the Solow residual. Now, the aggregative output Y_t varies over time and is governed by production factors – labour and capital – as well as non-production factors – labour augmenting productivity and efficiency wedge. Changes in output over time are measured as changes in these output determinants over time. This is obtained by totally differentiating firms Cobb-Douglas output technology. To see how each component contributes to output growth, I totally differentiate the Cobb Douglas technology as follows

$$\frac{dY}{dt} = \frac{\partial Y}{\partial A}\frac{dA}{dt} + \frac{\partial Y}{\partial K}\frac{dK}{dt} + \frac{\partial Y}{\partial X}\frac{dX}{dt} + \frac{\partial Y}{\partial h}\frac{dh}{dt}$$

$$\frac{dY}{dt} = \frac{Y_t}{A_t}\frac{dA}{dt} + \frac{\alpha Y_t}{K_t}\frac{dK}{dt} + (1-\alpha)\frac{Y_t}{X_t}\frac{dX}{dt} + \frac{(1-\alpha)Y_t}{h_t}\frac{dh}{dt}$$

$$\frac{1}{Y_t}\frac{dY}{dt} = \frac{\alpha}{K_t}\frac{dK}{dt} + \frac{(1-\alpha)}{h_t}\frac{dh}{dt} + \frac{1}{A_t}\frac{dA}{dt} + \frac{(1-\alpha)}{X_t}\frac{dX}{dt}$$

$$\frac{1}{Y_t}\frac{dY}{dt} = \delta_1(K_t, h_t) + \delta_2(A_t, X_t)$$

This yields an expression which splits growth contributors into two components - $\delta_1(K_t, h_t)$ and $\delta_2(A_t, X_t)$. The left-hand side represents growth of an economy over time due to changes in the right-hand side over time. The changes in the right-hand side come from a combination of growth in the production factors, labour and capital, i.e. $\delta_1(K_t, h_t)$and growth/changes in non-production factors, i.e. $\delta_2(A_t, X_t)$, where

$$\delta_1(K_t, h_t) = \frac{\alpha}{K_t}\frac{dK}{dt} + \frac{(1-\alpha)}{h_t}\frac{dh}{dt}$$

$$\delta_2(A_t, X_t) = \frac{1}{A_t}\frac{dA}{dt} + \frac{(1-\alpha)}{X_t}\frac{dX}{dt}$$

The changes in non-production factors represent improvements in productivity/efficiency, that is, $\delta_2(A_t, X_t)$ represents the determinants of growth not due to changes/growth in labour (h_t) and capital (K_t). These growth determinants not directly attributable to production factors actually come from changes/growth in the Solow residual. Thus, if we denote the Solow residual by SR_t, then it follows that

$$\frac{1}{SR_t}\frac{dSR}{dt} = \delta_2(A_t, X_t) = \frac{1}{A_t}\frac{dA}{dt} + \frac{(1-\alpha)}{X_t}\frac{dX}{dt}$$

Solving this first order ordinary differential equation (ODE), neglecting the constant of integration, yields

$$\int \frac{1}{SR_t}\frac{dSR}{dt}dt = \int \delta_2(A_t, X_t)dt = \int \frac{1}{A_t}\frac{dA}{dt}dt + \int \frac{(1-\alpha)}{X_t}\frac{dX}{dt}dt$$

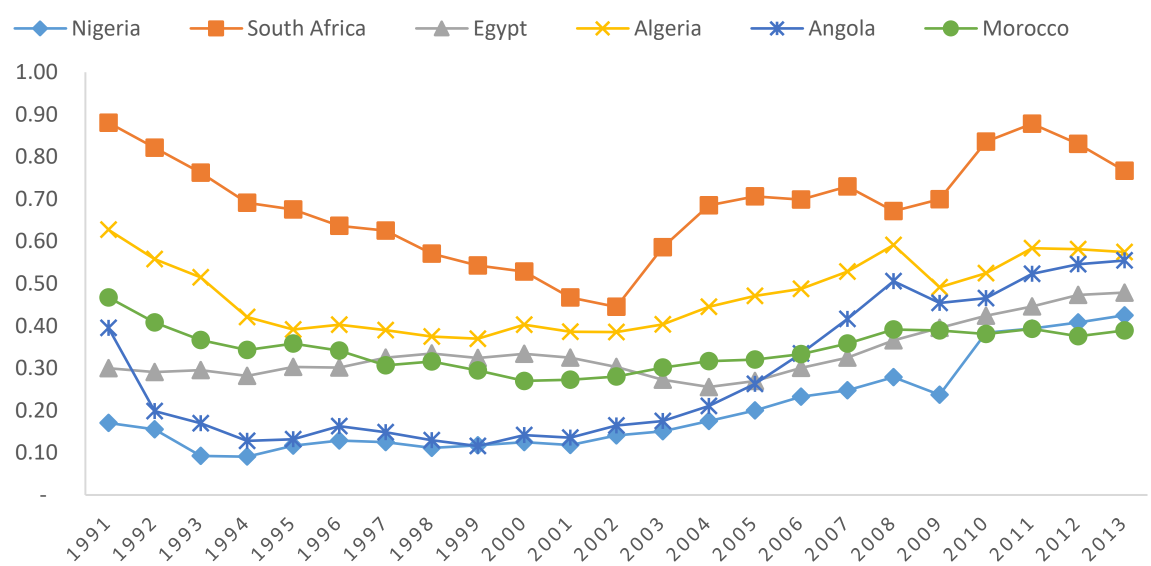
$$\ln SR_t = \ln A_t + (1-\alpha)\ln X_t$$

Thus, the Solow residual at time t, as the solution of the ODE, is given by $SR_t = A_t X_t^{1-\alpha}$. The Solow residual combines the efficiency wedge A_t and labour augmenting productivity growth X_t. To get the efficiency wedge, I follow the method of Konya (2013) and remove the trend growth from the Solow residual using the expression

$$A_t = \frac{SR_t}{\gamma^{(1-\alpha)t}}$$

Since South Africa was the most productive economy at the beginning of the sample, I normalize the efficiency wedge by the value of South Africa in 1990 – the start of the sample. The aim of the normalization is to transform all the variables in the efficiency wedge sample to a specific range of values for each of the computed efficiency wedge, guaranteeing stable convergence within the specific ranges and allowing for easy comparisons across countries when the specific ranges are defined. With this normalization, the specific range of values becomes $(0,1]$. The figure below shows the efficiency wedge for each of the six African economies following removal of the common trend productivity growth.

