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# Examining the Efficiency, Labor and Investment Wedges in Africa

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**ABSTRACT**

Cross-country differences in per capita income are known to be high among Sub-Saharan Africa's economies (Nigeria, South Africa and Angola), and North Africa's economies (Egypt, Algeria and Morocco). The aim of this paper is hence to examine the phenomenon of income discrepancies in Africa for periods 1990-2013 and then apply the combined methodologies of Development Accounting (Caselli (2005) and Konya (2013)) as well as Business Cycle Accounting (Chari, Kehoe and McGrattan (2007)) in a standard neoclassical, small open economy model. Our main finding is that although efficiency wedge plays an important role in explaining income differences in Africa, labor wedge and investment wedge are also important for understanding income differences in these economies.

**Keywords**: Business Cycle Accounting, Development Accounting, Labor Wedge, Efficiency Wedge, Investment Wedge

**JEL Classification**: E13, N17, O11

# Afrika'da Verimlilik, İşgücü ve Yatırım Kamalarının İncelenmesi

**ÖZ**

Kişi başına gelirdeki ülkelerarası farklılıklar Sahra altı Afrika ekonomileri (Nijerya, Güney Afrika ve Angola) ve Kuzey Afrika ekonomileri (Mısır, Cezayir ve Fas) arasında yüksek olduğu bilinmektedir. Bu makalenin amacı, Afrika'daki 1990-2013 dönemi için gelir farklılıkları olgusunu incelemek ve sonrasında standart neoklasik, küçük açık ekonomi modeline İş Döngüsü Muhasebesi'nin (Chari, Kehoe and McGrattan (2007)) yanı sıra Kalkınma Muhasebesi'nin (Caselli (2005) ve Konya (2013)) birleşik metodolojilerine başvurmaktır. Ulaşılan temel sonuç, verimlilik kaması Afrika'daki gelir farklılıklarını açıklamada önemli bir rol oynamasına rağmen işgücü ve yatırım kamalarının da bu ekonomilerdeki gelir farklılıklarını anlamada önemli olduğu gözükmektedir.

**Anahtar Kelimeler**: İş Çevrimi Muhasebesi, Kalkınma Muhasebesi, Işgücü Kaması, Verimlilik Kaması, Yatırım Kaması

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## 1. INTRODUCTION

An important part of income in African economies is produced from the export of commodities. Although the similarity among these economies, there are significant differences in income levels which are known to be high. Though the income gap appears to be less pronounced for some countries, the difference in income levels among these economies nonetheless remains evident. It is more noticeable within the regions starting from the 2000s and no work that we are aware of has attempted to figure out the sources of these differences from the context of development accounting and business cycle accounting applying the neoclassical growth model. In this paper, we look for the role of factor distortions in accounting for the observed cross-country income dispersion among African economies by employing the method of development accounting, Caselli (2005) and Konya (2013) as well as business cycle accounting, Charry, Kehoe and McGrattan (2007) in a standard neoclassical, small open economy model.

In the literature, Caselli (2005) examines efficiency wedge for representative countries across six continents – Europe, Asia, North America, Africa, South America and Australia. He finds that efficiency wedge is the most important source of underdevelopment across the world. However, the literature concentrated on less on Africa and provides a little focused view on the labor and capital wedges that characterize the situation in Africa's largest economies. This creates a gap in the literature that needs to be filled, especially given the differences in income levels observed across many African countries. In the other seminal work, Chari, Kehoe and McGrattan (2007) figure out that wedge does not play a prominent role in the US during the great depression. Moreover, Christiano and Davis (2006) fault their findings by identifying two major procedural issues with their work. The first issue is that the procedure employed to compute the wedge has a big effect on the data. The other one is that the fact that wedges are associated to each other, as documented in Curdia and Reis (2010), makes it difficult to identify the partial impact of any one individual distortion. These issues drive the empirical method of wedge estimation as in Konya (2013) on which the current paper is built.

The approach employed in this paper closely follows Caselli (2005) and Konya (2013); the standard business cycle accounting of Chari, Kehoe and McGrattan (2007); and assumes a small open economy model setting. We use the standard neoclassical growth model to provide relationships on macroeconomic variables via the production function, labor market equilibrium, resource constraint and Euler equation of consumption and investment. We employ non-filtered data to identify the distortions. As a result, it becomes possible to perform cross-country comparisons of distortions as well as the time series changes within a country. By using data between 1990 and 2013 for Africa's top six economies – Nigeria, South Africa, Egypt, Algeria, Angola and Morocco – we perform two different comparisons. First, we form two distinct groups with the three Sub-Saharan African economies and the three North-African economies. Following this, we examine the possibility of heterogeneity in labor and capital market outcomes within each group, given that countries in each group are in a similar economic region. Second, we analyze how capital and labor market distortions illustrate income differences among Sub-Saharan and North African economies.

