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# Specification of Investment Functions in Sub-Saharan Africa\*

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**Abstract:** It is a well-known fact that one of the most important determinants of growth is private investment. However, in the developing country context of widespread poverty, the effects of initial conditions on the process of capital accumulation have seldom been investigated. This paper highlights heterogeneity in the process of capital accumulation across different countries in Sub-Saharan Africa, and derives a formal specification of investment functions in the primary, industry and service sectors in the region, using a variation of the combined Tobin's Q Theory and the neoclassical models of investment. The results highlight a more rapid accumulation of capital in the relatively high income sub-panel and a widening public-private capital accumulation gap. A functional specification points to the significance of aggregate profitability shocks, the financing cost of investment and public capital stock in estimating the growth rate of private capital accumulation. These results are supported empirically, as highlighted by the relatively small absolute deviation between actual and predicted value distributions.

*Keywords:* investment, investment uncertainty, profitability shocks, public-private capital accumulation gap.

*JEL Classification Number:* E22, O11, O55

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# 1 Introduction

Sub-Saharan Africa is generally described as the poorest region of the world; one that is getting poorer in the face of sustained growth and significant improvement of living standards in the rest of the world [World Bank (2005a), United Nations (2005)]. This general characterization of the region almost implies uniform and widespread poverty. Naturally, such an implied uniform and deteriorating welfare, continent-wide, can only assume homogenous and stagnant economic growth rates. However, a close look at the cross-country patterns of investment and capital accumulation, the driving forces of growth, shows a marked difference across countries. The differences are significant at the aggregate level, but also when total investment functions are further disaggregated to capture the dynamics of public and private capital accumulation.

The disaggregation highlights the significant public-private capital accumulation gap across different income sub-panels of countries and heterogeneity in the process of capital accumulation across countries. The gap is consistent over most the 1980s and 1990s, the reference period corresponding to the era of structural adjustment programs in part characterized by the implementation of expenditure-reducing policies. These policies are believed to have been partly responsible for the rapid decline of public investment and the resulting widening gap between public and private capital accumulation over the period [IMF (1987), Fokam (2005)]. Implemented in response to rising public deficits and balance of payments crises, the effects of these policies were further exacerbated by macroeconomic instability and growing uncertainty. The relative stagnation of private investment and declining level of public investment, in a context of economic crisis and uncertainty, suggests a correlation between macroeconomic stability and capital accumulation.

In fact the implications of macroeconomic stability for growth have been the subject of extensive research in the literature [Serven and Solimano (1993), Serven (1998)]. In a context of credit rationing and increasing complementarity between public and private fixed capital formation, private investment is also likely to be affected by financial variables, particularly the soundness of the banking system and real interest rates, as well as public investment [Fofack (2005), Agenor, Izquierdo and Fofack (2003)]. While the general trend of public investment is negative at the aggregate level, important differences exist across income sub-panels. A significantly higher investment rate is recorded in the high-income sub-panel of countries, notwithstanding the generally declining trend. Presumably, the overall implications of these differences for private fixed capital formation vary considerably with the income level. The objectives of this paper are to assess the dynamics of fixed capital formation across income levels, derive a formal specification of investment functions, and investigate how the specification of these functions varies across the different income sub-panels of countries in Sub-Saharan Africa.

To the extent that investment and capital accumulation play a key role in the growth process, notably through a parameterization, a functional specification of investment functions and particularly the private capital accumulation process may prove quite valuable in assessing the differences in growth estimates across income sub-panels [Fofack and Bayraktar (2007)]. Yet, in spite of this apparent correlation, research on the investment-growth link has not used a functional specification and parameterization approach. In this paper, we use a variation of Tobin's Q theory and the neoclassical theory of investment to model 2-period investment behavior and empirically derive a formal specification of investment functions and private capital accumulation across different income sub-panels.

The model shows a more rapid accumulation of capital stock in the relatively high-income sub-panel of countries, even assuming a constant depreciation rate across income sub-panels. The model also points to the significance of financing costs of investment, public capital stock, and profitability shocks in estimating the determinants of private investments. Profitability shocks include aggregate components and account for macroeconomic variables, including real exchange rate volatility and inflation. Irrespective of the sector, the structure of the model is stable and invariant to sectors' specifics; the difference lies in the parameterization, however. The performance and reliability of the model are assessed by comparing the actual and predicted values empirically derived following the parameterization. The small deviations of actual versus predicted values for the cumulative distributions of private capital stock across economic sectors and income sub-panels support the modeling specification.

The remainder of this paper is organized as follows. The next section focuses on the dynamics of investment in Sub-Saharan Africa and investment uncertainty across the different income sub-panels of countries. Section 3 provides details on the underlying model for estimating private capital accumulation across the different economic sectors. Section 4 discusses the empirical specification of investment functions and the empirical results. The last section provides concluding remarks.

## **2 Investment in Sub-Saharan Africa**

The dynamics of capital accumulation differ markedly across Sub-Saharan African countries, where significant gaps are observed along welfare and income levels. The difference in the capital accumulation process has implications for aggregate investment over time. This section focuses on the pattern and dynamics of investment in Sub-Saharan Africa. In order to highlight the sharp contrast across income levels, we use the welfare function to classify countries into three groupings. The underlined measure of classification is the GDP per capita expressed in constant 2000 US dollar terms. The countries are divided in three sub-panels, according to their level of GDP per capita. The sub-panel of low-income countries (LIC) includes countries with estimated average GDP per capita below US\$325 over the period.<sup>1</sup> This sub-panel mainly includes conflict-affected countries and some of the poorest heavily indebted countries in the region [World Bank (2005b, 2005c)].<sup>2</sup> Countries in this first panel have an annual average GDP per capita of US\$222 (see Table 1 in Annex). The sub-panel of middle-income countries (MIC) has a GDP per capita between US\$325 (the lower

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<sup>1</sup>The median income for the distribution of annual GDP per capita is about US\$384, slightly above the current threshold of US\$325, the upper bound for the distribution of income associated with the sub-panel of low-income countries. Exactly 50 per cent of countries in the overall sample have per capita income below the median, and taking a lower threshold allows a more balanced representation and distribution of countries across the three income sub-panels, while at the same time taking into account the significant income gap. That income gap is best illustrated by the mean differences across income sub-panels, as the latter indicator is more influenced by outliers (see Table 2 in Annex).

<sup>2</sup> There are nine countries in this first sub-panel, of which the conflict-affected and post-conflict ones include Burundi, Central African Republic, Democratic Republic of Congo and Sierra Leone; other countries in this sub-panel include Ethiopia, Gambia, Malawi, Niger and Togo, most of which went through political instability in the reference period as well. One of the common features of these countries is their vulnerability to exogenous and macroeconomic shocks; they are also PRSP and HIPC eligible.

range) and US\$1000.<sup>3</sup> The sub-panel of relatively high-income countries (HIC) has a significantly higher income, with an average above US\$2760.<sup>4</sup> Gabon and South Africa enjoy the largest per capita income.<sup>5</sup>

The large income gap observed across sub-panels is reflected in the rate of capital accumulation. Aggregate fixed capital stock and accumulation vary significantly across countries and income groups (Table 1). This table provides estimates of total fixed capital accumulation expressed as a percentage of GDP across the three income sub-panels. Total fixed capital formation is an increasing function of per capita income, the higher the per capita GDP, the higher the rate of capital accumulation. This empirical regularity is consistent with the direction of causality between investment and growth [Milbourne et al. (2003)]. Countries in the relatively high-income sub-panel enjoy a much larger aggregate fixed capital stock over most of the period. Total investment is slightly above 25 percent of GDP in that sub-panel in the 1980s, representing about twice the level of investment in the sub-panel of low-income countries. Interestingly, the capital accumulation gap across the different sub-panels is preserved overtime.<sup>6</sup>

Moreover, the generally declining trend of aggregate fixed capital formation, which characterized most of the adjustment era in the 1980s and 1990s, affected the public and private capital accumulation rate. Numerous studies on the dynamics of investment in Sub-Saharan Africa have underlined the falling of private capital formation during the adjustment era [Zeufack (1997), Oskikoya (1994)].<sup>7</sup> However, in spite of the more pronounced fluctuations, the declining rate of public capital formation is significantly much higher. Public capital stock, which was already low, fell dramatically over the period, irrespective of the income sub-panel. For countries in the low-income sub-panel, it fell from over 12 percent of GDP to less than 5 percent between 1980 and 1997 (see Figure 1a). However, the late 1990s witnessed a reversal in the trend, particularly in the low-income sub-panel, with public investment increasing from its all time low level of less than 5 percent of GDP in 1997 to about 10 percent in 2004, exceeding the levels recorded in higher income sub-panels. Most probably, the resumption of and rapid increase in public capital formation in the low-income sub-panel after a long and protracted declining phase is associated with the alleviation of the external debt burden within the context of the Highly Indebted Poor Country (HIPC) initiative, which in principle translates into increased additionality and net transfers of resources to eligible countries.<sup>8</sup>

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<sup>3</sup> Countries in this sub-panel include Cameroon, Cape Verde, Comoros, Côte d'Ivoire, Kenya, Nigeria, Senegal, Swaziland, Zambia, and Zimbabwe. Note that Kenya and Nigeria have the lowest per capita GDP, well below US\$549, the group average; while Cape Verde and Swaziland have the highest value.

<sup>4</sup> This implies an extremely large income gaps; indeed, the gap with other countries in the middle and low-income sub-panels is significant, over US\$2000 for the former and US\$2500 for the latter.

<sup>5</sup> Other countries in this panel include Botswana, Mauritius, and Namibia; clearly these are the high performance countries. Botswana and Mauritius have constantly recorded strong and robust growth rate over the last decade, an illustration of their stronger drive for investment.

<sup>6</sup> While the declining trend in investment observed in most of the 80s is consistent with the trend observed in other developing countries, the reversal observed in Latin America and Asia in the 90s is in contrast with the Sub-Saharan African region, and sure enough may have further exacerbated the income and welfare gap with the rest of the world [Servén (1993)].

<sup>7</sup> In fact, the lack of response of private investment in the context of implementation of macroeconomic and structural reforms is often cited to highlight the limits of stabilization programs [Zeufack (1997)].

<sup>8</sup> In particular, most countries in this sub-panel have reached either the decision point which provides interim assistance or the completion point which provides full relief under the extended HIPC Initiative. Some of the completion point countries include Ethiopia, Niger, Zambia and Senegal.

Surprisingly, in spite of the significant income differences across the three sub-panels, the public capital formation gap remains relatively low. In contrast, the private capital formation gap is significant (see Figure 1b). Total fixed private capital formation is over 16 percent of GDP in the high-income sub-panel, representing about 2.5 times the level registered in the sub-panel of low-income countries where private investment remains particularly low, accounting for less than 8 percent of GDP. The result is consistent throughout the sample period. The low level of total fixed capital accumulation in the low-income sub-panel may be attributed to the higher risk-aversion of investors in highly unstable political and macroeconomic environments in these countries.<sup>9</sup>

The extremely low level of private capital accumulation in the low-income sub-panel is a result of the high degree of uncertainty, both political and macroeconomic, often found in a conflict context, and tends to constrain investment [Collier (1999), Obidegwu (2004), Fred-Mensah (2004)].<sup>10</sup> In fact, political instability and macroeconomic volatility have a tendency to magnify uncertainty and risks perceived by investors. They play a key role in firms' decisions to invest, as they have potential for increasing the costs of investment by raising the transaction and adjustment costs implied by the acquisition and installation of new equipment.<sup>11</sup> They also have potential for shrinking the profitability of investment by lowering and depressing demands. However, under the constant-returns to scale assumption, marginal profitability of firms is a convex function of output prices, and Jensen's inequality implies that higher price uncertainty raises the expected profitability of capital, thereby increasing the desired capital stock and hence investment [Abel (1983)].

For this regard, the higher aversion to risk in these low-income countries may reflect the prohibitively high adjustment and irreversibility costs expected to be bore by investors who, in the face of increasing political risks and macroeconomic instability, may choose to forgo or delay their investment decisions as a mitigation strategy. Under these conditions, the expected high returns may not be the sole condition for investments to materialize. In fact, empirical analysis shows that even disturbances that raise the profitability of all investment projects, but make their relative ranking more uncertain, can lead to inaction — and hence depress aggregate investment as investors try to avoid the irreversible mistake of investing in the wrong activity [Bernanke (1983)]. The risk profile may be even higher for countries in the low-income sub-panel to the extent that these countries tend to face much higher prospects of macroeconomic instability, partly as a result of their narrow tax base, growing fiscal deficits, and excessive reliance on unpredictable foreign financing [Fofack (2007)].

The rising scope of public debt to unsustainable levels may be perceived by investors as a path toward debt overhang and further exacerbate perceived risk. When risk factors, whether induced by macroeconomic volatility or policy environment, are compounded by onerous external debt servicing and looming debt overhang, private investors become reluctant to invest out of fear that the growing stock of debt will eventually be repaid by

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<sup>9</sup> The capital accumulation gap across income sub-panels is also partly explained by the relatively low saving rate in the highly indebted poor countries. The low saving rates reflect the initial level of per capita income and declining income in real terms under the implementation of stabilization programs.

<sup>10</sup> Moreover, most countries in this sub-panel have narrow tax base, which may further exacerbate macroeconomic instability via the fiscal deficit financing channel [Fofack (2006)].