Fig 5: Efficiency wedge excluding common trend productivity growth



The figure reveals several important findings within and across the two country groups. Unlike in European economies where the efficiency wedges of countries with similar income levels are almost similar (see Konya (2013)), the case of the six African economies considered here is different. Except for South Africa whose efficiency wedge in the period under consideration differ from those of other countries, the disparity in efficiency wedges among the other economies appears largely muted, especially beginning from 2004. For most of these countries, the efficiency wedge recorded an upward trend until 2007 and declined considerably over the 2008-2009 financial crisis. This pattern is relatively more evident in Nigeria, Angola and Algeria that rely on crude oil as their main source of foreign earnings. The sharp drop in efficiency wedge over this period possibly highlights the resilience of the countries' labour markets, i.e. productivity of labour, during the financial crisis.

By and large, all North African economies display a higher convergence, especially Egypt and Morocco, compared to Sub-Saharan African economies. Furthermore, on average, North African economies recorded higher productivity levels compared to Sub-Saharan African economies especially from 1990-2005, except for South Africa that has the highest productivity of all the countries considered. All 3 North African economies experienced rapid productivity declines from 1990. Egypt, the largest economy in the North Africa region, began experiencing growth in productivity after 1995. However, this growth lasted till 2000 after which the country's productivity started to decline. The decline continued until 2004. Following this, the country began experiencing rapid productivity growth without breaks.

Algeria's productivity suffered a setback until after 2000 when it then began experiencing a steady increase. The increase came to a halt during the financial crisis; however, it continued, albeit slowly, after the financial crisis. Morocco, on the other hand, was the last to join the party of increasing productivity amongst North Africa's top economies. The country's productivity only started to follow an upward trajectory, on average, after 2001 and has remained at this level. From this, one concludes that Algeria and Egypt have the largest and most stable productivity growth and that, overall, the productivity of North Africa's top economies have been on the increase.

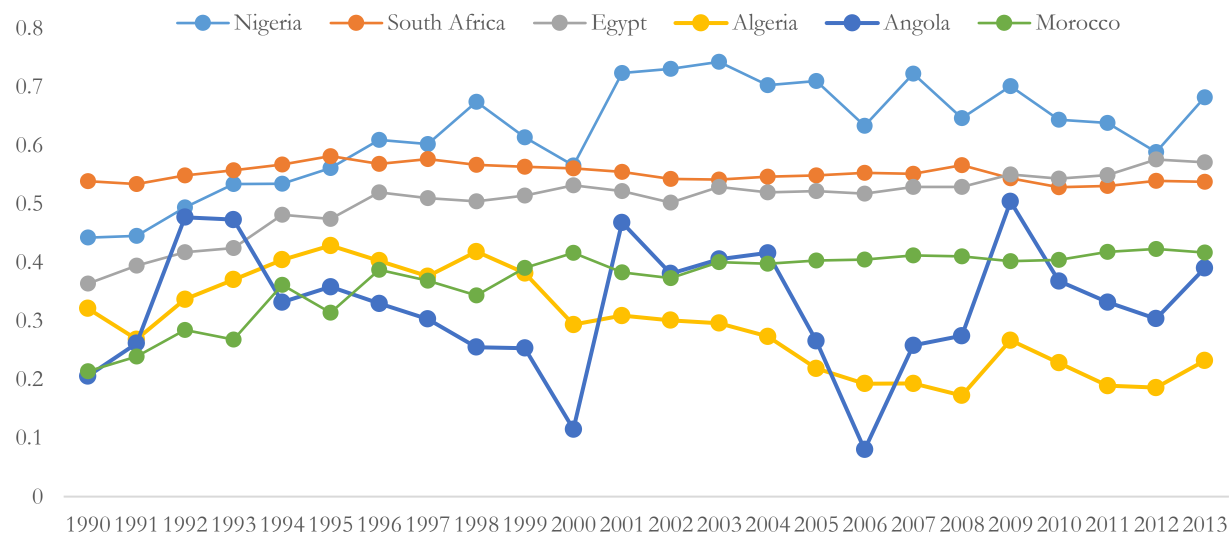
The largest economies in Sub-Saharan Africa display lower levels of convergence, especially South Africa which diverges from the two other countries within the set and from all the countries under consideration. However, it is important to note that Nigeria and Angola display a considerable degree of convergence in productivity and have managed to close some of the initial efficiency gap relative to South Africa and the North African economies, especially beginning from 2003.

On the whole, the results indicate that (1) the three major economies in Sub-Saharan Africa and North Africa, on average, experienced unimpressive period of productivity wherein productivity slowed rapidly; (2) all countries closed some of the initial efficiency gap relative to South Africa, but the rate of convergence is slow; (3) North African countries displayed stronger convergence and homogeneity in efficiency within their group than Sub-Saharan African countries, and (4) the degree of heterogeneity in productivity is higher in the Sub-Saharan African economies than the North African economies.

3.5 The labour wedge

The figure below shows the logarithm of labour wedge for the six countries under consideration. For most of these countries, labour wedge was high. Moreover, none of the countries has a consistently low labour wedge, although Angola recorded the most instances of low labour wedge. South Africa has the most stable labour wedge even if it started with a relatively very high labour wedge which neither decreased nor increased significantly over time. As a result, other countries' labour wedges such as Egypt and Nigeria caught up with and exceeded South Africa's labour wedge as time progressed. The sharpest increase and decrease in labour wedge are observed in Angola and Algeria, while the most moderate decline or no decline at all is seen in Morocco, Egypt, South Africa and Nigeria. In terms of the frequency of upward trend in wedges, Morocco and Egypt, two North African economies, led the pack. In Nigeria, the relatively steady rise in the first half of the period was first followed by a sharp decline and consequently a volatile behavior in the second half of the sample.