We find that all six African economies benefit much more and experience significant increases in per capita output if labor and capital wedges are simultaneously reduced to their minimum levels. In such a 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 show the most significant gains, on average, from a joint reduction in labor and capital wedges compared to North African economies. Angola and Morocco also record gains in output, hours worked and capital after a reduction in labor 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. Overall, the paper argues that efficiency and investment distortions, as well as labor distortions, explain income differences in Sub-Saharan Africa and North Africa, and are also important for understanding income differences within both regions. Also, labor and capital taxes are connected to the wedges in some but not all countries, and the significant unexplained components remain.

Gourinchas and Jeanne (2006), in their calibrated small open economy model, find that capital market liberalization is equal to a decrease in investment distortions, leads to significant output gains but cannot produce large cross-country income differences. Caselli and Feyrer (2007) find that returns from investing in capital is no higher in poor economies than in rich economies, 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 labor wedge explains cross-country disparities in labor supply in OECD economies, an explanation which can also explain observed differences in income levels but cannot be generalized to Africa. 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. We figure out 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 with reductions in capital and labor market wedges being an important channel.

The remainder of the paper is organized as follows. In Section 2, we present the theoretical framework of the model. In Section 3, we describe the data, explain the empirical procedure and present the results. In Section 4, we provide some analyses and interpretation of the estimated wedges as well as discuss how income and factor input behave with changes in the wedges. Section 5 concludes the paper.

## 2. THE MODEL

In this section, we describe the general equilibrium model presented here follows Otsu (2010) and Konya (2013). The model is an open-economy, one-sector neoclassical growth model populated by infinitely lived households. They obtain income from providing labour and capital to firms, gaining interests on bonds purchased and paying interests on bonds issued. The model includes productivity growth, capital, labour supply and the bonds at an exogenously determined world real interest rate.

### 2.1. Households

The household receives utility from consumption $C_t$ and disutility supplying labour $h_t$. After drawing income from providing labour and capital to firms and gaining 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

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

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

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

where $\mathbb{E}_t$ is the expectation operator conditional on information at time $t$, $\beta$ is the discount factor and $N_t$ is the population size. $s_t$ is human capital, $\left(1-\tau_t^h\right) W_t N_t h_t s_t$ 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. 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. As a result, when household maximizes utility, the associated optimization problem is given by

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

subject to the budget constraint

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

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

where $K_t$ denotes the capital stock, $B_{t+1}$ next period bond holdings and $r_t^*$ is the world real interest rate. Human capital is specified, which yields an effective labour supply given by $N_t h_t s_t$. We also include into the optimization wedges $\tau_t^h$, $r_t^k$ and $\tau_t^b$, representing labour wedge, capital wedge and borrowing wedge respectively.

### 2.1.1. Optimality Conditions

The value function related to the optimization problem as follows

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

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

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

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

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

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

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

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

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 allows the Capita-Euler equation as follows

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

$$\Rightarrow\quad (1+\tau_t^k)\frac{N_t}{C_t}$$

$$=\beta\mathbb{E}_t\left[(1-\delta+r_{t+1}^k)\frac{N_{t+1}}{C_{t+1}}\right] \qquad (1.7)$$

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

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

Thus, the bond equation is given by

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

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 allows the Bond-Euler equation as follows

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

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

Thus, the optimality conditions linking the wedges are as follows

$$\begin{cases} \dfrac{\chi C_t}{1-h_t}=N_t(1-\tau_t^h)W_t s_t \\ (1+\tau_t^k)\dfrac{N_t}{C_t}=\beta\mathbb{E}_t\left[(1-\delta+r_{t+1}^k)\dfrac{N_{t+1}}{C_{t+1}}\right] \\ \dfrac{N_t}{C_t}=(1+\tau_t^b)\beta(1+r_t^*)\mathbb{E}_t\left[\dfrac{N_{t+1}}{C_{t+1}}\right] \end{cases} \tag{1.10}$$