<sup>11</sup> At the theoretical level, the scope and expected high level of adjustment costs is at the heart of irreversibility models, which as a result of prohibitively high downward adjustment costs makes overall investment costs asymmetric for fixed investment projects [Dixit and Pindyck (1994)].

levying extra taxes on corporations [Greene (1992), Emini and Fofack (2004)].<sup>12</sup> In some cases, the rising costs of external debt servicing and inherent crowding-out of public resources is also accompanied by build-up of domestic debt and accumulation of arrears to domestic suppliers, with tremendous implications for growth in the short run [Beaugrand et al. (2002)].

However, with resumption of capital accumulation in the HIPC era characterized by structurally low public investment rates across all income sub-panels; and the exceptionally low level of private investment in the poorest sub-panel may therefore be driven by the adoption of contractionary and expenditure-reducing policies in the context of balance of payments crises and fiscal deficits in low-income countries during the adjustment era [Fokam (2005), IMF (1987)].<sup>13</sup> In particular, this may be the case for most countries, especially given the seemingly low level of public capital formation registered across countries in the middle-income sub-panel, most of which also face unsustainably large external debt burden and current account deficits over the period. On the other hand, countries with significantly higher private investment in the high-income sub-panel are not HIPC-eligible. The significantly large private capital formation gap between these countries and the much poorer low-income, highly indebted ones may therefore reflect the risk-averse nature of private investors who in the face of increased uncertainty and looming debt overhang may choose to forgo their investment decisions in the poorest countries.<sup>14</sup>

In addition to the looming debt overhang, investment decisions are also affected by other variables, which may exacerbate the volatility of capital accumulation. In order to further account for this volatility, we estimate the investment uncertainty function for public, private and aggregate capital formation across the three sub-panels. Table 2 in the Annex provides a summary of these estimates. Instead of using the sample variance as measure of uncertainty, we use a GARCH (1,1) specification in a simple equation in which the (log) of real investment follows an AR(1) process with trend.<sup>15</sup> Following [Servén (1998, 2003)], we take the conditional variance from the GARCH procedure as the relevant measure of investment uncertainty.<sup>16</sup> The results show that aggregate estimates of investment uncertainty are generally higher when the sample is restricted to the public capital accumulation and much lower when it is based on private capital.<sup>17</sup> However, there is no discernible consistent pattern across income sub-panels. While countries in the relatively high-income sub-panel

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<sup>12</sup> Already the average ratio of external debt to exports of goods and services was above 352 percent in the late 80s across Sub-Saharan Africa [Greene (1992)], and this ratio is even higher for most countries in the low-income sub-panel, given their extremely low export base. In fact it is about 470 percent.

<sup>13</sup> In general, the philosophy underpinning adjustment programs focuses on absorption-reducing measures and policies, since it assumes that overcoming the supply-side constraints and increasing output growth through a rightward shift in the transformation function to maximize the production of tradable and non-tradable goods is more challenging. For these reasons, measures to increase government revenues and reduce public sector outlays, and hence public investments are first considered in the face of rapid decline in a current account deficit [for further details, see IMF (1987)].

<sup>14</sup> Naturally, initial conditions may also play against increased investments. For instance, in the absence of financial and equity markets, firms may have to rely exclusively on banks for short and long-term financing, which can be a problem in a context of excessive credit rationing.

<sup>15</sup> Different parameters are assumed for each country. For further details on the procedure, see Servén (2003).

<sup>16</sup> To measure investment uncertainty exposed, we use a GARCH(1,1) specification in which investment, expressed in percent of GDP, follows an AR(1) process with trend.

<sup>17</sup> Figure 1 in Annex provides a graphic illustration of conditional variance estimates for a number of selected income sub-panels.

have the largest aggregate measure of investment uncertainty, the poorest low-income countries have a measure that is much larger than the one recorded in the middle-income countries.

The public-private investment uncertainty gap is significant, especially for the relatively high income countries. The estimate of investment uncertainty associated with public capital formation is over twice the level associated with private capital formation for the highest income sub-panel. Clearly, while high uncertainty may have played against increased capital stock and accumulation, especially for the highly risk-averse private investors, it is difficult to fully attribute the poor performance of African economies characterized by lower aggregate investment rates and extremely high volatility to investment uncertainty alone, especially given the ambiguous nature of the uncertainty-investment link [Lee and Shin (2000), Servén (2003)]. The decreasing level of private investment for falling per capita income and rising external debt, at the aggregate level on one hand, and the level of economic stagnation recorded during most of the period on the other, may therefore also find its origins in the structurally low level of public investment, given the complementarity between public and private capital formation [Agénor (2000), Fokam (2005)].<sup>18</sup>

There are abundant empirical studies supporting the existence of a causal relationship between investment and growth [Servén (1993)]. However, that relationship may be unstable when investment is subject to high volatility. In order to assess the nature and stability of the relationship between investment uncertainty and growth, we investigate the direction and strength of the correlation between these two variables using the GARCH (1,1) procedure. Table 2 in the Annex provides empirical results. While the magnitude of the correlation between investment uncertainty and GDP growth is generally stronger for countries in the relatively high-income sub-panel, it is much weaker for the poorest countries.

At the same time, negative correlations are obtained for the investment uncertainty-growth relationship in a number of countries in the relatively high-income sub-panel and the middle and low-income groups, suggesting that investment uncertainty may be harmful for growth. Investment uncertainty may be harmful for growth, and the extremely low level of private capital accumulation in the poorest countries may be the consequence of a strong aversion of private investors to risk and uncertainty.<sup>19</sup> However, the sign of the correlation is not consistent across income sub-panels and investment functions, which may further support the ambiguous nature of investment uncertainty and growth relationships [Servén (2003)].<sup>20</sup>

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<sup>18</sup> Indeed, the possibility of public investment crowding-in private investment is increasingly singled out as a key limitation to fiscal adjustment with growth models which have underpinned development economics and adjustment programs. Public capital formation may provide positive externalities on the private sector through a number of channels: the public provision of economic and social infrastructures may create favorable conditions for private investments to occur, particularly through development of communication and transport networks and education systems; similarly, higher public capital may increase total factor productivity and reduce production and transaction costs; public investment may also increase aggregate demands and hence raise profitability and sales expectations.

<sup>19</sup> These risks and uncertainties may be fueled by conflicts and/or macroeconomic instability exacerbated by the conflict context. Indeed, conflicts and political instability have significant implications for macroeconomic stability. It generally comes with fiscal deficits and inflation, depression in aggregate output production, particularly following reduction of public investment; and shortage of foreign reserves, which as a result of depression in production and exports often lead to the adoption of exchange controls and development of parallel exchange markets. For further details see Fofack and Nolan (2001), and Obidegwu (2004).

<sup>20</sup> For instance, the correlation coefficient is about 63 percent for aggregate fixed capital accumulation in Botswana, a country which recorded robust and sustained economic growth rates over the reference period, implying that over 60 percent of the growth proportional variance is explained by investment uncertainty in

In fact, the investment uncertainty and growth relationship depends on the degree of aversion of investors to risks. Furthermore, the coexistence of risk-averse and risk-neutral investors in the same market may further reinforce the ambiguous nature of that relationship. If investors are risk averse then investment uncertainty has an independent adverse effect on growth, which suggests it that the investment uncertainty and growth link will be negative. The degree of risk aversion is proportional to uncertainty; and the latter has an inverse relationship with profitability [Zeufack (1997)].<sup>21</sup> In contrast, when investors are risk-neutral, investment decisions are guided by other considerations than the simple arbitrage based on the profitability-uncertainty relationship, and the sign of the correlation can be either positive or negative. In fact, the effect of uncertainty on investment is undetermined and depends largely on profitability potentials [Malinvaud (1987)].

Meanwhile, for some of the poorest low-income countries, initial conditions may also play a role in the dynamics of capital formation, taking the form of a resilience effect. This effect may arise when a declining trend of capital accumulation in a context of increased uncertainty and growing risks cannot fall below a certain minimum threshold. That resilience effect may partly explain the extremely low and almost constant rate of public capital accumulation over time and across income sub-panels during the adjustment era. Indeed, in spite of the generally declining trend and significant difference across income sub-panels, the levels and rates of public investment are almost constant across income sub-panels.<sup>22</sup>

The implications of these policies may partly explain the growing capital accumulation and welfare gap between the poorest low-income and relatively high income sub-panels of countries. In spite of the mild increase in public capital formation observed lately in the poorest low-income sub-panel, particularly during the HIPC era, that gap remains important and probably reflects the difference in the parameterization of investment functions across these countries. In the poorest low-income countries where the production process is highly labor-intensive, the absence of financial instruments (equity and capital markets) may increase the costs of investment, as a result of prohibitively high interest rates in a credit rationing environment. Similarly, the capital intensity and relatively high technological content of investment functions in the relatively high income sub-panel, which may contribute to increased overall productivity in the medium to long term, might also raise the actual cost of investments in this last sub-panel.<sup>23</sup> The next sections focus on the specification of investment functions across income sub-panels.

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that country. However, that sign is positive, suggesting that investment uncertainty may be good for growth.

<sup>21</sup> In fact Zeufack (1997) shows that the effect of uncertainty on investment and growth is positive under low uncertainty and extremely high expected profits. On the other hand, when expected profit is low and uncertainty is high, the latter contributes to significant reduction of investment and production potentials of firms.

<sup>22</sup> This resilience and threshold effect might be necessary for a continued production and delivery of essential goods and services to fulfill basic need requirements in a context of generalized adoption of expenditures-reducing policies, which overwhelmingly result in drastic cuts in public expenditures, and specially, public capital formation [IMF (1987), Easterly and Levine (1995)].

<sup>23</sup> The difference in the rate of capital accumulation and parameterization of investment functions between the low-income and relatively high-income countries has implications on output growth and composition of GDP. In the sub-panel of low-income countries where the production process is labor-intensive, the primary sector production accounts for over 50 percent of GDP, while industrial production accounts for a little over 15 per cent. In contrast, industrial production accounts for over 40 percent of GDP in the relatively high-income sub-panel of countries (see Figure 2 in Annex).



### 3 Model

As one of the major determinants of economic growth, private investment has been investigated extensively in the literature. However, in spite of the abundance of investment models available, very few are devoted to the study of private investment in Africa.<sup>24</sup> In this section, we model a 2-period investment behavior, using Tobin's  $Q$  theory and the neoclassical theory of investment.<sup>25</sup> The production function is assumed to be a function of profitability shock ( $A$ ), private capital stock in the primary sector (agriculture and mining,  $KPP$ ), private capital stock in the industrial sector ( $KPI$ ), labor ( $L$ ), and exogenous public capital stock ( $KG$ ).<sup>26</sup>

$$\Pi(A, KPP, KPI, L, KG) = A.KPP^\alpha.KPI^\beta.KG^\phi.L^{1-\alpha-\beta-\phi},$$

where  $0 < \alpha < 1$ ,  $0 < \beta < 1$ , and  $0 < \phi < 1$ . The production function exhibits constant returns to scale, suggesting that the product market is perfectly competitive.

The actual cost of investment is represented by  $c$ , which is a relative price of investment to the price of output in each sector. It is assumed that there is no additional cost of capital adjustment, such as convex or non-convex costs. The cost of investment is

$$C(IPP, IPI) = c.(IPP + IPI),$$

where  $IPP$  is private investment in the primary sector, and  $IPI$  is private investment in the industrial sector.

The additional cost of investment relates to financing investment spending.<sup>27</sup> This cost of capital is essential, especially for low-income countries where financial markets are imperfectly competitive and less developed. In order to capture imperfections in these markets, we introduce the  $\phi$  variable, which is assumed to be proportional to private investment; in other words, the higher the level of investment, the higher the cost of financing. Thus, the cost of financing private investment,  $CF$ , is

$$CF(IPI, IPP) = \phi.(IPP + IPI).$$

The cost of labor (wage bill) is given as

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<sup>24</sup> Shafik (1992) models private investment in Egypt. She finds that private investment is determined by mark ups, internal financing, demand and the cost of capital. Similarly, du Toit, Charlotte and Moolman (2004) model a neoclassical investment function for South Africa. They find that external and domestic financial constraints play a big role in modeling gross domestic fixed investment for South Africa.

<sup>25</sup> See Tobin (1969) and Hayashi (1982), for seminal contributions as well as Abel (1990) for a review.

<sup>26</sup> Several papers in the literature take private and public capital stocks as separate inputs in the production function. Barro (1990), Aschauer (1988), Barth and Cordes (1980), Ramirez (1994), Chatterjee, Sakoulisb, and Turnovsky (2003), Agénor, Bayraktar, and El Aynaoui (2005) are some of these studies.

Cooper and Haltiwanger (2003), Cooper and Ejarque (2003), Bayraktar (2002), and Bayraktar, Sakellaris, and Vermeulen (2005) have been also introduced profitability shocks in the production function to capture aggregate and idiosyncratic shocks.

<sup>27</sup> Given the implications of financial market frictions and financial constraints for private investment [Schiantarelli (1996) and Hubbard (1998)].

$$CL(L) = w.L,$$

where  $w$  is the relative wage rate with respect to the price of output. The relative wage is assumed constant.

In the model, the capital stock is accumulated through a perpetual inventory method. This means that the current stock of capital is equal to investment in the previous period plus capital stock from the previous period, net of depreciation. The private capital stock in the primary sector and the industrial sector is

$$KPP_t = (1-\delta P).KPP_{t-1} + IPP_{t-1},$$

$$KPI_t = (1-\delta P).KPI_{t-1} + IPI_{t-1},$$

respectively; where  $\delta P$  is the depreciation rate of the private capital stock in both sectors. We assume the depreciation rate to be uniform across different sectors. In the model, it takes one period to make capital productive after any investment by firms. Similarly, it is assumed that the public capital stock is accumulated through a perpetual inventory method. Thus, the public capital stock in the current period is

$$KG_t = (1-\delta G).KG_{t-1} + IG_{t-1},$$

where  $\delta G$  is the depreciation rate of the public capital stock and  $IG$  is public fixed capital investment. Likewise, the model assumes that public investment becomes effective with a one-period lag. At the same time, it is assumed that labor is growing at the growth rate of total population. Thus, the number of workers in the current period takes the following expression,

$$L_t = L_{t-1}.(1+n),$$

where  $n$  is the growth rate of the population.