Fig.6: Evolution of labour wedge with time across Africa's top 6 economies

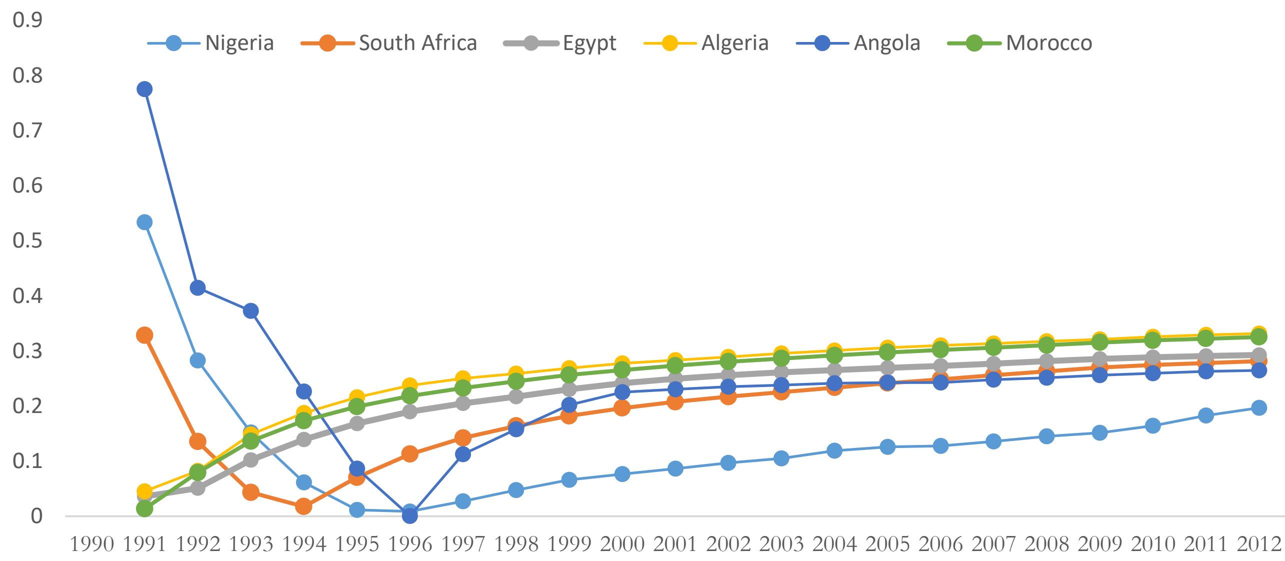


In Algeria, labour hours increased from 1990 until 1995 after which its increase slowed and then stabilized till the end of the sample period in 2013. However, labour wedge started declining steadily later, i.e. in 2000. Moreover, consumption-output ratio declined beginning from 1998; however, the investment rate, though declined until 1997, picked up in 1998 and recorded a relatively upward trend. Thus, the stability in labour hours from 1995 and onwards largely reflects enhancement in investment activity, not a decline in labour wedge.

3.6 The investment wedge

The investment wedges for the set of six countries are displayed in the figure below. An important finding is that significant homogeneity exists across countries, although Sub-Saharan African economies initially had higher investment wedges than their North African counterparts – a situation which reversed in 1994 when the North African economies generally took over. In fact, after 1994, the investment wedges of North African economies dominated those of Sub-Saharan Africa and this was led by Algeria which recorded the highest investment wedge among all six economies, reflecting low investment in the country at variance with its relatively high productivity and low labour wedge. Furthermore, the investment wedge across all countries simultaneously recorded significant increases beginning from 1996, a situation which continued into 2013.

Fig. 7: Evolution of investment wedge with time across Africa's top 6 economies



3.7 Analysis and interpretation of wedges

The wedges computed above can be interpreted in several ways. Although the measured wedges are estimates of distortions which can emanate from taxes, I do not interpret them solely as taxes since distortions result not only from taxes but also from a few other sources which are not necessarily observable. Thus, the wedges can be thought of as distortions emanating from taxes and elsewhere. As such, labour distortions, or any other distortions for that matter, comprise different components, one of which is taxation. In this section, I interpret the estimated wedges in two ways. First, I compare the estimated wedges to the observed labour and capital taxes in each of the six African economies by superimposing the observed taxation alongside the wedges; second, I analyze the effects on output and input (labour – hours worked – and capital stock) when labour and capital wedges are reduced or eliminated. As these wedges are not assumed independent of one another, implementation of results from the analysis should be viewed with much caution since any strategy aimed at influencing certain wedges could impact other wedges, given that the wedges are not necessarily independent.

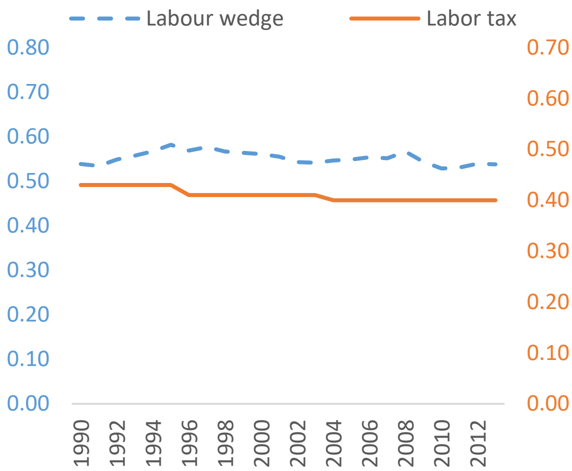
4. Superimposition of observed taxation and wedges