The three equations represent the intertemporal conditions describing labor supply, capital investment and purchase/sale of bonds. The other conditions are linked by a common factor $N_{t+1}/C_{t+1}$ and, under certain cases, can be associated to have the arbitrage case that explains capital investment in an economy. 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, $\mathbb{E}_t\left[(1-\delta+r_{t+1}^k)\frac{N_{t+1}}{C_{t+1}}\right]=\mathbb{E}_t\left[(1-\delta+r_{t+1}^k)\right]\mathbb{E}_t\left[\frac{N_{t+1}}{C_{t+1}}\right]$. Under this assumption, the second optimality condition becomes

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

and combining with the third optimality condition yields

$$(1+\tau_t^k)(1+\tau_t^b)(1+r_t^*)=\mathbb{E}_t\left[(1-\delta+r_{t+1}^k)\right] \tag{1.11}$$

The above equation explains 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 $r_t^*$. Thus, $(1+\tau_t^i)(1+r_t^*)=\mathbb{E}_t\left[(1-\delta+r_{t+1}^k)\right]$, where $1+\tau_t^i=(1+\tau_t^k)(1+\tau_t^b)$ is the investment wedge – a combination of wedges emanating from the two investing activities.

### 2.2. Firms and Production Technologies

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

$$Y_t=A_tK_t^{\alpha}(\Gamma_tN_th_ts_t)^{1-\alpha} \tag{1.12}$$

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

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

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 $\pi_t = Y_t - W_t N_t h_t s_t - r_t^k K_t$ and firms optimize profit by selecting the appropriate amount of labour and capital which solves the optimization problem

$$\max_{\{h_t,\ K_t\}} \pi_t = Y_t - W_t N_t h_t s_t - r_t^k K_t$$

subject to

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

which reduces to

$$\max_{\{h_t, K_t\}} \pi_t = A_t K_t^{\alpha} (\Gamma_t N_t h_t s_t)^{1-\alpha} \quad - W_t N_t h_t s_t - r_t^k K_t$$

### 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 - $r_t^k$

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

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

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

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

### 2.3. The Wedges

In this paper, we consider three 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. The labour wedge 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 effect on labour availability and then output and income level. The investment wedge constitutes distortions in the capital/investment market.

The wedges are obtained by combining the household and firm equations. Thus, eliminating $w_t$ and $r_t^k$ between household and firm equations and solving for $A_t$ from the Cobb Douglas technology relating input to output allows expressions for the labour, investment and efficiency wedges as

$$1-\tau_t^h=\frac{\chi C_t}{(1-\alpha)Y_t}\frac{h_t}{(1-h_t)} \tag{1.13}$$

$$1+\tau_t^i=\frac{1}{1+r_t^*}\left[\mathbb{E}_t\left(\alpha\frac{Y_{t+1}}{K_{t+1}}+1-\delta\right)\right] \tag{1.14}$$

$$A_t=\frac{Y_t}{[K_t^\alpha((1+\gamma)^t\Gamma_0 N_t h_t s_t)^{1-\alpha}]} \tag{1.15}$$

These expressions allow us to interpret these three wedges. The labour wedge is occurred by hours worked and the consumption-output ratio. The efficiency wedge contains 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.

## 3. EMPIRICAL ANALYSIS

### 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 collected from these sources for six countries for periods 1990 – 2013 as dictated by data availability. The data contains real GDP per capita in constant dollars, consumption and investment as a fraction of output, and total population size. Hours worked data come from Laborsta where such data are unavailable, we 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. We then proxy the missing data using corresponding data from these countries. For each country in this paper, we assume there are 6 work days in a week and 16 hours of work per day. This yields a weekly time endowment of 6x16=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, we 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), we 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

$$s_t=\sum_{i=1}^{3}\vartheta_i\, e^{\varphi(\sigma_i)} \tag{1.16}$$

where $\vartheta_i$ is the rate of employment associated with category $i$, with $i$ being the level of educational attainment. In this paper, we consider three categories of educational attainment according to the UNESCO ISCED 1997 classification system which partitions educational attainment into 3 segments. Caselli (2005) identifies $\varphi(\sigma_i)$ as a piecewise linear function defined as

$$\varphi(\sigma_i) = \begin{cases} 0.134\,.\,\sigma_i \ \text{ if } \sigma_i \leq 4 \\ 0.134\,.\,4 + 0.101\,.\,(\sigma_i - 4) \ \text{ if } 4 < \sigma_i \leq 8 \\ 0.134\,.\,4 + 0.101\,.\,4 + 0.068\,(\sigma_i - 8) \text{ if } \sigma_i > 8 \end{cases} \tag{1.17}$$

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 collected from the World Bank. Actual employment rates for each educational category are not available, so we use the assumption that higher human capital/educational attainment attracts higher employment prospect and hence higher employment rates for each country.