A representative firm wants to optimally choose the stock of private capital that maximizes the firm's value. Hence, before any decision is made, the current level of private capital stock and labor must be known. Exogenous public capital stocks affect private investment with one-period lag since it is assumed that it takes time for public capital to affect the productivity of private capital. The current profitability shocks are also given. The current actual cost of investment,  $c$ , and the current financial cost of investment,  $\phi$ , are known by the representative firm. The value of the representative firm in period  $t$  is given by the following function:

$$V(A_t, KPI_t, KPP_t, L_t, KG_{t-1}, \phi_t) = A_t.KPP_t^\alpha.KPI_t^\beta.KG_{t-1}^\phi.L_t^{1-\alpha-\beta-\phi} - c.(IPI_t + IPP_t) - \phi_t.(IPP_t + IPI_t) - w.L_t + \gamma.EV(A_{t+1}, KPI_{t+1}, KPP_{t+1}, L_{t+1}, KG_t, \phi_{t+1}),$$

where  $V(\cdot)$  is the value of the representative firm and  $EV(\cdot)$  is the expected value of the firm.  $\gamma$  is the discount factor which is assumed to be equal to  $1/(1+r)$ , where  $r$  is the real interest rate. Thus,  $\gamma.EV(\cdot)$  is the present discounted future value of the firm.

Since the goal is to identify the determinants of private investment to specify investment functions, focusing on two periods is sufficient to understand the dynamics of the model. The value function in a 2-period setting is:

$$V(A_1, KPI_1, KPP_1, L_1, KG_0, \phi_1) = A_1 \cdot KPP_1^\alpha \cdot KPI_1^\beta \cdot KG_0^\phi \cdot L_1^{1-\alpha-\beta-\phi} - c \cdot (IPP_1 + IPI_1) - \phi_1 \cdot (IPP_1 + IPI_1) - w \cdot L_1 + \gamma \cdot A_2 \cdot KPP_2^\alpha \cdot KPI_2^\beta \cdot KG_1^\phi \cdot L_2^{1-\alpha-\beta-\phi} - \gamma \cdot w \cdot L_2.$$

where  $KG_0$  is the exogenous public capital stock at the beginning of period 1 and  $KG_1$  is the exogenous public capital stock at the beginning of period 2. Both are assumed to be known by the investor at the beginning of period 1.

In period 2, private investment is taken to be zero since it is the last period. The objective of the representative firm is to maximize its value with respect to  $KPI_2$  and  $KPP_2$ . The maximization problem is

$$\underset{KPI_2, KPP_2}{Max} V(A_1, KPI_1, KPP_1, L_1, KG_0, \phi_1)$$

The constraints are

$$KPP_2 = (1 - \delta P) \cdot KPP_1 + IPP_1,$$

$$KPI_2 = (1 - \delta P) \cdot KPI_1 + IPI_1,$$

$$L_2 = L_1 \cdot (1 + n).$$

Since the production function and the actual and financing cost functions are constant returns to scale and homogenous of degree one, we can normalize the value function by dividing both sides by  $L_1$ , as follows:

$$v(A_1, kpi_1, kpp_1, kg_0, \phi_1) = A_1 \cdot kpp_1^\alpha \cdot kpi_1^\beta \cdot kg_0^\phi - c \cdot (ipi_1 + ipp_1) - \phi_1 \cdot (ipi_1 + ipp_1) - w + \gamma \cdot A_2 \cdot kpi_2^\alpha \cdot kpp_2^\beta \cdot kg_1^\phi \cdot (1 + n)^{1-\alpha-\beta-\phi} - \gamma \cdot w \cdot (1 + n),$$

where  $v(.) = V(.)/L_1$ ,  $kpp_1 = KPP_1/L_1$ ,  $kpi_1 = KPI_1/L_1$ ,  $kg_0 = KG_0/L_1$ ,  $ipp_1 = IPP_1/L_1$ ,  $ipi_1 = IPI_1/L_1$ ,  $kpp_2 = KPP_2/L_1$ ,  $kpi_2 = KPI_2/L_1$ , and  $kg_1 = KG_1/L_1$ . Thus the maximization problem becomes

$$\underset{ipp_1, ipi_1}{Max} v(A_1, kpi_1, kpp_1, kg_0, \phi_1)$$

where the constraint becomes

$$kpp_2 = ipp_1 + (1 - \delta P) \cdot kpp_1,$$

$$kpi_2 = ipi_1 + (1 - \delta P) \cdot kpi_1.$$

The first order conditions with respect to  $ipp_1$  and  $ipi_1$  are

$$-c - \phi_1 + \alpha\gamma A_2 (ipp_1 + (1 - \delta P)kpp_1)^{\alpha-1} kpi_2^\beta .kg_1^\varphi .(1+n)^{1-\alpha-\beta-\varphi} = 0,$$

$$-c - \phi_1 + \beta\gamma A_2 (ipi_1 + (1 - \delta P)kpi_1)^{\beta-1} kpp_2^\alpha .kg_1^\varphi .(1+n)^{1-\alpha-\beta-\varphi} = 0.$$

After rearranging the equation, we can write it in terms of  $kpp_2$  and  $kpi_2$ :

$$kpp_2 = \left[ \frac{\alpha\gamma A_2 kpi_2^\beta .kg_1^\varphi .(1+n)^{1-\alpha-\beta-\varphi}}{c + \phi_1} \right]^{\left(\frac{1}{1-\alpha}\right)},$$

$$kpi_2 = \left[ \frac{\beta\gamma A_2 kpp_2^\alpha .kg_1^\varphi .(1+n)^{1-\alpha-\beta-\varphi}}{c + \phi_1} \right]^{\left(\frac{1}{1-\beta}\right)}. \quad (1)$$

After plugging in  $kpi_2$  into  $kpp_2$  equation, we can solve  $kpp_2$ , in terms of other exogenous variables:

$$kpp_2 = C_1 .(c + \phi_1)^{\frac{1}{1-\alpha-\beta}} .A_2^{\frac{-1}{1-\alpha-\beta}} .kg_1^{\frac{-\varphi}{1-\alpha-\beta}} .(1+n)^{\frac{-(1-\alpha-\beta-\varphi)}{1-\alpha-\beta}}, \quad (2)$$

where  $C_1 = \alpha^{\frac{-(\beta-1)}{1-\alpha-\beta}} .\beta^{\frac{\beta}{1-\alpha-\beta}} .\varphi^{\frac{-1}{1-\alpha-\beta}}$ .

If we take the logs of both sides of equation (2) specifying  $kpp_2$ , we obtain:

$$\ln kpp_2 = \ln(C_1) + \frac{1}{1-\alpha-\beta} . \ln(c + \phi_1) - \frac{1}{1-\alpha-\beta} . \ln(A_2)$$

$$- \frac{\varphi}{1-\alpha-\beta} . \ln(kg_1) - \frac{1-\alpha-\beta-\varphi}{1-\alpha-\beta} . \ln(1+n), \quad (3)$$

where

$$kpp_2 = ipp_1 + (1 - \delta P)kpp_1.$$

Equation (3) indicates that there are four key determinants of private investment. The first one is profitability shocks ( $A_2$ ) in the period when the capital stock becomes productive. The profitability shocks may include both aggregate and firm specific components; however, since we assume that the model is a one-representative-firm model, the aggregate component is the most important one. The aggregate profitability shocks contain information about macroeconomic stability. In that regard, components of the aggregate profitability shocks include the growth rate, stability of prices, and real exchange rate volatility.

The second important determinant of investment is the financing cost of investment ( $\phi_1$ ) in the period when the investment decision is made. Indeed, the means and process of financing investment expenditures plays an important role in investment decisions by firms,

especially in low-income countries where credit rationing and the prohibitively high cost of capital are constraints in less developed financial markets.<sup>28</sup>

The third factor in determining private investment is public capital stock ( $kg_t$ ). Since the public fixed capital stock is an important component of production, especially given its complementarity with private investment, its role is expected to be significant.<sup>29</sup>

We can obtain equation  $kpi_2$  by plugging the value of  $kpp_2$  given in Equation (2) in Equation (1):

$$\ln kpi_2 = C_2 + \frac{1-2\alpha-\beta}{(1-\alpha-\beta)(\beta-1)} \cdot \ln(c + \phi_1) - \frac{1-2\alpha-\beta}{(1-\alpha-\beta)(\beta-1)} \cdot \ln(A_2) \quad (4)$$

$$- \frac{\varphi(1-\alpha-\beta) - \varphi\alpha}{(1-\alpha-\beta)(\beta-1)} \cdot \ln(kg_1) - \frac{(1-\alpha-\beta-\varphi)(1-2\alpha-\beta)}{(1-\alpha-\beta)(\beta-1)} \cdot \ln(1+n),$$

where  $C_2 = -\frac{1}{\beta-1} \ln(\alpha \cdot \beta \cdot C_1^\alpha)$ , and

$$kpi_2 = ipi_1 + (1 - \delta P) \cdot kpi_1.$$

## 4 Empirical Analysis

In this section, empirical specification, estimation methodology, and empirical results are presented.

### 4.1 Empirical Specification of Investment Functions

In our general empirical specification of the model, we focus on the basic determinants of investment following equations (3) and (4):

$$\ln kpp_t = \eta_1 \ln E(A_t) + \eta_2 \ln kg_{t-1} + \eta_3 \ln E(\phi_t) + \varepsilon_t, \quad (5)$$

$$\ln kpi_t = \theta_1 \ln E(A_t) + \theta_2 \ln kg_{t-1} + \theta_3 \ln E(\phi_t) + \xi_t, \quad (6)$$

where  $kpp_t$  is the private capital stock in the primary sector,  $kpi_t$  is the private capital stock in the industrial and service sectors,  $E(A_t)$  is the expected value of aggregate profitability shocks,  $kg_{t-1}$  is the value of public capital stock in previous period,  $E(\phi_t)$  is the expected cost of financing investment in period  $t$ .  $\eta_1$ ,  $\eta_2$ ,  $\eta_3$ , and  $\theta_1$ ,  $\theta_2$ ,  $\theta_3$  are the coefficients.  $\varepsilon_t$  and  $\xi_t$  stand for residuals capturing all other determinants of private investment that are not included in the model. For simplification purposes, we assume that the relative price of investment is constant at 1.

<sup>28</sup> Lucas (1990) points out the negative effects of capital market imperfections on economic growth. Capital market imperfection is a constraint to domestic resources mobilization and capital flows to poor countries.

<sup>29</sup> As the infrastructure capital stock increases, private investment and efficiency of factors increase as well. As public investment in education and health increases, in turn the stock of public capital is going to rise as well, this basically affects the productivity of labor.

In the absence of private capital stock data in the Sub-Saharan Africa, we use a perpetual inventory method to approximate them. The aggregate capital stock accumulation is done such that:

$$KKP_t = (1 - \delta P).KPP_{t-1} + IPP_{t-1},$$

$$KPI_t = (1 - \delta P).KPI_{t-1} + IPI_{t-1},$$

where  $\delta P$  is the depreciation rate of the private capital stock. It is assumed that the depreciation rates may take different values. The following rates are considered for simulation purposes: uniform depreciation rate of 15 percent across the three income sub-panels, and varying rates of 10 percent in the high income countries, 15 percent in the middle income countries, and 20 percent for the low income countries.<sup>30</sup> In the initial period,  $KPP$  and  $KPI$  are taken to be zero.  $IPP$  and  $IPI$  are the private fixed capital formation in constant dollar terms. After estimating the  $KPP$  and  $KPI$  series,  $kpp$  and  $kpi$  are obtained by dividing  $KPP$  and  $KPI$  by total population ( $L_t$ ). It should be noted that in empirical regressions, the end-of-period value of  $kpp$  is specified as  $kpp_{t+1}$ .

Similarly, the data for the public fixed capital stock are not available for most countries in SSA. Thus we once again draw on a perpetual inventory method for estimation. Under that assumption, the aggregate public fixed capital formation is

$$KG_t = (1 - \delta G).KG_{t-1} + IG_{t-1},$$

where  $\delta G$  is the depreciation rate of the public capital stock, assumed to take different values: 10 percent in the high income countries, 15 percent in middle income countries, and 20 percent in low income countries. Similarly,  $KG$  is taken to be zero in the initial period.  $IG$  is the public fixed capital formation in constant dollar terms. After calculating  $KG$  series,  $kg$  is obtained by dividing  $KG$  by total number of  $L_t$ , which is assumed to be equal to total population.