4.1 Labour taxes and labour wedges

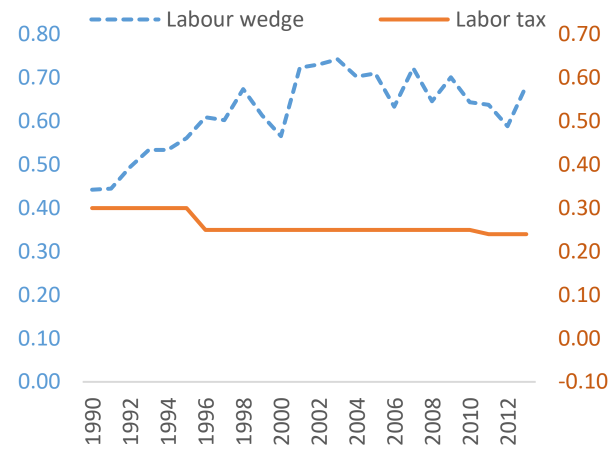
The wedges estimated above incorporate distortions and processes that are not necessarily observable. As a result, I compare the estimated wedges to observable taxes to get a sense of the magnitude of distortions emanating from unobservable factors. Available data and assumptions used to plot the implicit tax rates come from The World Bank, Trading Economics and African Economic Outlook (AEO) websites. The plots of labour taxes and wedges are in the figure below. In Nigeria and South Africa, the two leading economies in Africa, the labour wedge is consistently above the labour tax in all the sample periods, with Nigeria's economy recording the widest gap between labour wedge and labour tax.

Fig. 8: Comparison of observed labour taxes versus estimated labour wedges

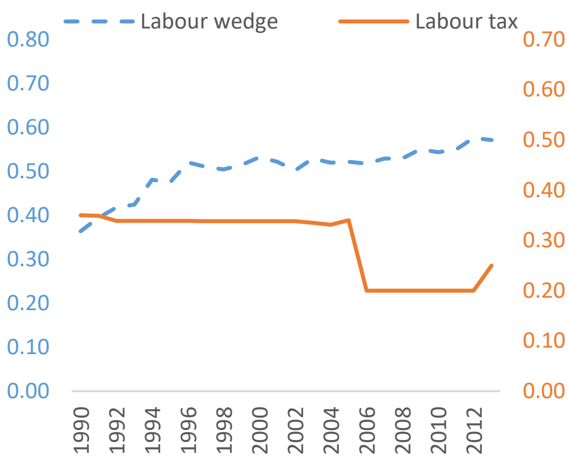
South Africa



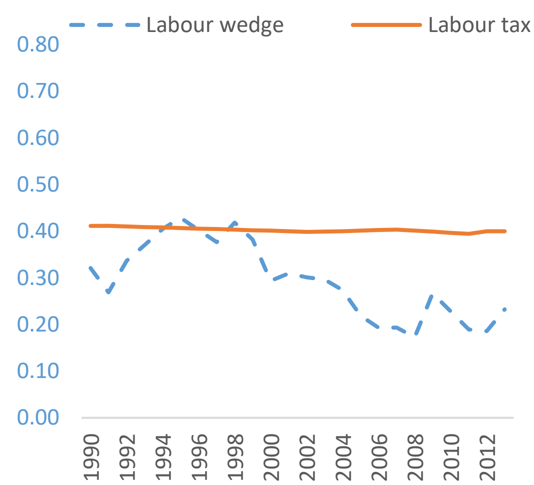
Nigeria



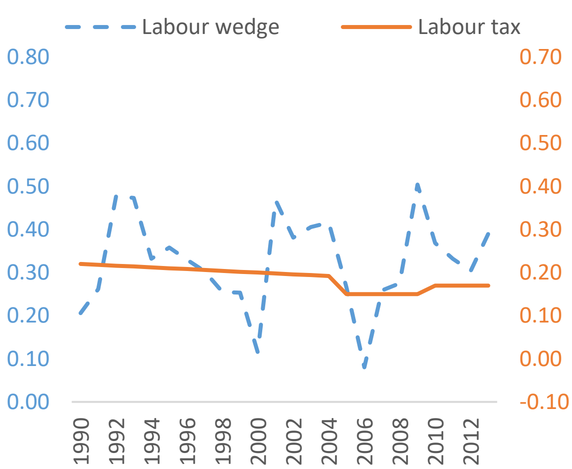
Egypt



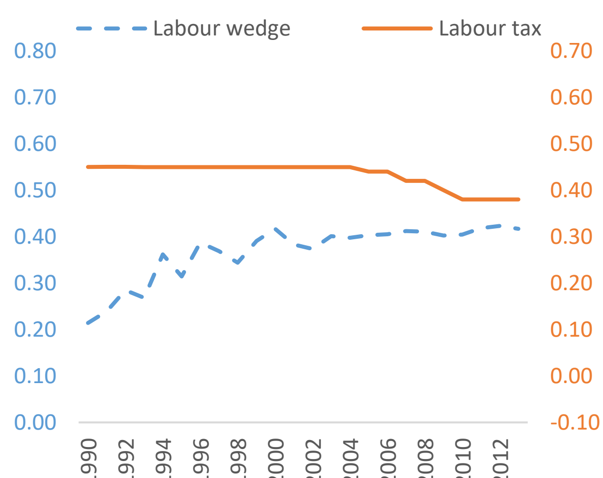
Algeria



Angola



Morocco



The economies of Egypt and Angola also behaved in a similar fashion, as the labour wedge is above the labour tax. However, while there is no overlap in the cases of Nigeria and South Africa, labour wedge and labour tax rate overlap at certain points in Egypt and Angola. Despite the overlap, the superimposed graphs for each of the four economies are an indication that apart from higher tax rates which are generally observable, there exist other factors or variables, different from taxes, which are not necessarily observable but are responsible for sizable labour market distortions in Nigeria, South Africa, Egypt and Angola. Without regard to region, the result indicates that the four economies largely demonstrate some congruence in this regard. North African economies like Egypt, exhibit a completely different behavior as their labour wedges are mostly below the labour taxes rates. This implies that in these economies, most labour market distortions come from taxes, which are observable, implying that the unobserved factors that generate labour market distortions in Algeria and Morocco are either negligible or non-existent.