### 3.2. Calibration

Here, we 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 $\beta$. As a result, the discount factor is not required for computing the wedges. To calibrate $\gamma$, we follow Konya (2013) and find the average growth rate of US real GDP per capita between 1990 and 2013. This produces $\gamma$=0.036 or a gross growth $(1+\gamma) = 1.036$. Any productivity growth above this rate for a country is obtained by the efficiency wedge. The reason for using US data is that the parameters are assumed to be common across the economies 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 capital share as in Valentinyi and Herrendorf (2008) and, following Caselli (2005), this value is common across countries. Meanwhile, the calibrated depreciation rate from the capital accumulation equation in steady state is $\delta = 0.04$. This value is obtained as the same for all the economies considered. Finally, the importance of leisure in utility, $\chi$, is computed from the labour steady state equation which is given by

$$\chi = \left(1 - \bar{\tau}_t^h\right) \frac{(1-\alpha)}{\frac{\bar{C}}{\bar{Y}}} \frac{\left(1-\bar{h}\right)}{\bar{h}} \tag{1.18}$$

where $\bar{C}/\bar{Y} = 0.6$ is the steady state consumption-output ratio obtained as the pooled sample average of South Africa, Angola and Algeria. To compute $\chi$, we 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 we 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 for these economies are available within the period of analysis. In order to address the unavailability of $K_0$ in the baseline estimations, we follow Caselli (2005) and assume that the initial capital stock $K_0$ grows at a steady state, 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

$$K_0 = \frac{I_0}{n\gamma - 1 + \delta} \quad (1.19)$$

The capital-output ratios generated for the six countries using this assumption 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 showed a largely steady increase between 1990 – 2013, an indication of a steady investment in capital stock as these countries on average showed 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.

### 3.4. The Efficiency Wedge

We obtained the efficiency wedge associated with Cobb-Douglas technology. Thus, to compute this wedge, we 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. For the efficiency wedge, we follow the method of Konya (2013) and remove the trend growth from the Solow residual by following below

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

The Solow residual at time $t$ is given by $SR_t = A_t X_t^{1-\alpha}$. It combines the efficiency wedge $A_t$ and labour augmenting productivity growth $X_t$.

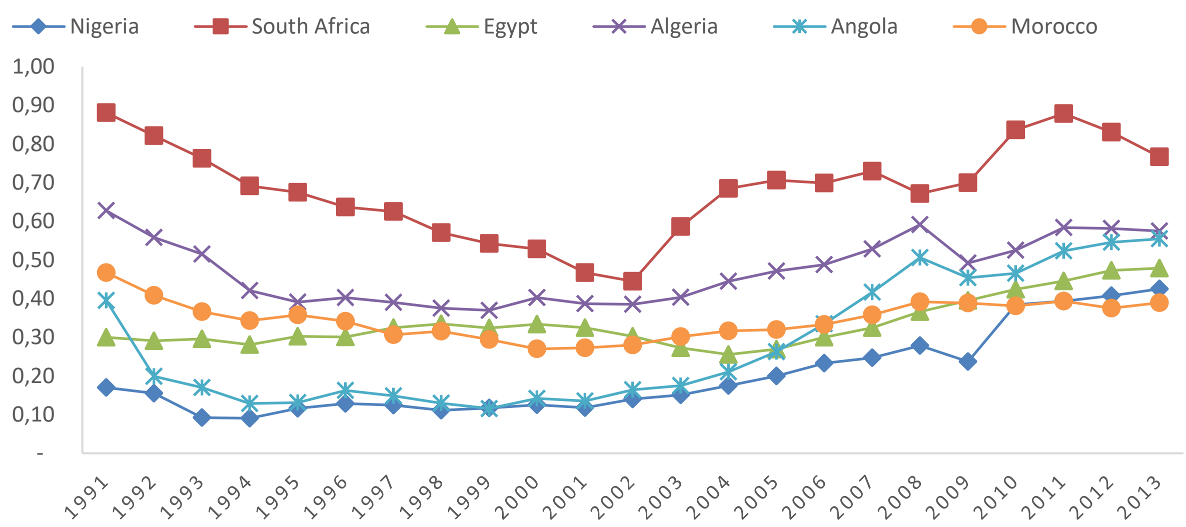


**Figure 1:** Efficiency Wedge Excluding Common Trend Productivity Growth

The figure 1 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 showed an upward trend until 2007 and declined considerably over the 2008-2009 financial crisis. This pattern is relatively more conclusive in Nigeria, Angola and Algeria that rely on crude oil as their main source of foreign earnings.