The first panel of Figure 2 shows public capital accumulation per capita in constant U.S. dollars. The last two panels of Figure 2 present private capital accumulation per capita in constant U.S. dollars in industrial and service, and agricultural sectors, respectively. The capital accumulation gap between the relatively high income sub-panels and poorer income sub-panels is significant at the aggregate level, irrespective of the sectoral classification (industry and agriculture). This impressive gap is driven by the higher investment rate in the high income sub-panel of countries which enjoy a more stable macroeconomic environment illustrated by profitability shocks and lower costs of investment financing. The seemingly linear trend associated with higher income countries in the last two panels suggests a more robust rate and sustained private investment over time. This should be contrasted with the curvilinear shape associated with accumulation of public capital stock, which has a declining

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<sup>30</sup> The higher depreciation rates in the lower income countries reflect the fact that these countries face higher budget constraints and tend to allocate much lower revenues to maintenance expenditures. Rapid depreciation is also accelerated by the conflict context in these countries. In general, it is customary to assign higher depreciation rates to developing countries. For instance Beddies (1999) chose a rate of 15 percent for capital depreciation. And Vera-Martin (1999) recommended an even higher rate, suggesting that a rate of 15 percent does not to significantly alter econometric results.

rate of growth over time. In low income countries, the capital accumulation curve is almost flat, reflecting a slower growth rate of capital, in the face of rapid depreciation.

The expected value of profitability shocks,  $E(A_t)$ , is also specified empirically. We assume that it is a function of current macroeconomic conditions such as the level of GDP per capita, inflation rate, changes in the real effective exchange rate. The income level is one of the most important factors for the profitability of firms. Increased demand for domestic goods under higher income is expected to increase the demand for intermediate goods and inputs for investment motives. The inflation rate is introduced to account for macroeconomic stability. Price volatility affects aggregate demand and lowers expectations of investors. Real exchange rate volatility also affects growth and investment, and may be particularly costly for undiversified African economies that depend on imports for most inputs and intermediate goods. Similarly, the volatility of the real exchange rate may affect investment decisions and growth through the portfolio effect, especially if firms rely on foreign borrowings to finance investments and/or for working capital [Fofack (2005)]. The aggregate profitability shocks are assumed to be determined by the following variables:

$$\begin{aligned} \ln E(A_t) &= a_1 \ln GDPPC_t + a_2 INFL_t + \varepsilon_t, \\ \text{OR } \ln E(A_t) &= b_1 \ln GDPPC_t + b_2 CREER_{t-1} + \varepsilon_t, \end{aligned} \quad (7)$$

where  $GDPPC$  is GDP per capita,  $INFL$  is the inflation rate, and  $CREER$  is the change in the real effective exchange rate.

The cost of financing investment is assumed to depend on the level of development of financial markets, which is measured by either one of the following variables: domestic credit to private sector expressed in percent of GDP ( $CREDIT$ ), M2 in percent of GDP ( $M2$ ), and (M2-M1) in percent of GDP ( $M2-M1$ ). The last measure also approximates the size of the informal sector.<sup>31</sup>

To the extent that the study aims at deriving the specification of private investment functions across income sub-panels, an empirical estimation of coefficients in equations corresponding to functions of profitability shocks, public capital stock, and financing cost of investment is essential. Assuming that these coefficients are derived and known, the functional specification of private investment can be represented by inserting equation (7) into equations (5) and (6) and solving for  $\ln kpp_t$  or  $\ln kpi_t$ . Following the substitution, the initial functional representation expressed in a compact form by equation (10) takes the following form:

$$\begin{aligned} \ln kpp_t [\text{or } \ln kpi_t] &= c_1 \cdot \ln GDPPC_t + c_2 \cdot INFL_t [\text{or } CREER_t] + c_3 \cdot \ln(kg_{t-1}) \\ &+ c_4 \cdot M2_t [\text{or } (M2 - M1)_t, \text{ or } CREDIT_t] + \varepsilon_t, \end{aligned} \quad (8)$$

$$\ln kpp_t [\text{or } \ln kpi_t] = f_A(\cdot) + f_\phi(\cdot) + f_{KG}(\cdot) + \varepsilon_t, \quad (9)$$

$$kpp_t [\text{or } kpi_t] = \exp(f_A(\cdot) + f_\phi(\cdot) + f_{KG}(\cdot) + \varepsilon_t),$$

<sup>31</sup> In principle, as the volume of deposits (M2-M1)/GDP grows, the size of informal activities will drop; the higher the share of deposits, the smaller the size of informal economy.

$$kpp_t[or\ kpi_t] = \left[ \prod_j \exp(f_j(\cdot)) \right] \cdot \exp(\varepsilon_t), \text{ where } j = A, KG, \text{ and } \phi, \quad (10)$$

where  $f_A(\cdot)$ ,  $f_\phi(\cdot)$ , and  $f_{KG}(\cdot)$  are the profitability shock, financing cost, and public capital functions respectively.<sup>32</sup>

## 4.2 Estimation Methodology

The private capital stock regressions presented above are estimated using the general method of moments (GMM), introduced by Holtz-Eakin, Newey, and Rosen (1988), Arellano and Bond (1991), and Arellano and Bover (1995).<sup>33</sup> The estimation involves differencing regression variables to control for country effects. The instruments consist of lagged values of dependent and independent variables.<sup>34</sup> This methodology also allows for endogeneity in the dependent variables.

To eliminate country-specific effects, we take the first difference of equation (8):

$$KP_t = c_1 \cdot dGDPPC_t + c_2 \cdot MSI_t + c_3 \cdot dkg_{t-1} + c_4 \cdot FV_t + (\varepsilon_t - \varepsilon_{t-1}), \quad (11)$$

where  $MSI_t = dINFL_t$  or  $dCEER_t$ ;  $FV_t = dM2_t$  or  $d(M2-M1)_t$  or  $dCREDIT_t$ ;  $KP_t = dkpp_t$  or  $dkpi_t$ .<sup>35</sup> The results are provided in Tables 2-5. In the regressions, we use 3-year averages to combine short-and long-run effects. These tables also report the Sargan and second-order serial correlation specifications whenever the number of observation is large enough to calculate them. These tests indicate that we cannot reject the hypothesis of correct identification, which support the model specification and robustness of methodology. Standard errors and test statistics are robust to the presence of heteroskedasticity.

## 4.3 Empirical Results

We derive the empirical specification of capital stock (predicted value) for each sub-panel using equation (11) above, and compare the estimated function with actual values.<sup>36</sup> The main data sources are the World Bank Development Indicators, and Everhart and Sumlinski (2002). The regression analysis is based on a total number of 23 countries covering the period 1980-2003. Private investment series in the primary sector (agricultural

<sup>32</sup> Other set of factors affecting private capital accumulation include the quality of governance and leadership. For instance, the quality of leadership may lead to a faster deterioration of capital infrastructure in turn lower private capital accumulation. However, due to missing data points, we did not include these factors in the empirical model. For further details on the implications of government policy for private investment, see Dailami and Walton (1992).

<sup>33</sup> Since the number of countries is limited, especially after separating countries into different income groups, we could not use any methodologies that may allow us to separate short- and long-run determinants of private capital, such as pooled mean group estimator, introduced by Pesaran, Shin, and Smith (1999).

<sup>34</sup> Due to the limited number of observations, we only included only the first lags of variables in the instrumental set.

<sup>35</sup>  $dkpp_t = \ln(kpp_t) - \ln(kpp_{t-1})$ ;  $dkpi_t = \ln(kpi_t) - \ln(kpi_{t-1})$ ;  $dGDPPC_t = \ln(GDPPC_t) - \ln(GDPPC_{t-1})$ ;  $dINFL_t = INFL_t - INFL_{t-1}$ ;  $dCREER_t = CREER_t - CREER_{t-1}$ ;  $dkg_{t-1} = \ln(kg_{t-1}) - \ln(kg_{t-2})$ ;  $dM2_t = M2_t - M2_{t-1}$ ;  $d(M2-M1)_t = (M2-M1)_t - (M2-M1)_{t-1}$ ;  $dCREDIT_t = CREDIT_t - CREDIT_{t-1}$ .

<sup>36</sup> Some examples of empirical studies on private investment in Sub-Saharan Africa countries include Ghura and Goodwin (2000), Ndikumana (2000).



and mining), and industrial and service sectors are approximated by multiplying total private investment by the output share of each sector.<sup>37</sup>

As specified earlier, we use different values of depreciation rate to estimate the scope of capital stock in real terms. The regression analyses reported in Tables 2-5 are based on the depreciation rates of 10 percent in relatively high-income countries, 15 percent in middle-income countries, and 20 percent in relatively low-income countries.<sup>38</sup>

The regressions are run sequentially to estimate the coefficients associated with the specification of investment functions in the primary, industrial and service sectors. In each table, the dependent variable in the first set of regression results is the first difference of the log of private capital stock per capita in the primary sector, *dkpp*; in the second set of regression results in each table, it is the first difference of the log of private capital stock per capita in the industrial and service sectors, *dkpi*. Table 2 reports the results when we use the pooled sample. Tables 3, 4, and 5 give the results for relatively-high-income countries, middle-income and low-income countries, successively.

Empirical results suggest that public capital stock per capita is a positive and significant determinant of private capital stock in the primary sector (*dkpp*) across all income sub-panels. The consistency of this result across all income sub-panels further reinforces the complementarity between public and private investment [Agénor (2000) and Fokam (2005)]. However, the variation in the process of private capital stock accumulation across income sub-panels is significant. This variation is captured by differences in the magnitude of the estimated coefficients, which is much smaller in the middle income sub-panel of countries. But the coefficient tends to be higher for low-income countries. One possible explanation is that since the level of public capital stock is already low in low-income countries, any improvement in the public capital stock is expected to have a higher complementary effect on private capital stock. The gap in the estimated coefficients has implications for the empirical specification of investment function. In particular, the smaller coefficient associated with the middle-income countries suggests that the impact of public investment for the private capital accumulation is much lower.

Similarly, the positive correlation between macroeconomic stability and private capital accumulation in the primary sector, increases with the growth rate of GDP across all income sub-panels, further corroborating the investment and profitability shock link. While investment drives growth in the initial stage, robust and sustained growth may further enhance investment rates in a growing virtuous cycle configuration at the latter stages. The strength of the correlation is weaker in the sub-panel of high-income countries when restricted to the capital accumulation in the primary sector. However, this contrast may reflect the nature of these economies which are more diversified with a higher share of investment in industry and service sectors.

The empirical results also support the negative effects of inflation on private capital accumulation. Inflation is a significant and negative determinant of private investment particularly in low income countries. The limited number of assets in the structure and

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<sup>37</sup> *Gross fixed private capital formation*. Private investment covers gross outlays by the private sector (including private nonprofit agencies) on additions to its fixed domestic assets. *Gross fixed public capital formation*. Public investment covers gross outlays by the public sector on additions to its fixed domestic assets. *Gross fixed capital formation*, (formerly gross domestic fixed investment) includes land improvements; plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings.

<sup>38</sup> When different depreciation rates are used, the results are very similar, and hence, are not reported in the paper; they are available upon request, however.

composition of portfolios owned by poor households in the low-income country sub-panel may disproportionately increase their risk exposure in a high-inflation prone environment [Easterly and Fischer (2001)]. Moreover, in the extreme case of hyper-inflation that affected a number of countries in the sub-panel over the reference period, macroeconomic instability fueled by excessive money supply and correlatively rapid price increases might be exacerbated by exchange rate volatility [Beaugrand (2003)].<sup>39</sup>

Changes in exchange rates also appear as a significant determinant of private capital accumulation, as evidenced in some cases. The parameter associated with this variable is negative and significant - suggesting that higher volatility of the exchange rate is a source of uncertainty and may lower expected returns on investment and/or delay investment decisions, particularly in high- and low-income countries.<sup>40</sup> Excess real exchange rate volatility may affect investment decisions in several ways, including through increased variance of expected profitability to investors and costs of new capital goods [Serven (2003), Fofack (2005)]. In particular, the costs of new capital goods may become extremely expensive in the event of depreciation of a domestic currency for the poorest low-income countries whose investment tends to have relatively high-import content. The larger coefficient associated with the distribution of the low-income sub-panel suggests a higher vulnerability and exposure of the poorest segment of the population to exchange rate volatility. In some cases, we obtain positive coefficients for the growth rate of real effective exchange rate. This may be explained by the positive effect of appreciated currency. Exchange rate appreciation is likely to harm exports, thus the profitability and investment decision of export-oriented firms. The results show that, in low- and high-income countries, this effect dominates. Currency appreciation, on the other hand, also reduces the cost of investment with high-import contents. Given that we obtain positive coefficients for this group of countries, this second effect is expected to be significant for middle-income countries.

Financial variables are important determinants of private investment, especially in high-income countries. The higher level of domestic credits to private sector improves private investment in high-income countries. But its effect is either insignificant or unexpectedly negative in most cases for low- and middle-income countries. We may relate this insignificant effect to the development level of financial markets in low- and middle-income countries. Similarly, as  $(M2-M1)/GDP$  increases, private investment rises in high-income countries. One explanation for insignificant coefficients in low- and middle-income countries would be the fact that the scope of informal sector activities is larger in these countries. As a result, minor changes in  $(M2-M1)/GDP$  may not be that effective on private investment for them. The results with  $M2$  as a share of  $GDP$  are also similar to the ones with other financial variables: It is more effective in high-income countries.

The right hand side panels in Tables 2-5 provide the regression results when the dependent variable is private capital stock per capita in the industrial and service sectors. The regression results are consistent with the first set. Public investment is catalysts to private capital accumulation in the primary and industrial sectors. Similarly,  $GDP$  per capita growth enhances private capital stock accumulation in a virtuous cycle, especially in middle- and

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<sup>39</sup> Indeed, the Democratic Republic of Congo experienced several episodes of hyper-inflation in the nineties, which were closely associated with currency substitution effects resulting from increased demand for foreign currency by economic agents in the face of rapid depreciation of the local currency. For further details see Beaugrand (2003).