This further implies that policies aimed at addressing much of the distortions in the labour markets of these countries can be channeled towards taxes, as it has been found that the distortions are mainly tax driven. Overall, Sub-Saharan Africa's top three economies largely demonstrate more congruence in labour market distortions than North African economies. While labour market distortions in all SSA's top 3 economies are significantly driven by both observable labor taxes and other exogenous factors which are not observable, the result is mixed for North Africa's top three economies. For Algeria and Morocco, the other top North African economies, distortions in labour market are skewed, in large parts, towards taxes, an indication that observable taxes control labour market distortions in these economies while other unobservable factors are either negligible or do not exist.

4.2 Capital taxes and investment wedges

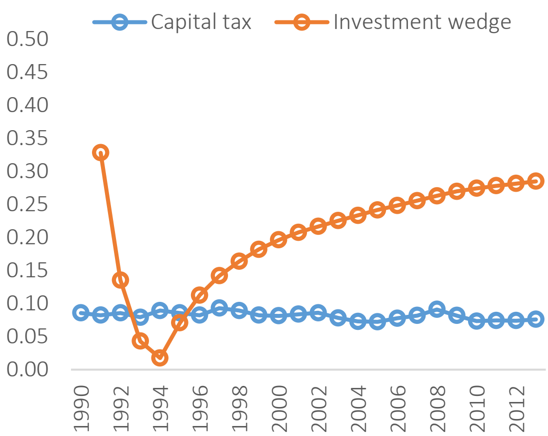
Like the comparison done between the identified labour taxes and labour wedges, I compare the capital taxes of each of the six economies to their investment wedges. The capital tax, which is observed, is taken as the tax imposed on the value of the return earned on capital stock, K. This represents the tax imposed on the capital income. The investment wedge, on the hand, is measured in proportion to the capital stock. Since the investment wedge is measured in proportion to the capital stock K, while the available/observable capital tax is reported on capital income, it is imperative to convert the observed capital tax to an equivalent capital tax that, like the investment wedge, is measured in proportion to the capital stock. Thus, following Konya (2013), I use the steady state relationship between the observed capital income tax rate and its capital tax equivalent (measured in proportion to the capital stock K) to convert the capital tax equivalent to the same base as the investment wedge. The conversation factor is given by

$$\frac{\bar{\tau}^{rk}}{\bar{\tau}^{k}} = \frac{\gamma/\beta(1-\bar{\tau}^{rk})}{\frac{\gamma}{\beta}-1+\delta},$$

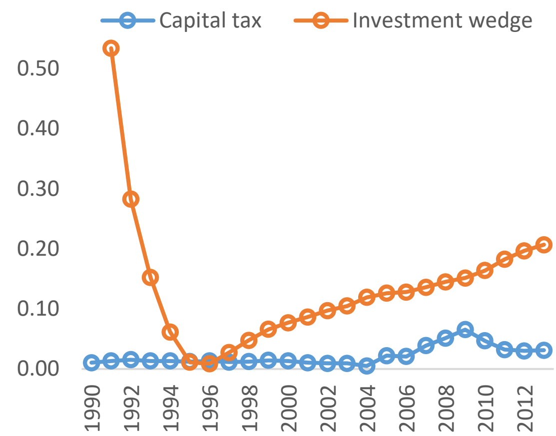
where $\bar{\tau}^{rk}$ is the observed capital income tax rate and $\bar{\tau}^{k}$ is its capital tax equivalent that bears the same base with the investment wedge. The graphs below show the derived capital tax rates and the investment wedges. The investment wedges and capital tax rates – both on regional basis and on country by country basis – are such that in none of the countries is the investment wedge close to the capital tax rates. The difference is significant in all the countries and most significant especially in North Africa's top 3 economies.

Fig 9: Observed versus estimated capital taxes and investment wedges across countries over time