By and large, all North African economies display a higher convergence, especially Egypt and Morocco, compared to Sub-Saharan African economies. Also, North African economies showed 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 three North African economies showed rapid productivity declines from 1990. Egypt, the largest economy in the North Africa region, started 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 started experiencing rapid productivity growth without breaks. 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.

### 3.5. The Labour Wedge

The figure 2 shows the logarithm of labour wedge for the six countries under consideration. For most of these countries, labour wedge was high. Also, 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 Algeria, labour hours raised from 1990 to 1995. However, labour wedge began declining steadily later, i.e. in 2000. Moreover, consumption-output ratio declined beginning from 1998 but the investment rate, though declined until 1997, picked up in 1998 and showed 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.

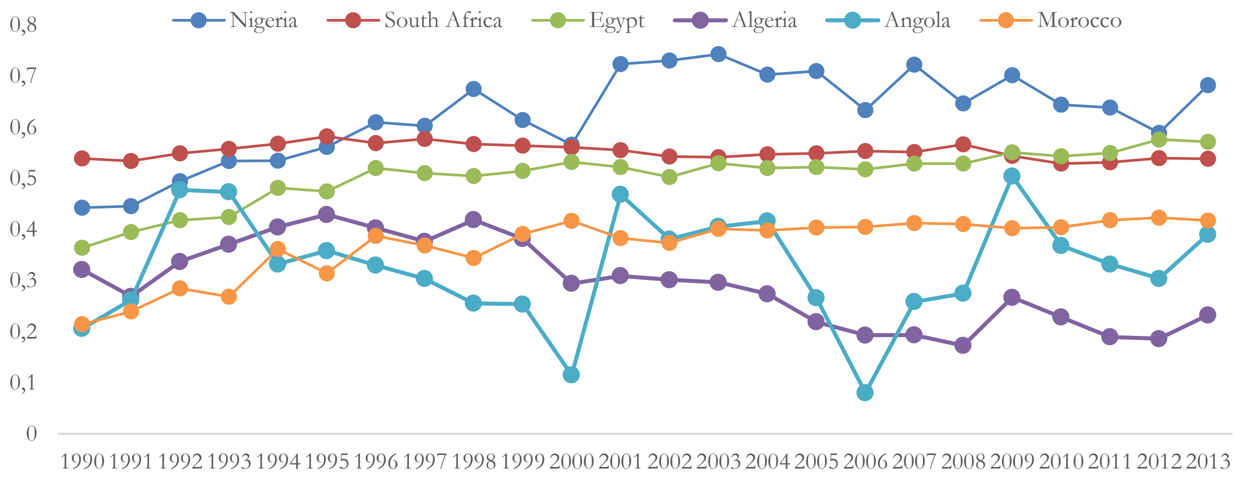


**Figure 2:** Evolution of Labour Wedge with Time Across Africa's Top 6 Economies

### 3.6. The Investment Wedge

The investment wedges for the set of six countries are displayed in the figure 3. We find 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. Indeed, after 1994, the investment wedges of North African economies influenced over those of Sub-Saharan Africa and this was led by Algeria which showed the highest investment wedge among these countries, showing low investment at variance with its relatively high productivity and low labour wedge. Moreover, it simultaneously showed significant increases across all countries beginning from 1996, a situation which continued into 2013.

## 4. ANALYSES AND INTERPRETATION OF WEDGES

The wedges computed can be interpreted in a few ways. Although the measured wedges are estimates of distortions which can emanate from taxes, we do not express them only as taxes since distortions result not only from taxes but also from a few other sources which are not naturally observable. Hence, the wedges can be thought of as distortions emerging 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, we interpret the estimated wedges in two ways. First, we 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, we analyze the effects on output and input (labour – hours worked – and capital stock) when labour and capital wedges are reduced or eliminated.