<sup>40</sup> This result is consistent with existing empirical findings. Indeed, Hausmann and Gavin (1995) report a negative correlation between an index of macroeconomic volatility (which combines real  $GDP$  and real exchange rate volatility) and investment. Similar results are reported by Aizenman and Marion (1995, 1996) and Serven and Solimano (1993).

high-income countries. Macroeconomic stability, whether measured by price stability or change in the real effective exchange rate, is an important determinant of private capital accumulation in the industrial and service sectors. The impact of financial stability on private capital accumulation in the secondary and tertiary sectors is also sustained in high-income countries.

The consistency of regression parameters associated with estimates of private capital accumulation not only in the primary sectors, but also in industry and service sectors derived from the empirical model using equation (11) is worth pointing out. These parameter estimates are used to empirically estimate investment functions specified across the different income sub-panels. A comparison between the actual and predicted values of that function provides the basis for assessing the validity and performance of model specifications.

The predicted values of the first difference of the private capital stock per capita expressed in log terms are derived for the primary, industrial and service sectors for all countries in the samples, irrespective of income level. The results are provided by Figure 3a at the aggregate level. The "goodness of fit" of the functional specification is illustrated by the gap between the actual and predicted values in Figure 3a. In fact, the absolute deviation between the actual and predicted values is larger, especially in the industrial and service sectors. The larger gap in the late 1990s is partly explained by the unexpected jumps in the predicted value of capital accumulation specifically in the mid 1990s. This unexpected jump may partially be explained by increased macroeconomic instability, especially in the poorest low-income countries [Serven (1998)].<sup>41</sup>

The goodness of fit improves significantly when countries are grouped according to income levels. The empirical model better predicts the private capital accumulation, especially the one in the secondary sector. Indeed, when the predicted value estimation is restricted to the relatively high income sub-panels (Figure 3b), the absolute deviation between the predicted and actual empirical distribution is significantly much smaller. However, the absolute deviation between the actual and predicted distribution of private capital stock increases with a declining level of per capita income for the low- and middle-income sub-panel of countries, particularly in the distribution associated with industrial and service sectors (Figures 3c and 3d). The higher variability in the predicted values' distribution for the lower-income countries sub-panel in the 1990s, may corroborate the larger effects of macroeconomic instability, particularly exchange rate volatility and changes in relative prices in the poorest low-income countries. The mid-1990s are characterized by increased inflationary pressures, particularly in the Democratic Republic of Congo and Zimbabwe, which were confronted with hyper inflation and balance of payments crises [Beaugrand (1997)]. At the same time, inflationary pressures increased in a number of countries in the sub-sample of the CFA group following the nominal devaluation of their currency in 1994 [Fokam (2005)].<sup>42</sup>

The income and sectoral effects are captured by the rate of growth rate of capital. While the growth rate of capital is declining and getting negative in most of the 1990s in the low-income sub-panel of countries (in the primary sector as well as in the industry and

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<sup>41</sup> Inflation is often considered as a summary measure of macroeconomic instability, and the aggregate negative effect of macroeconomic instability, particularly in the low-income sub-panel of countries, may reflect excessive fluctuations of prices [Easterly and Fischer (2001)].

<sup>42</sup> The CFA franc, which has been pegged to the French franc at the fixed parity of 1 French franc to 50 CFA franc since 1945, underwent a 100 percent devaluation in 1994, stabilizing the new parity of 1 French franc to 100 CFA franc. For further details see Tchundjang (1979) and Monga (1997).

service sectors), reflecting the declining level of investment and rapid depreciation of private capital stock over the period, a different distributional shape is associated with the growth rate of private capital in the middle and relatively high-income sub-panel of countries. The rate of growth and process of capital accumulation are continuous throughout the 1990s in the middle- and high-income countries.<sup>43</sup>

## 5 Conclusion

This paper focuses on the dynamics of investment and capital accumulation in Sub-Saharan Africa during the structural adjustment era in the 1980s and 1990s. It investigates the determinants of private capital accumulation and derives a formal specification of functions underlying these distributions using a variation of Tobin's Q theory and the neoclassical theory of investment in a 2-period investment behavior model, taking into account the significant welfare and income gaps across different sub-panels of countries. A specification of the different investment functions across income sub-panels is followed by an empirical estimation of the underlying parameters and a comparison between actual and predicted values as a way of assessing the performance and reliability of the specified model.

The dynamics of investment and capital accumulation are assessed at the aggregate level, but also across three income sub-panels during the period 1980-2003, characterized by a dramatic decline of public investment and depreciation of public capital stock. Irrespective of income levels, public investments decline systematically and the capital accumulation gap across income sub-panels is marginal over most of the reference period, further corroborating the negative effects of contractionary and expenditure-reducing policies on investments in Sub-Saharan Africa. In spite of the resumption of public investment and capital formation, particularly during the HIPC era in the late 1990s, the level of public capital stock remains extremely low, especially compared to other developing countries.

In contrast, private investment shows some resilience over the period, especially for the relatively high income sub-panel of countries. In spite of fluctuations, the long-term trend of private capital accumulation is positive. Private investment is much lower in the relatively low-income sub-panels; as a result, the private capital accumulation gap across income sub-panels is significant, and remains important in spite of a rapid accumulation observed in low-income countries in the post-HIPC era.

In spite of the significant public-private investment and capital accumulation gap, especially for the relatively high income sub-panel of countries, the study found the relationship between investment uncertainty and growth to be ambiguous, for both public and private investment alike. The specification of private investment functions in the primary sector, but also in the industrial and service sectors, under the 2-period investment behavior model, which assumes that the accumulation process is achieved through a perpetual inventory method, is therefore largely driven by profitability shock variables in the latter period when the capital stock becomes productive. The most significant profitability shock

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<sup>43</sup> The contrast with the declining rate of capital accumulation in the low-income sub-panel of countries is reflected in the level of capital stocks. For instance, while the income range associated with the distribution of private capital accumulation in the primary sector varies between US\$90 and US\$665 in constant US dollar terms over the entire period in the high-income countries, it ranges between US\$4.5 and US\$20, approximately, in the low-income sub-panel of countries (the last panel in Figure 2). The gap in the income range is even higher when the comparison is based on the cumulative distribution of private capital stock associated with industry and service sectors (the second panel in Figure 2). The upper range is over US\$2980 in the higher-income sub-panel and only about US\$20 in the low-income sub-panel of countries.

variables in the model include income level, price stability and real exchange rate volatility - all indicators of macroeconomic stability. In addition to profitability shocks, private capital accumulation is driven by the financing cost of investment in the period when investment decisions are made. It is also driven by public capital stock.

A parameterization of investment functions and empirical specification reveals a large contrast between industrial and primary sectors and across income sub-panels in the private capital accumulation scale. Irrespective of the depreciation rate and sectors, the accumulation of private capital stock is significant in the relatively high income sub-panels of countries. The rate of accumulation in the high income sub-panel is very strong at the aggregate level, but also in the primary and industrial sectors over the reference period. That rate of accumulation is even higher in the industrial and service sectors where the private capital stock grew by over 7 percent on average over the reference period. In contrast, empirical specification reveals a significantly much lower growth rate and accumulation of private capital stock for the middle and relatively low-income sub-panel of countries. The cumulative distribution functions associated with these two sub-panels of countries are almost flat over the same reference period.

The performance of the behavioral model is assessed by comparing the actual and predicted values of the cumulative private capital stock derived empirically from the specified investment function. The relatively small absolute deviation between actual and predicted value functions, particularly for the relatively high-income sub-panel of countries, is an indication of the goodness of fit of the empirical model, which captures a host of factors, including public sector incentives, macroeconomic stability and financial sector variables. Financial variables play a key role in the parameterization of private capital accumulation, especially in the relatively high income sub-panel of countries. In addition, the parameterization of private capital accumulation functions is uniformly affected by income level, taken as one of the profitability shock variables. The inflation rate is more significant in the low-income sub-panel of countries and less so in the relatively high income sub-panel, probably reflecting the much higher inflationary pressures in the poorest low-income countries.

The dynamics of private capital accumulation are affected by public investment, macroeconomic stability and access to credit through the parameterization of coefficients specifying the underlying variables. The significant private capital accumulation gap observed in the empirical specification across income sub-panels is therefore partly driven by differences in the parameter estimates across countries. The key issue is the stability of these parameters over time and its implication for private capital accumulation gaps across income sub-panels. Also important is the private capital accumulation and growth link, especially given the extremely high and consistent capital accumulation gap across income sub-panels and the much lower variation in economic growth rates across countries in Sub-Saharan Africa. Future research will assess the stability of parameter estimates and implications of varying private capital accumulation for economic growth across income sub-panels in the Sub-Saharan Africa.