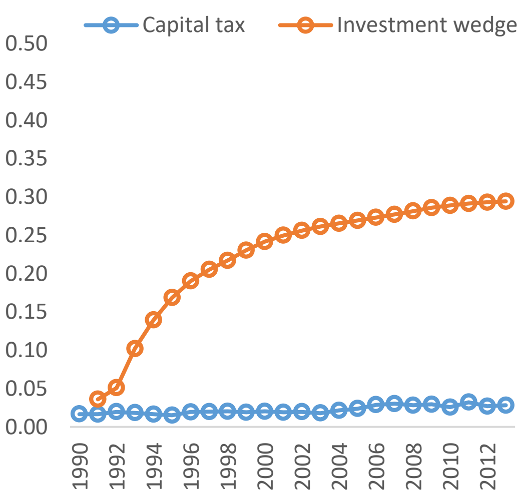
South Africa



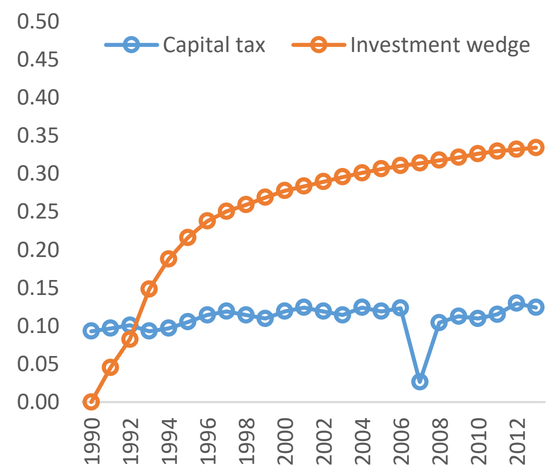
Nigeria



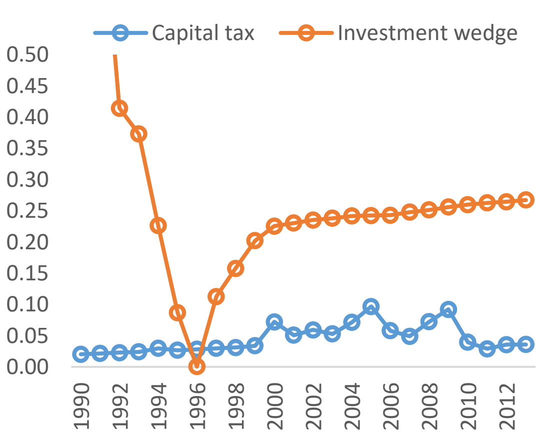
Egypt



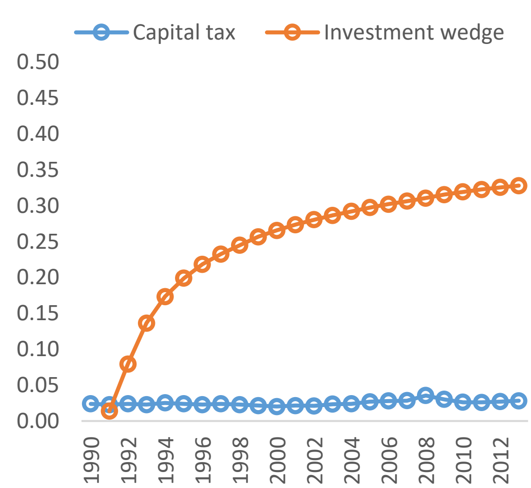
Algeria



Angola



Morocco



Thus, in all countries, capital taxation is not necessarily the most important reason for cross-country differences in investment efficiency as there are other unobservable factors, different from capital taxes, which result in distortions in investments and capital markets. These unobserved factors which distort investment and capital markets are relatively more pronounced among the North African economies compared to the sub-Saharan African economies. As such, capital taxation is a more important explanation for cross country differences in investment efficiency among sub-Saharan African Africa's top 3 economies than North Africa

5.0 How output and factor inputs react to reductions in capital and labour wedges

What happens to output and input when capital and labour wedges are reduced? In this section, I provide answers to this question by computing the impact of reducing the labour and capital wedges on output, hours worked and capital stock. To do this, I look at how the original wedges impact the steady state values of the main macroeconomic variables – output, hours worked and capital stock – and then compare this to how the main macroeconomic variables are impacted when the wedges are reduced or eliminated. Following Konya (2013), the steady state values for input (hours worked and capital stock per capita) and output, obtained from the efficiency, labour and investment wedge equations, at original wedge levels are given by

$$\bar{h} = \frac{(1-\bar{\tau}^h)(1-\alpha)}{(1-\bar{\tau}^h)(1-\alpha)+\frac{\chi\bar{c}}{\bar{y}}}, \qquad \frac{\bar{k}}{\bar{y}} = \frac{\alpha}{(1+\bar{\tau}^i)(1+r^*)+\delta-1}, \qquad \frac{\bar{c}}{\bar{y}} = 1-(n\gamma-1+\delta)\frac{\bar{k}}{\bar{y}}-\frac{\bar{g}}{\bar{y}}$$

$$\bar{k} = \left(A\frac{\bar{k}}{\bar{y}}\right)^{\frac{1}{1-\alpha}}\bar{h}\bar{s}, \quad \bar{y} = \frac{\bar{k}}{\bar{k}/\bar{y}}$$

Now, when labour wedge τ^h is reduced, what happens to steady state values of input and output? When investment wedgeτ^i is reduced, what happens to the steady state values of input and output? These are answered in the subsections below

5.1 Changes in steady state input and output due to reduction in labour and investment wedges

Let the proportional changes in output, hours worked and capital due to a reduction in labour wedge be $\frac{\bar{y}_{\tau^h}}{\bar{y}_{\tau^h{}_\Phi}}$, $\frac{\bar{h}_{\tau^h}}{\bar{h}_{\tau^h{}_\Phi}}$ and $\frac{\bar{k}_{\tau^h}}{\bar{k}_{\tau^h{}_\Phi}}$, where $\bar{y}_{\tau^h}$, $\bar{h}_{\tau^h}$ and $\bar{k}_{\tau^h}$ are the steady state output, hours worked and capital when the labour wedge τ^h_Φ is reduced to τ^h while $\bar{y}_{\tau^h{}_\Phi}$, $\bar{h}_{\tau^h{}_\Phi}$ and $\bar{k}_{\tau^h{}_\Phi}$ represent the steady state output at the original labour wedge τ^h_Φ where $\tau^h = \min_{\forall i} \mathbb{E}\ (\tau^h_i)$, that is the reduced labour wedge is taken as the minimum or smallest average wedge after the wedge data of each of the country i has been averaged. From the above steady state values, the proportional changes in output, hours worked and capital emanating from a reduction in labour wedge are given by

$$\frac{\bar{h}_{\tau^h}}{\bar{h}_{\tau^h{}_\Phi}} = \frac{1-\alpha+\frac{\frac{\chi\bar{c}}{\bar{y}}}{1-\bar{\tau}^h}}{1-\alpha+\frac{\frac{\chi\bar{c}}{\bar{y}}}{1-\bar{\tau}^h_\Phi}}, \qquad \frac{\bar{y}_{\tau^h}}{\bar{y}_{\tau^h{}_\Phi}} = \frac{\bar{h}_{\tau^h}}{\bar{h}_{\tau^h{}_\Phi}} = \frac{\bar{k}_{\tau^h}}{\bar{k}_{\tau^h{}_\Phi}}$$