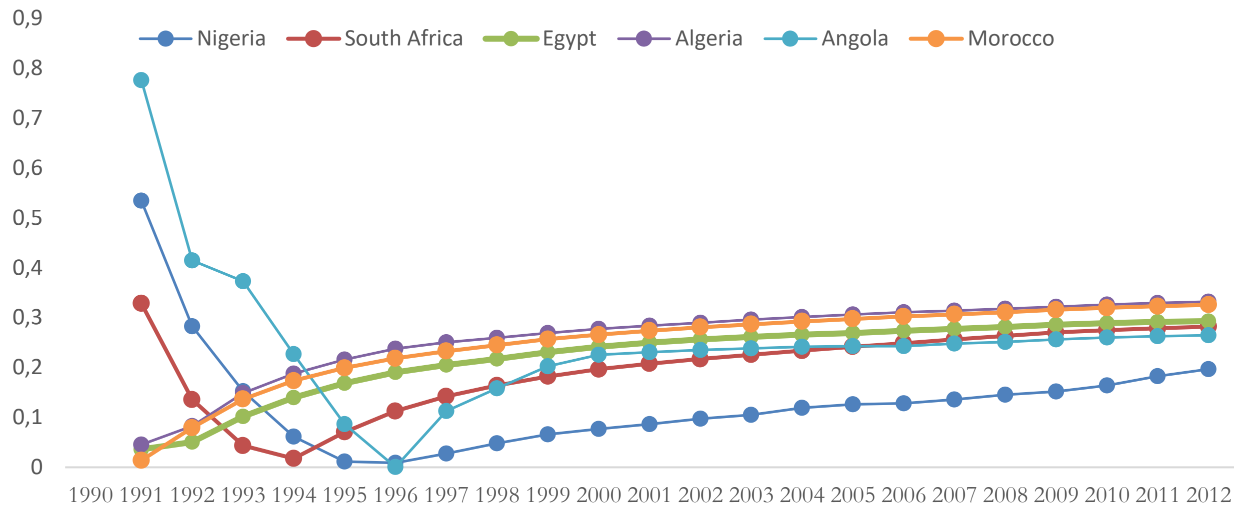


**Figure 3:** Evolution of Investment Wedge with Time Across Africa's Top 6 Economies

### 4.1. Labour Taxes and Labour Wedges

The wedges estimated incorporate distortions and processes that are not naturally observable. Consequently, we compare the estimated wedges to observable taxes to have a sense of the magnitude of distortions emerging from unobservable factors. Available data and assumptions used to plot the implicit tax rates is obtained from The World Bank, Trading Economics and African Economic Outlook (AEO) websites. The plots of labour taxes and wedges are in the figure 4 in appendix. In Nigeria and South Africa, the labour wedge is consistently above the labour tax in all the sample periods, with Nigeria's economy showing the widest gap between labour wedge and labour tax.

In addition, the economies of Egypt and Angola showed in a similar fashion, as the labour wedge is above the labour tax. On the other hand, while there is no overlap in the cases of Nigeria and South Africa, labour wedge and labour tax rate shows an 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 countries such as Egypt, shows 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. Overall, Sub-Saharan Africa's top three economies largely demonstrate more congruence in labour market distortions than North African economies.

### 4.2. Capital Taxes and Investment Wedges

Like the comparison done between the identified labour taxes and labour wedges, we 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 is the tax imposed on the capital income. However, the investment wedge is calculated in ratio to the capital stock. Since it is calculated in ratio 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 calculated in ratio to the capital stock. Thus, following Konya (2013), we use the steady state relationship between capital income tax rate and its capital tax equivalent which can be calculated in ratio to the capital stock K to convert the capital tax equivalent to the similar ground 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 capital income tax rate and $\bar{\tau}^{k}$ is its capital tax equivalent that bears the same base with the investment wedge. Figure 5 in appendix shows the capital tax rates and the investment wedges. The difference is significant in all the countries and most significant especially in North Africa's top 3 economies. Hence, in all countries, capital taxation is not naturally the most important reason for cross-country differences in investment efficiency as there are other unobservable factors, different from capital taxes, which cause 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 description for cross-country differences in investment efficiency among sub-Saharan African Africa's top 3 economies than North Africa.

**4.3. 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, we provide answers to this question by computing the effect of decreasing the labour and capital wedges on output, hours worked and capital stock. 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

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

$$\frac{\bar{c}}{\bar{y}} = 1-(n\gamma-1+\delta)\frac{\bar{k}}{\bar{y}}-\frac{\bar{g}}{\bar{y}}$$

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

The reduced values for labour and investment wedges are set to the minimum (least) average values when the wedges are averaged for each country. By observing this, in the case of labour wedge, we find that the reduced value (i.e. the minimum average value across countries) answer 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. Hence, the value of the reduced investment wedge is 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 reduced at the same time, none of the proportional changes in output and input factors such as hours and capital is 1 as 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 1 presents the results of the proportional deviations when A) labour wedge alone is reduced, in which case the reduced labour wedge is equal to the average labour wedge of Algeria; B) investment wedge alone is reduced, in which case the reduced investment wedge is equal to the average investment wedge of Nigeria; and C) labour and investment wedge are both reduced at the same time – in which case labour wedge equates Algerian average and investment wedge is equal to Nigerian average.