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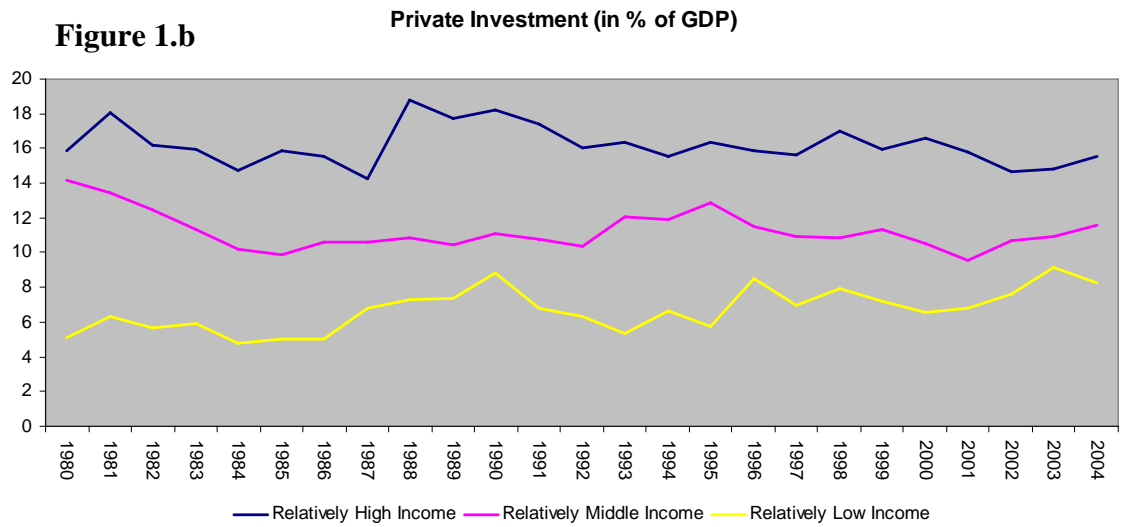
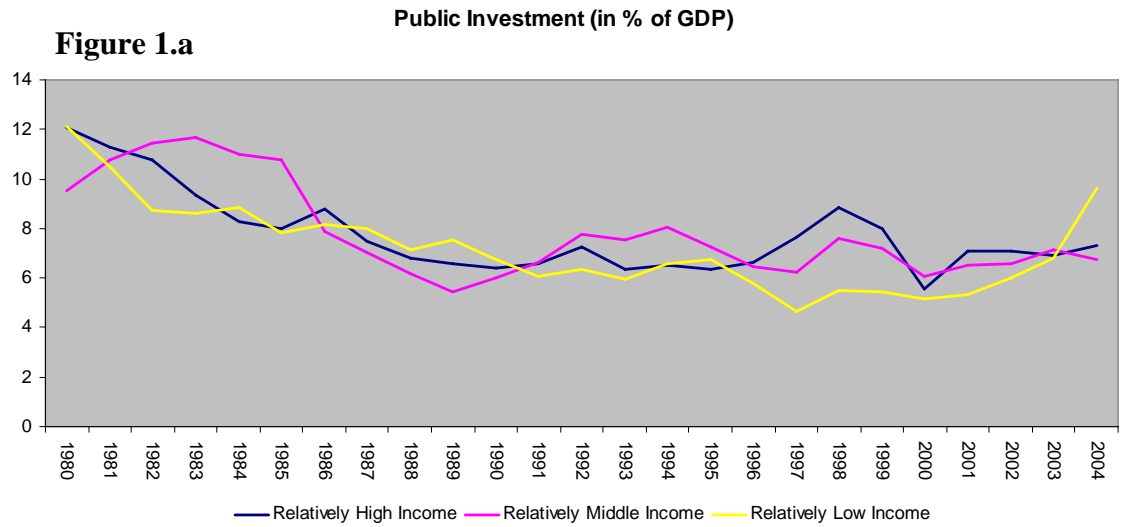
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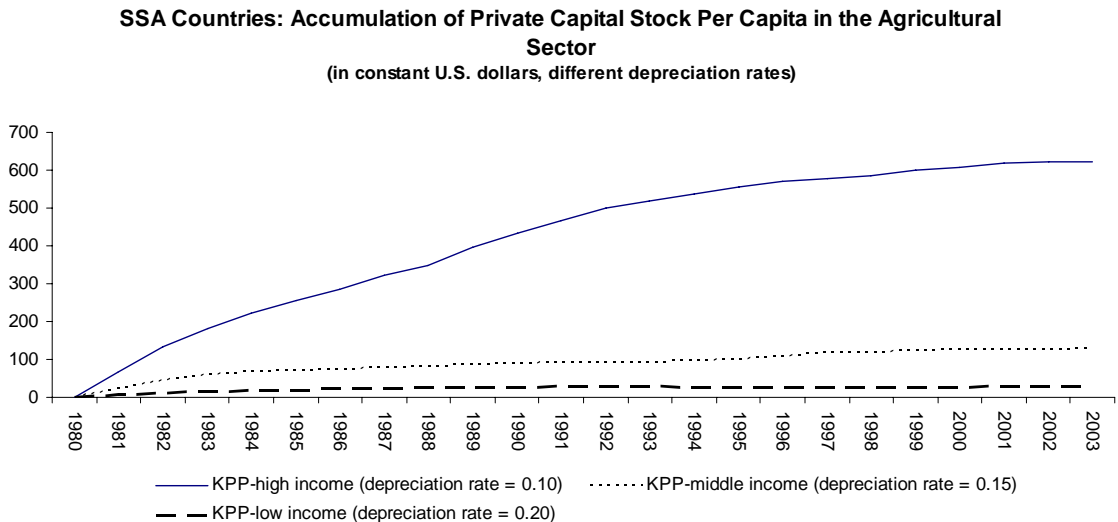
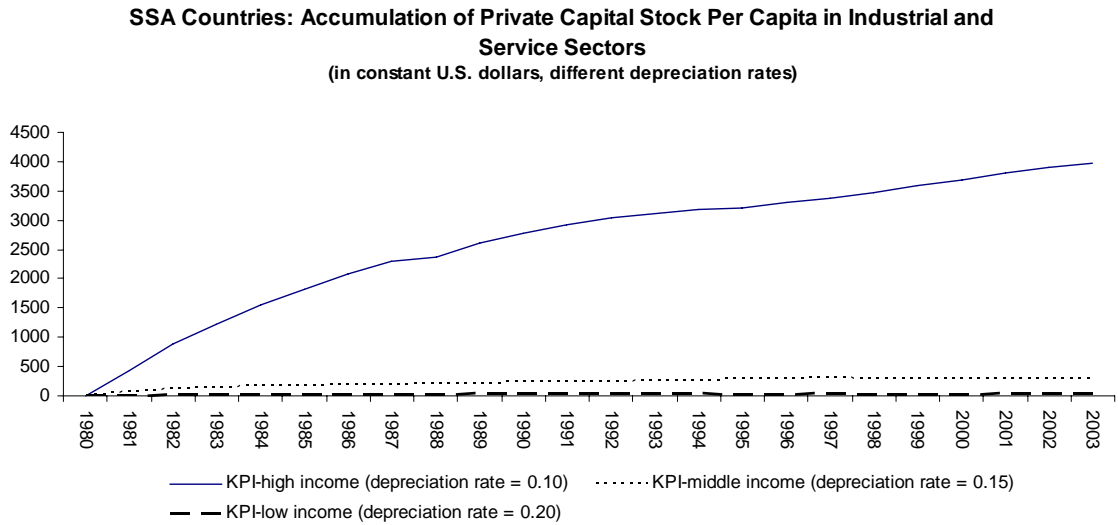
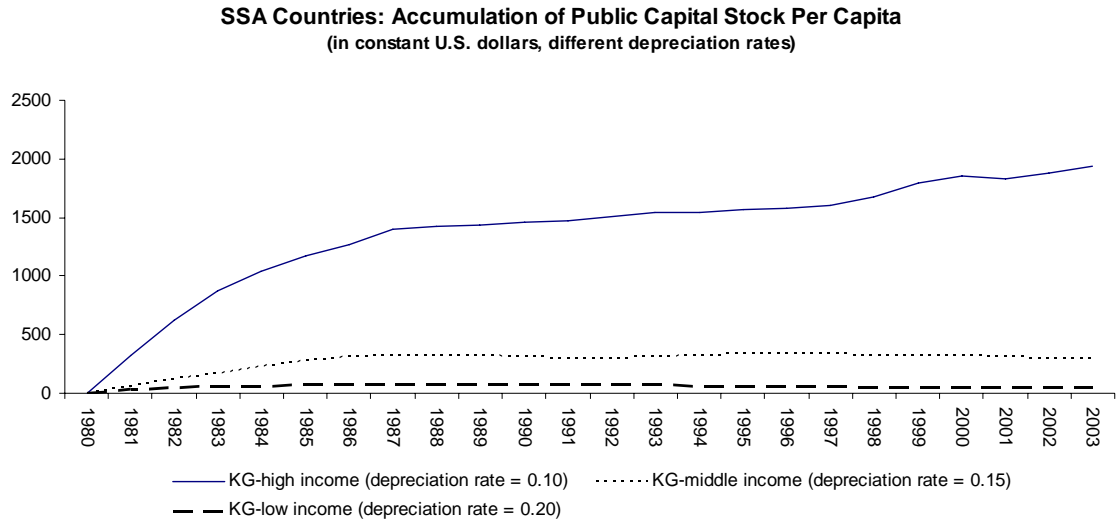
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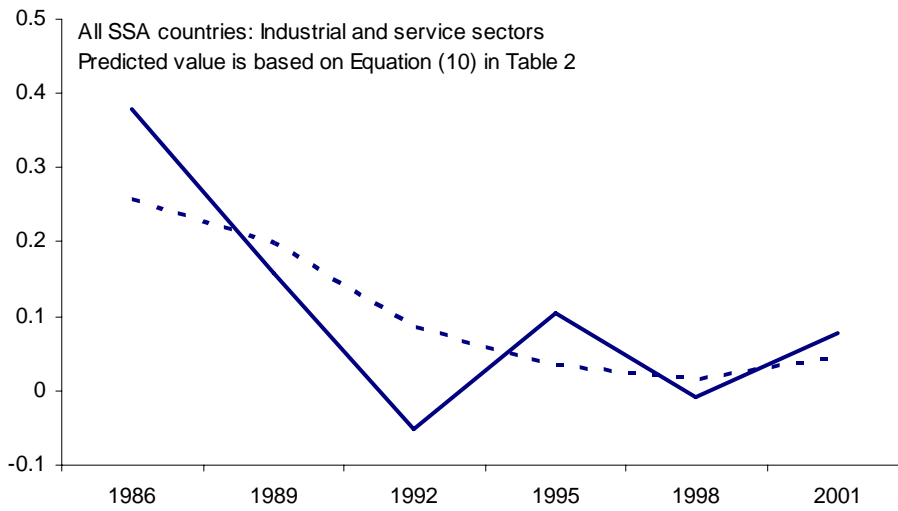
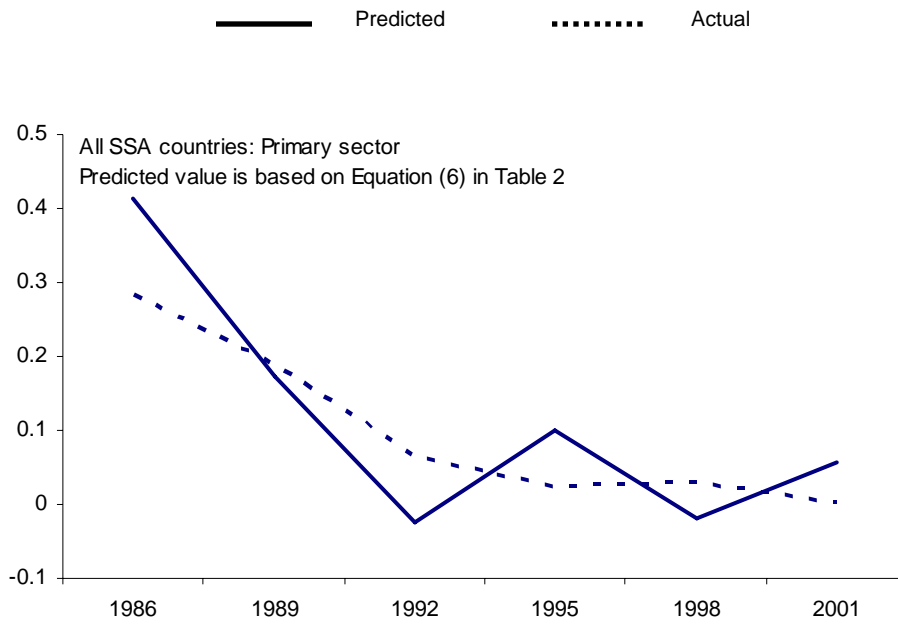
**Figure 1**  
**Sub-Saharan African Countries: Public and Private Investment**



**Figure 2**  
**SSA Countries: Accumulation of Capital Stock Per Capita**  
**(in constant U.S. dollars)**

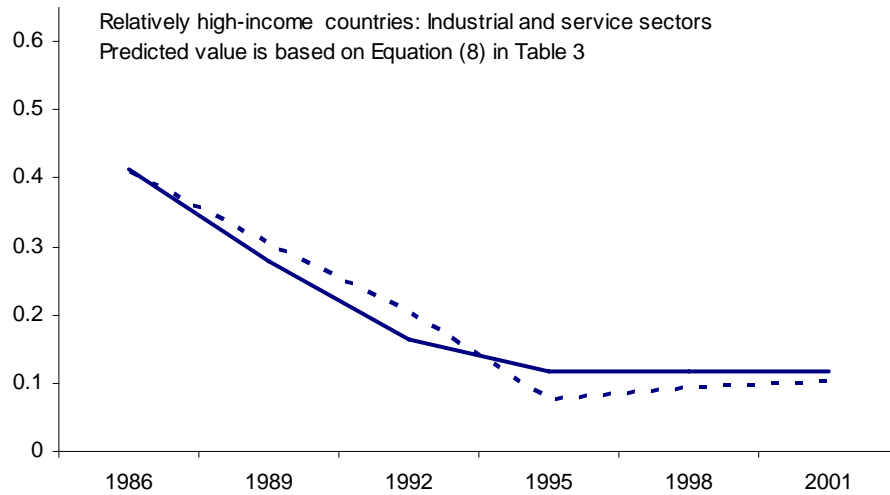
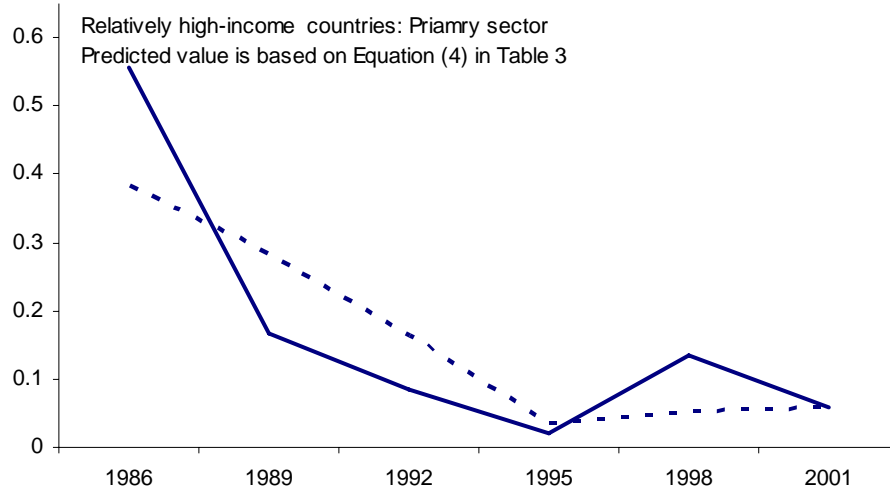


**Figure 3a**  
**Predicted and Actual Values of the First Difference of Private Capital Stock Per Capita in Log Terms**

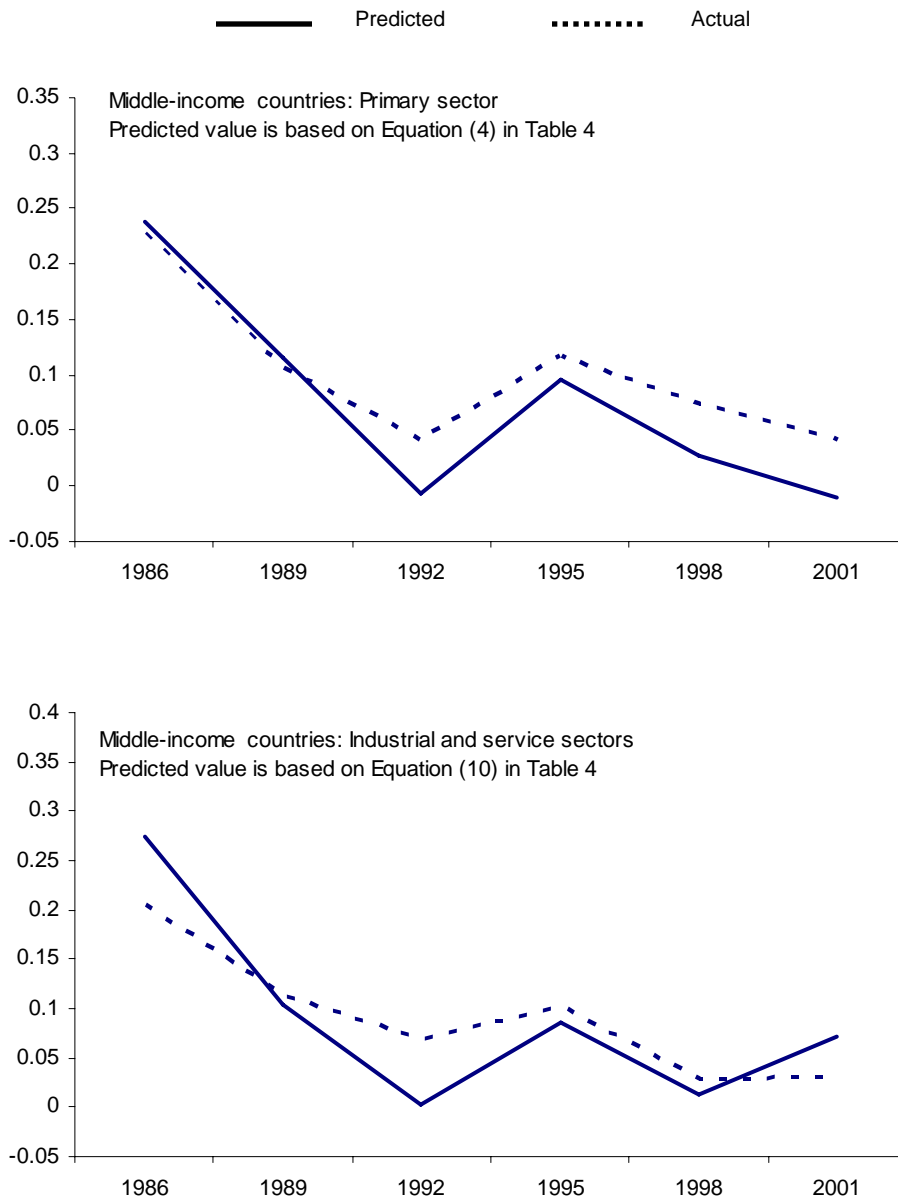


**Figure 3b**  
**Predicted and Actual Values of the First Difference of Private Capital Stock**  
**Per Capita in Log Terms**