This gives the changes in steady state values of input and output due to a reduction in labour wedge. The relationship shows that reducing the labour wedge leads to the same proportional changes in output, hours worked and capital stock because the capital-output ratio is independent of the labour wedge and the capital is a function of the capital-output ratio and hours worked while output is a function of capital which implies both capital and output are a function of capital-output ratio and hours worked. Thus, capital and output must be proportional to hours worked. For a reduction in investment wedge, notice that in steady state, $\frac{\bar{k}}{\bar{y}}$ is the only function of the investment wedge. Let $\frac{\bar{k}_{\tau^i}/\bar{y}_{\tau^i}}{\bar{k}/\bar{y}}$, $\frac{\bar{h}_{\tau^i}}{\bar{h}}$, $\frac{\bar{k}_{\tau^i}}{\bar{k}}$ and $\frac{\bar{y}_{\tau^i}}{\bar{y}}$ represent proportional changes in capital-output ratio, hours worked, capital stock and output. As in the case for a reduction in labour wedge, the reduced investment wedge τ_u^i is taken as the smallest average investment wedge among all the six economies considered. Using the steady state conditions, the proportional changes due to a reduction in investment wedge are as follows

$$\frac{\bar{k}_{\tau^i}/\bar{y}_{\tau^i}}{\bar{k}/\bar{y}} = \frac{(1+\bar{\tau}_u^i)(1+r^*)+\delta-1}{(1+\bar{\tau}^i)(1+r^*)+\delta-1}, \quad \frac{\bar{h}_{\tau^i}}{\bar{h}} = \frac{(1-\bar{\tau}^h)(1-\alpha)+\bar{c}\ \ /\bar{y}}{(1-\bar{\tau}^h)(1-\alpha)+\bar{c}_{\tau^i}/\bar{y}_{\tau^i}}$$

$$\bar{h}_{\tau^i} = (1-\bar{\tau}^h)(1-\alpha)+\frac{\bar{c}}{\bar{y}}, \qquad \frac{\bar{k}_{\tau^i}}{\bar{k}} = \left(\frac{\bar{k}_{\tau^i}/\bar{y}_{\tau^i}}{\bar{k}/\bar{y}}\right)^{\frac{1}{1-\alpha}} \frac{\bar{h}_{\tau^i}}{\bar{h}}$$

$$\frac{\bar{y}_{\tau^i}}{\bar{y}} = \left(\frac{\bar{k}_{\tau^i}/\bar{y}_{\tau^i}}{\bar{k}/\bar{y}}\right)^{\frac{\alpha}{1-\alpha}} \frac{\bar{h}_{\tau^i}}{\bar{h}}, \qquad \frac{\bar{c}_{\tau^i}}{\bar{c}} = \frac{\bar{c}_{\tau^i}/\bar{y}_{\tau^i}}{\bar{c}/\bar{y}}\frac{\bar{y}_{\tau^i}}{\bar{y}}$$

When both labour and investment wedges are simultaneously reduced, the proportional changes in output and input factors are given as a combination of the case when labour wedge alone is reduced and when investment wedge alone is reduced. When these two cases are combined, the proportion changes in input and output are given by

$$\frac{\bar{k}_{\tau^i\tau^h}/\bar{y}_{\tau^i\tau^h}}{\bar{k}/\bar{y}} = \frac{(1+\bar{\tau}_u^i)(1+r^*)+\delta-1}{(1+\bar{\tau}^i)(1+r^*)+\delta-1}, \quad \frac{\bar{h}_{\tau^i\tau^h}}{\bar{h}} = \frac{1-\alpha+\frac{\frac{\chi\bar{c}}{\bar{y}}}{1-\bar{\tau}^h}}{1-\alpha+\frac{\frac{\chi\bar{c}_{\tau^i\tau^h}}{\bar{y}_{\tau^i\tau^h}}}{1-\bar{\tau}_{\Phi}^h}}$$

$$\frac{\bar{k}_{\tau^i\tau^h}}{\bar{k}} = \left(\frac{\bar{k}_{\tau^i\tau^h}/\bar{y}_{\tau^i\tau^h}}{\bar{k}/\bar{y}}\right)^{\frac{1}{1-\alpha}} \frac{\bar{h}_{\tau^i\tau^h}}{\bar{h}}, \quad \frac{\bar{y}_{\tau^i\tau^h}}{\bar{y}} = \left(\frac{\bar{k}_{\tau^i\tau^h}/\bar{y}_{\tau^i\tau^h}}{\bar{k}/\bar{y}}\right)^{\frac{\alpha}{1-\alpha}} \frac{\bar{h}_{\tau^i\tau^h}}{\bar{h}}, \quad \frac{\bar{c}_{\tau^i\tau^h}}{\bar{c}} = \frac{\bar{c}_{\tau^i\tau^h}/\bar{y}_{\tau^i\tau^h}}{\bar{c}/\bar{y}}\frac{\bar{y}_{\tau^i\tau^h}}{\bar{y}}$$

The proportional changes in output and input factors when either investment wedge is reduced or both wedges are simultaneously reduced are different from the proportional changes in the output and input factors when labour wedge alone is reduced because the capital-output ratio in the case of reduced labour wedge is independent of the labour wedge and thus output and capital are proportional to hours worked. This implies a reduction in labour wedge leads to the same proportional changes in output, hours worked and capital stock. As such, their proportional changes equate. However, when either investment wedge is reduced or both investment and labour wedges are simultaneously reduced, the capital-output ratio is not independent of the investment wedge; in fact, it is a function of the investment wedge. Consequently, a reduction in either investment wedge or both investment wedge and labour wedge does not lead to the same proportional changes in output, hours worked and capital stock because output and capital are not proportional to hours worked alone but also to the capital-output ratio which is itself a function of the reduced investment wedge.

The reduced values for labour and investment wedges are set to the minimum (least) average values when the wedges are averaged for each country. Following this rule, in the case of labour wedge, the reduced value (i.e. the minimum average value across countries) corresponds to the average labour wedge for Algeria and this equals 0.29. For investment wedge, the smallest average investment wedge is 0.13 and corresponds to Nigeria's average investment wedge. Thus, the value of the reduced investment wedge equals 0.13. In instances where either the reduced labour or investment wedge corresponds to the average of a given country, the proportional changes in the output and input factors in that country are each equal to 1. However, when labour and investment wedges are both simultaneously reduced, none of the proportional changes in output and input factors is 1 because the proportional changes are not driven by only one wedge at a time but simultaneously driven by both wedges at the same time.