**Table 1:** Sensitivity of Input Factors and Output 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 |

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 1. Section A shows the results attained when each country's labour wedge is reduced to the minimum average labour wedge without changing 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 showed 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 favor the most from policies aimed at decreasing or eliminating labour wedge while Angola and Morocco are least likely to get a help 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. Decreasing investment wedge results in similar moderate gains in the 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 decrease in investment wedge, although their average investment wedge is in the domain of Angola and Algeria that showed 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.

## 5. 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. 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. We find that the gains from a reduction in labour and investment wedges at the same time 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 reduction in capital and labor market distortions at the same time results in significant gains in income within SSA and NA, it pursues that capital and labour market distortions are important for figuring out differences in income levels within SSA and NA. This express that policies to bridge the income gap in Africa should be focused on decreasing distortions in labour and capital markets in addition to improving productivity.

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## APPENDIX

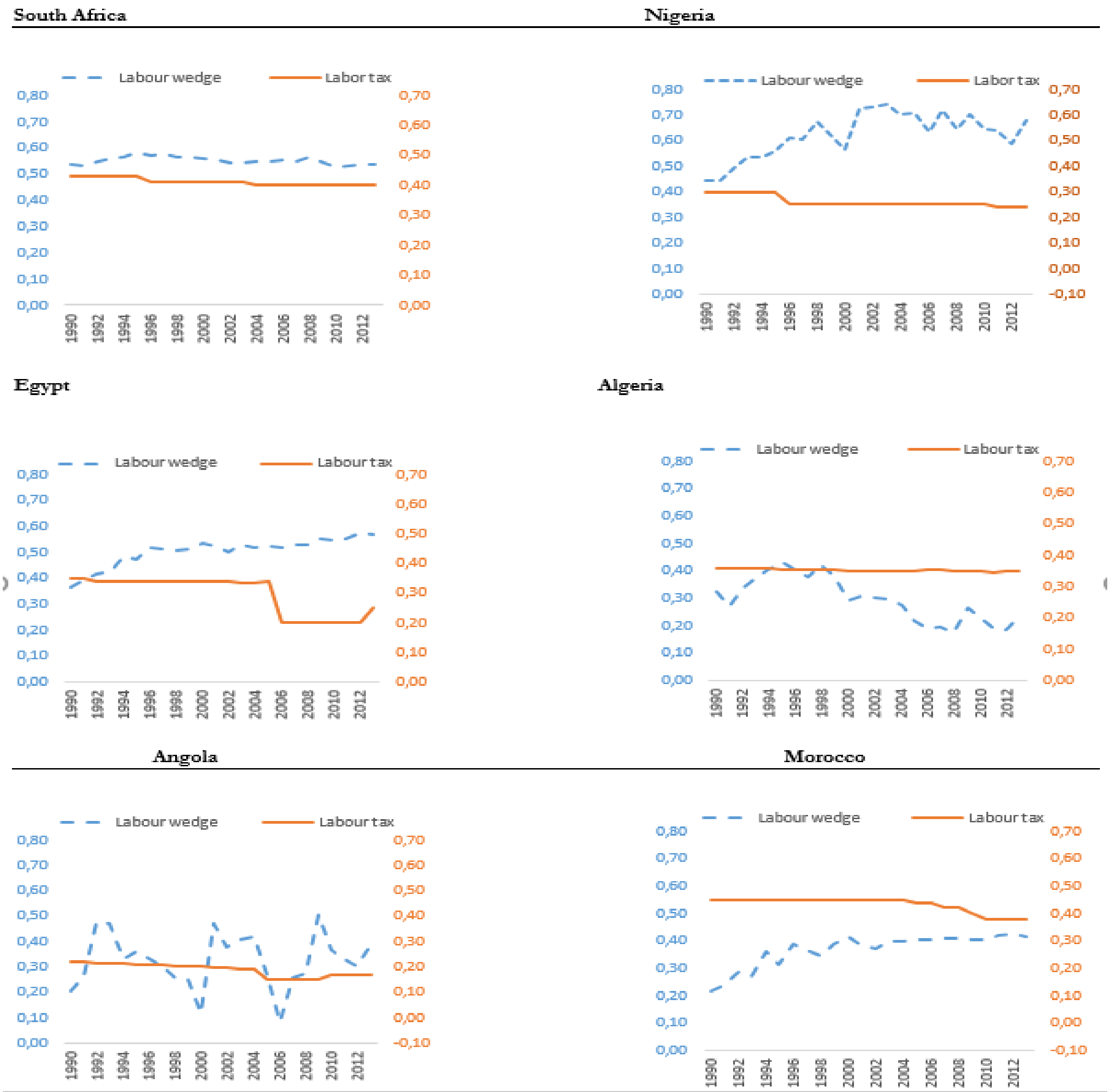


**Figure 4:** Comparison of Observed Labour Taxes Versus Estimated Labor Wedges

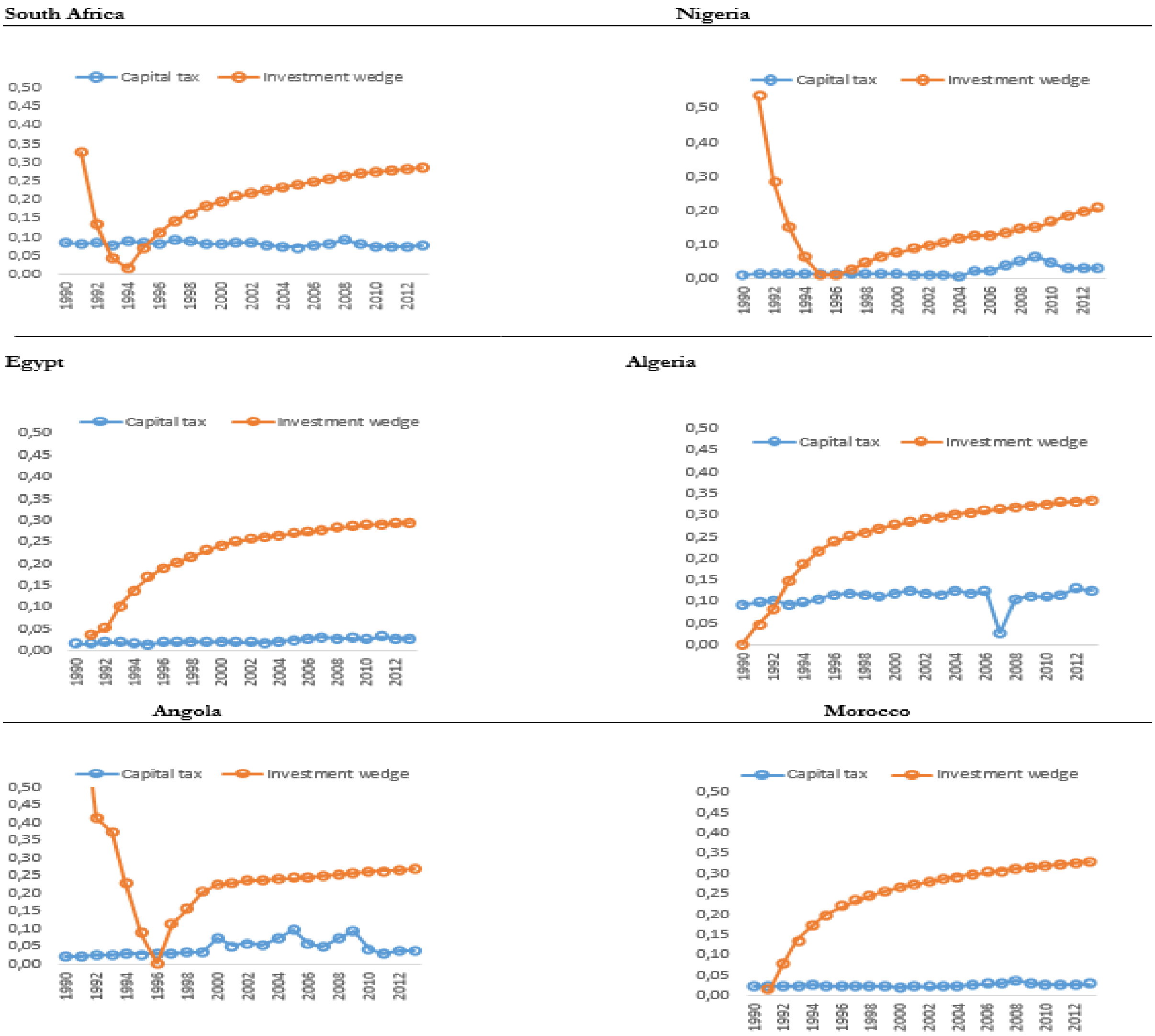


**Figure 5:** Observed Versus Estimated Capital Taxes and Investment Wedges Across Countries