Predicted     
  Actual

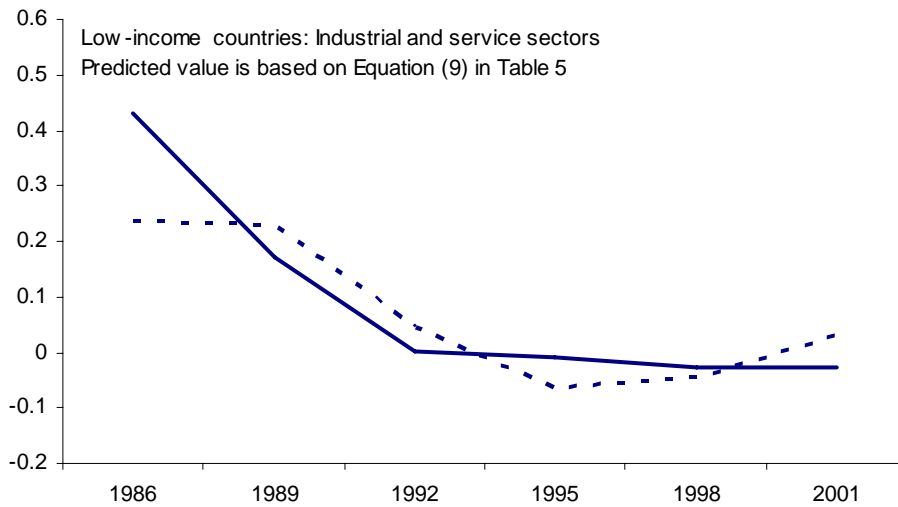
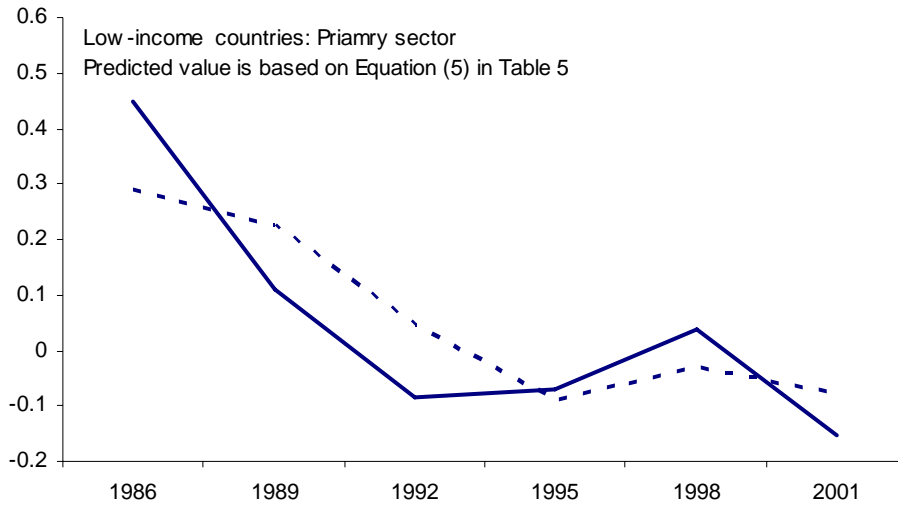


**Figure 3c**  
**Predicted and Actual Values of the First Difference of Private Capital Stock Per Capita in Log Terms**



**Figure 3d**  
**Predicted and Actual Values of the First Difference of Private Capital Stock**  
**Per Capita in Log Terms**

Predicted     
  Actual



**Table 1 - Capital Accumulation in Sub-Saharan Africa during the Adjustment Era, 1980-2004 (as percentage of GDP)**

	1980-1990	1991-2000	2001-2004	1980-2004
<i>High Income Countries</i>				
Private	16.47	16.27	15.20	16.19
Public	8.71	6.96	7.10	7.75
Total	25.07	23.27	22.25	23.90
<i>Middle Income Countries</i>				
Private	11.38	11.31	10.71	11.24
Public	8.89	7.08	6.75	7.82
Total	19.77	18.37	17.45	18.84
<i>Low Income Countries</i>				
Private	6.18	6.79	7.96	6.71
Public	8.56	5.82	6.95	7.20
Total	14.69	12.07	14.93	13.68
SSA				
Private	11.34	11.46	11.29	11.38
Public	8.72	6.62	6.93	7.59
Total	19.84	17.90	18.21	18.81

**Table 2 - Sub-Saharan Africa: Determinants of Private Capital Stock Per Capita, Different Depreciation Rates in Each Group, 1980-2004**  
(in constant U.S. dollars)

	<i>Dependent variable: First difference of ln of private capital stock per capita in the primary sector</i>					<i>Dependent variable: First difference of ln of private capital stock per capita in the industrial and service sectors</i>						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DKGPC(-1)	0.638 (9.244)***	0.598 (4.903)***	0.623 (15.338)***	0.453 (4.969)***	0.607 (8.709)***	0.603 (10.407)***	0.519 (3.525)***	0.581 (5.240)***	0.510 (4.291)***	0.566 (6.774)***	0.612 (4.237)***	0.696 (7.651)***
DGDPPC	0.184 (0.905)	-0.009 (0.564)	0.770 (9.291)***	0.974 (5.761)***	0.643 (3.701)***	0.767 (5.894)***	0.846 (4.337)***	0.361 (0.026)**	1.009 (7.544)***	1.181 (11.634)***	1.231 (8.983)***	0.954 (8.093)***
DINFL	-0.005 (-4.203)***		-0.001 (-1.714)*		-0.002 (-1.819)*		-0.003 (-1.533)		-0.002 (-1.345)		-0.001 (-0.472)	
DCREER		0.601 (6.146)***		0.484 (5.711)***		0.653 (12.070)***		0.678 (8.118)***		0.650 (8.602)***		0.784 (20.244)***
DDCGDP	0.416 (1.312)	1.026 (3.518)***					0.414 (2.576)***	1.070 (6.333)***				
DM2GDP			-0.008 (-0.041)	-0.658 (1.381)					0.825 (2.436)**	0.620 (2.601)***		
DM2M1GDP					0.481 (1.452)	0.441 (1.209)					0.183 (0.590)	1.347 (2.323)**
Sargan Test (p-values)	0.515	0.331	0.521	0.563	0.552	0.449	0.629	0.689	0.510	0.539	0.568	0.380
Second-order correlation	(0.441	0.233	0.428	0.878	0.470	0.342	0.996	0.208	0.950	0.520	0.831	0.220
Countries/observations	23/103	23/103	23/103	23/103	23/103	23/103	23/103	23/103	23/103	23/103	23/103	23/103

Note: The estimation methodology is GMM. The t-statistics, robust to the presence of heteroskedasticity, are given in paranthesis. 3-year averages are used in estimation. The depreciation rate is 10% for high-income countries, 15% for middle-income countries, and 20% for low-income countries. The null hypothesis of Sargan and second-order correlation test is correct identification of the model. DKGPC is the first difference of public capital per capita in logs. DGDPPC is the first difference of public capital per capita in logs. DINFL is the first difference of inflation rate. DCREER is the first difference of changes in real effective exchange rate. DDCGDP is the first difference of domestic credits to private sector as a share of GDP. DM2GDP is the first difference of M2 as a share of GDP. DM2M1 GDP is the first difference of (M2-M1) as a share of GDP.



**Table 3 - High-income SSA Countries: Determinants of Private Capital Stock Per Capita, Different Depreciation Rates in Each Group, 1980-2002**  
(in constant U.S. dollars)

	<i>Dependent variable: First difference of ln of private capital stock per capita in the primary sector</i>						<i>Dependent variable: First difference of ln of private capital stock per capita in the industrial and service sectors</i>					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DKGPC(-1)	0.451 (3.332)***	0.463 (4.656)***	0.533 (20.453)***	0.531 (28.774)***	0.512 (15.463)***	0.521 (17.446)***	0.418 (5.183)***	0.429 (7.484)***	0.476 (30.083)***	0.472 (15.712)***	0.467 (23.254)***	0.480 (12.742)***
DGDPPC	0.495 (1.191)	0.435 (1.031)	-0.280 (-1.072)	-0.337 (-1.675)*	-0.175 (-0.402)	-0.407 (-1.302)	1.271 (4.563)***	1.221 (4.493)***	0.801 (5.219)***	0.699 (6.542)***	0.303 (2.845)***	0.658 (3.190)***
DINFL	1.661 (1.387)	1.282 (1.697)*			-0.199 (-0.134)		1.213 (1.104)		0.348 (0.440)		-0.553 (-0.442)	
DCREER		-0.688 (-2.747)***		-0.409 (-1.213)		-0.014 (-0.047)		-0.583 (2.624)***		-0.326 (-1.065)		-0.058 (-0.218)
DDCGDP	0.921 (1.819)*	0.690 (1.770)*					0.868 (2.259)**	0.693 (2.435)**				
DM2GDP			3.179 (6.002)***	3.184 (5.833)***					2.208 (7.711)***	2.308 (15.100)***		
DM2M1GDP					2.954 (3.093)***	3.136 (4.191)***					2.062 (2.964)***	2.195 (4.267)***
Sargan Test (p-values)	na	na	na	na	na	na	na	na	na	na	na	na
Second-order correlation	(0.421	0.689	0.179	0.114	0.239	0.328	0.694	0.309	0.207	0.179	0.420	0.421
Countries/observations	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26	5/26

Note: The estimation methodology is GMM. The t-statistics, robust to the presence of heteroskedasticity, are given in parenthesis. 3-year averages are used in estimation. The depreciation rate is 10% for high-income countries, 15% for middle-income countries, and 20% for low-income countries. The null hypothesis of Sargan and second-order correlation test is correct identification of the model. DKGPC is the first difference of public capital per capita in logs. DGDPPC is the first difference of public capital per capita in logs. DINFL is the first difference of inflation rate. DCREER is the first difference of changes in real effective exchange rate. DDCGDP is the first difference of domestic credits to private sector as a share of GDP. DM2GDP is the first difference of M2 as a share of GDP. DM2M1GDP is the first difference of (M2-M1) as a share of GDP.

**Table 4 - Middle-Income SSA Countries: Determinants of Private Capital Stock Per Capita, Different Depreciation Rates in Each Group, 1980-2002**  
(in constant U.S. dollars)

	<i>Dependent variable: First difference of ln of private capital stock per capita in the primary sector</i>						<i>Dependent variable: First difference of ln of private capital stock per capita in the industrial and service sectors</i>					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DKGPC(-1)	0.351 (3.402)***	0.319 (2.608)***	0.421 (4.209)***	0.236 (1.743)*	0.409 (2.916)***	0.374 (5.136)***	0.437 (4.592)***	0.336 (2.194)**	0.515 (6.734)***	0.333 (3.708)***	0.501 (5.135)***	0.395 (2.739)***
DGDPPC	1.194 (2.775)***	1.114 (3.065)***	1.635 (3.385)***	1.201 (2.077)**	1.680 (2.309)**	2.258 (3.273)***	1.104 (3.612)***	1.107 (2.477)**	1.508 (2.633)***	0.973 (3.195)***	1.601 (4.585)***	1.232 (3.054)***
DINFL	-0.056 (-0.414)		-0.005 (-0.410)		-0.064 (-0.257)		0.022 (0.335)		0.210 (1.402)		-0.095 (-1.008)	
DCREER		0.172 (0.975)		0.377 (2.082)**		0.279 (0.896)		0.506 (2.691)***		0.519 (5.119)***		0.576 (2.337)**
DDCGDP	-3.057 (-2.399)**	-0.289 (-0.341)					-1.025 (-1.791)*	-0.229 (-0.264)				
DM2GDP			-1.515 (-1.743)*	-2.881 (-3.821)***					-1.179 (-1.780)*	-0.636 (-0.989)		
DM2M1GDP					-0.925 (-0.491)	-2.183 (-2.228)**					-3.781 (-4.297)***	-0.451 (-0.474)
Sargan Test (p-values)	0.982	0.956	0.999	0.997	0.994	0.999	0.962	0.173	0.983	0.962	0.999	0.686
Second-order correlation	(0.053	0.973	0.887	0.103	0.985	0.203	0.159	0.219	0.041	0.174	0.285	0.299
Countries/observations	9/43	9/43	9/43	9/43	9/43	9/43	9/43	9/43	9/43	9/43	9/43	9/43