The table below presents the results of the computation of the proportional changes when A) labour wedge alone is reduced, in which case the reduced labour wedge equates the average labour wedge of Algeria; B) investment wedge alone is reduced, in which case the reduced investment wedge equates the average investment wedge of Nigeria; and C) labour and investment wedge are both simultaneously reduced – in which case labour wedge equates Algerian average and investment wedge equates Nigerian average.

Table 2: Sensitivity of input factors and output per capita to reduction in labour and investment wedges

	Nigeria	**South Africa**	**Egypt**	**Algeria**	**Angola**	**Morocco**
			A –reduced labour wedge			
Output	1.74	1.49	1.36	1.00	1.04	1.10
Hours	1.74	1.49	1.36	1.00	1.04	1.10
Capital	1.74	1.49	1.36	1.00	1.04	1.10
			B –reduced investment wedge			
Output	1.00	1.21	1.22	1.13	1.13	1.16
Hours	1.00	1.07	1.04	1.10	1.09	1.03
Capital	1.00	1.23	1.25	1.17	1.16	1.19
			C –reduced investment and labour wedge			
Output	1.74	1.68	1.59	1.26	1.29	1.36
Hours	1.74	1.33	1.29	1.11	1.13	1.17
Capital	1.74	1.70	1.63	1.30	1.32	1.39

Note that the numbers can be written as (1+y), where y represents the percentage increase or decrease because of changes in wedges.

The changes in output, hours worked and capital following a reduction in at least one of the wedges are shown in sections A, B and C of Table 2 above. Section A presents the results obtained when each country's labour wedge is reduced to the minimum average labour wedge without altering the investment wedge, where the least average labour wedge is that of Algeria which equals 0.29. The most significant gain from a reduction in labour wedge is seen in Nigeria followed by South Africa and Egypt. In Nigeria, output, hours worked and capital each increased by 74%, while in South Africa and Egypt they each increased by 49% and 36% respectively, following a decline in labour wedge. Angola and Morocco also recorded gains in output, hours worked and capital following a reduction in wedges, but the gains are quite modest at around 4% for Angola and 10% for Morocco. The result shows that Nigeria, South Africa and Egypt appear to be more likely to benefit the most from policies aimed at reducing or eliminating labour wedge while Angola and Morocco are least likely to benefit from such policies.

The changes in output, hours and capital when investment wedge is reduced to the least average investment wedge, which is the average investment wedge for Nigeria, are presented in Section B. Reducing investment wedge would lead to similar moderate gains in the per capita output for Angola and Algeria. This is especially noteworthy given the similarity in the magnitude of the two countries' average investment wedge. South Africa, Egypt and Morocco are the most significant beneficiaries of a reduction in investment wedge, even though their average investment wedge is in the domain of Angola and Algeria that recorded a significantly lower gain from a reduction in wedges.

The last section, Section C, highlights that the six economies would benefit significantly more if labour and capital market wedges were both simultaneously, rather than individually, reduced to their minimum average levels. This means that if the average labour wedge for each country equates that of Algeria while the average investment wedge equates that of Nigeria, then each country would achieve the highest payoff in terms of a significant increase in per capita output, hours worked and capital. The gain would be largest for Nigeria, at around 74% for per capita output, and least for Algeria at more than 26% for per capita output. On a regional basis, compared to North African economies, Sub-Saharan African economies would record more significant gains in per capita output, on average, from a simultaneous reduction in labour and investment wedges.

Thus, even when all countries employ labor and capital at more efficient levels, i.e. levels where wedges or distortions are minimized, North Africa would still, on average, diverge from Sub-Saharan Africa. For some Sub-Saharan African countries, this divergence in income levels reflects stronger productivity (South Africa) while for others it reflects lower investment wedge (Nigeria). For some North African countries, the weaker additions to per capita output reflects higher investment wedge (Morocco) and lower productivity (Algeria). Thus, when comparing income levels in Africa, productivity explains some, but not all, of the important differences in income levels. In order words, differences in average GDP per capita of North Africa's top economies relative to Sub-Saharan Africa is not fully explained by the efficiency wedge.

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6. Conclusion

Using development accounting methodology in the spirit of Konya (2013) and Caselli (2005), this paper documents the importance of productivity, labour and investment distortions in explaining income differences across Africa's largest economies. It computes and analyzes capital and labor market distortions in Sub-Saharan Africa's and North Africa's three largest economies. The main findings are as follows. First, sizable wedges exist in Africa's labour and capital markets, at least for the African economies analyzed. Second, significant efficiency gains and improvement in income levels are possible in both country groups (North Africa (NA) and Sub-Saharan Africa (SSA)) when there is a simultaneous decline in labour and investment wedges to their minimum levels. The results show that the gains from a simultaneous reduction in labour and investment wedges are generally larger for SSA than NA economies. Third, the difference in gains is due not only to differences in productivity but can also be explained by the differences in labor and investment wedges across Africa.

Since a simultaneous reduction in capital and labor market distortions leads to significant gains in income within SSA and NA, it follows that capital and labour market distortions are important for understanding differences in income levels within SSA and NA. This implies that policies to bridge the income gap in Africa should be focused on reducing distortions in labour and capital markets in addition to improving productivity. For future research, further analysis is needed to develop a more structural approach to aid detailed policy recommendations on reducing unfavorable wedges. Such an analysis will be more rigorous, and it will require not only an empirical setup as presented in this paper, but also a detailed structural framework. Such an exercise is beyond the scope of the empirical analysis documented in this paper. Nonetheless, results presented in this paper can serve as a baseline scenario for more elaborate and targeted studies that are firmly rooted in theoretical considerations.

Although the finding that productivity improvement and declines in investment and labour wedges are benign for income levels, appears to have some support in the BRIC economies (see Chakraborty and Otsu (2013)) as it does in the African economies analyzed in this paper, one must be cautious of premature generalizations. On this note, further analysis is needed to explore whether this finding is a coincidence or whether it is a characteristic or feature of Africa, the BRIC and other developing economies. I leave this interesting exercise for future research.

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