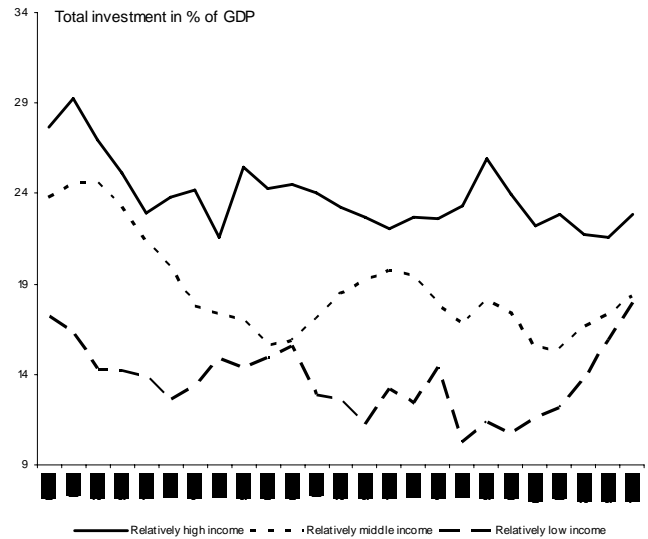
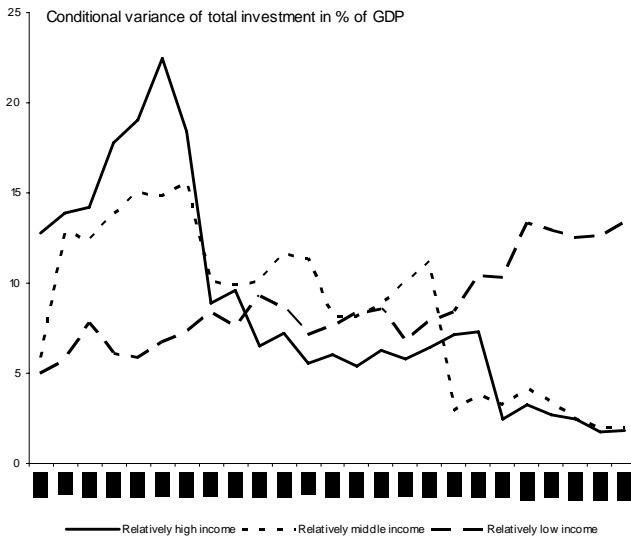
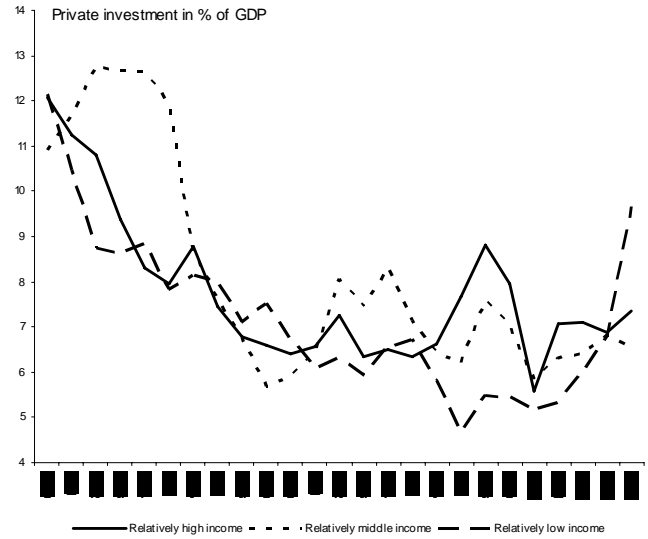
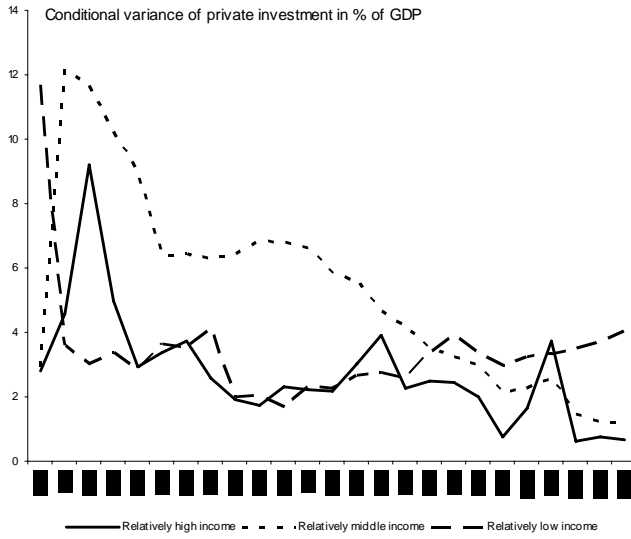
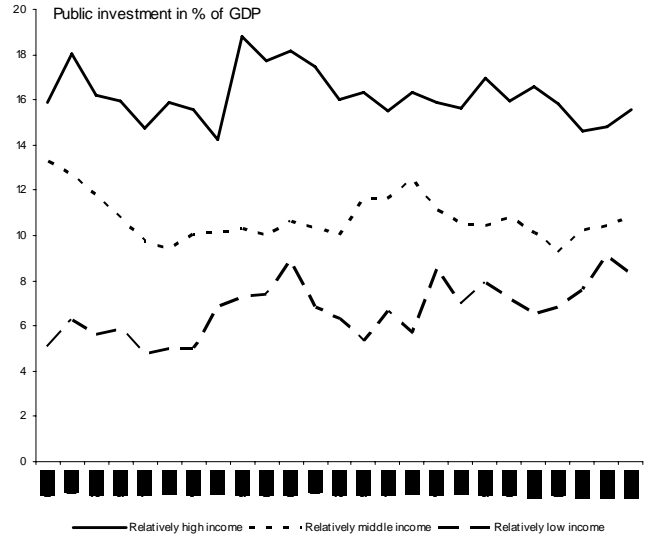
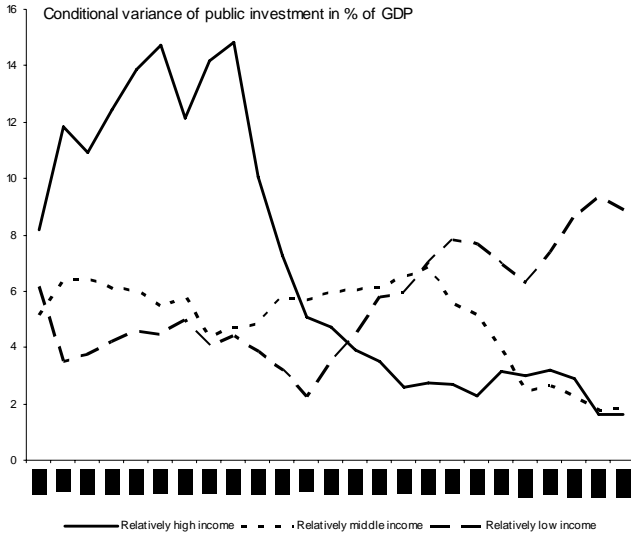
Note: The estimation methodology is GMM. The t-statistics, robust to the presence of heteroskedasticity, are given in parenthesis. 3-year averages are used in estimation. The depreciation rate is 10% for high-income countries, 15% for middle-income countries, and 20% for low-income countries. The null hypothesis of Sargan and second-order correlation test is correct identification of the model. DKGPC is the first difference of public capital per capita in logs. DGDPPC is the first difference of public capital per capita in logs. DINFL is the first difference of inflation rate. DCREER is the first difference of real effective exchange rate. DDCGDP is the first difference of domestic credits to private sector as a share of GDP. DM2GDP is the first difference of M2 as a share of GDP. DM2M1GDP is the first difference of (M2-M1) as a share of GDP.

**Table 5 - Low-Income SSA Countries: Determinants of Private Capital Stock Per Capita, Different Depreciation Rates in Each Group, 1980-2002**  
(in constant U.S. dollars)

	<i>Dependent variable: First difference of ln of private capital stock per capita in the primary sector</i>						<i>Dependent variable: First difference of ln of private capital stock per capita in the industrial and service sectors</i>					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
DKGPC(-1)	0.338 (2.382)**	0.712 (3.876)***	0.756 (3.031)***	0.709 (2.810)***	1.038 (3.381)***	0.641 (2.441)**	0.264 (1.235)	0.636 (2.542)**	0.847 (3.389)***	0.683 (2.740)***	0.416 (2.205)**	0.531 (1.930)*
DGDPPC	-0.016 (-0.040)	0.745 (2.778)***	-0.437 (-0.599)	0.711 (1.814)*	-1.267 (-1.828)*	0.724 (1.664)*	0.352 (0.638)	0.437 (1.270)	-0.669 (-1.139)	0.358 (1.295)	0.278 (0.604)	0.800 (1.756)*
DINFL	-0.006 (-2.033)**		-0.010 (-1.726)*		-0.015 (-3.076)***		-0.005 (-1.188)		-0.013 (-2.840)***		-0.005 (-1.406)	
DCREER		0.240 (0.403)		-0.720 (-3.313)***		-0.265 (-1.021)		0.263 (0.458)		-0.312 (-1.286)		-0.283 (-1.005)
DDCGDP	1.473 (1.277)	3.692 (1.132)					0.406 (0.399)	3.215 (0.976)				
DM2GDP			0.716 (0.604)	-1.964 (-2.265)**					1.211 (1.157)	0.219 (0.225)		
DM2M1GDP					9.893 (1.911)*	-1.860 (-0.531)					4.456 (0.959)	-2.563 (-0.693)
Sargan Test (p-values)	0.997	0.998	0.997	0.983	1.000	0.972	0.954	0.995	0.991	0.992	0.996	0.974
Second-order correlation (	0.204	0.015	0.146	0.403	0.000	0.621	0.643	0.026	0.212	0.364	0.161	0.431
Countries/observations	9/39	9/39	9/39	9/39	9/39	9/39	9/39	9/39	9/39	9/39	9/39	9/39

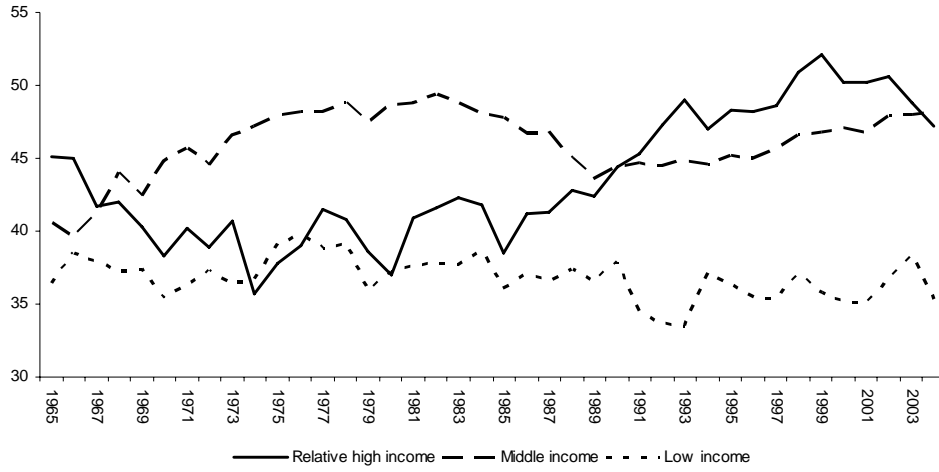
Note: The estimation methodology is GMM. The t-statistics, robust to the presence of heteroskedasticity, are given in parenthesis. 3-year averages are used in estimation. The depreciation rate is 10% for high-income countries, 15% for middle-income countries, and 20% for low-income countries. The null hypothesis of Sargan and second-order correlation test is correct identification of the model. DKGPC is the first difference of public capital per capita in logs. DGDPPC is the first difference of public capital per capita in logs. DINFL is the first difference of inflation rate. DCREER is the first difference of changes in real effective exchange rate. DDCGDP is the first difference of domestic credits to private sector as a share of GDP. DM2GDP is the first difference of M2 as a share of GDP. DM2M1GDP is the first difference of (M2-M1) as a share of GDP.

**Figure 1 – Annex**  
**Investment Uncertainty**

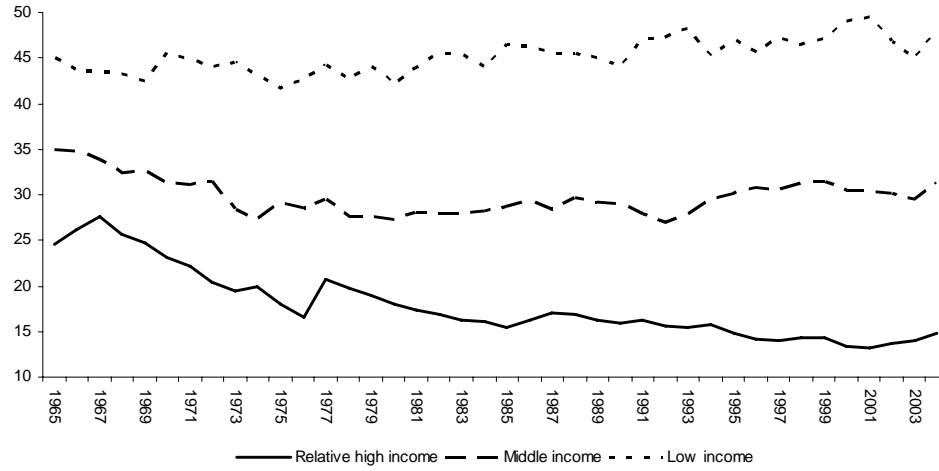


**Figure 2 – Annex**  
**Sub-Saharan Africa: Shares of Sectors in GDP**

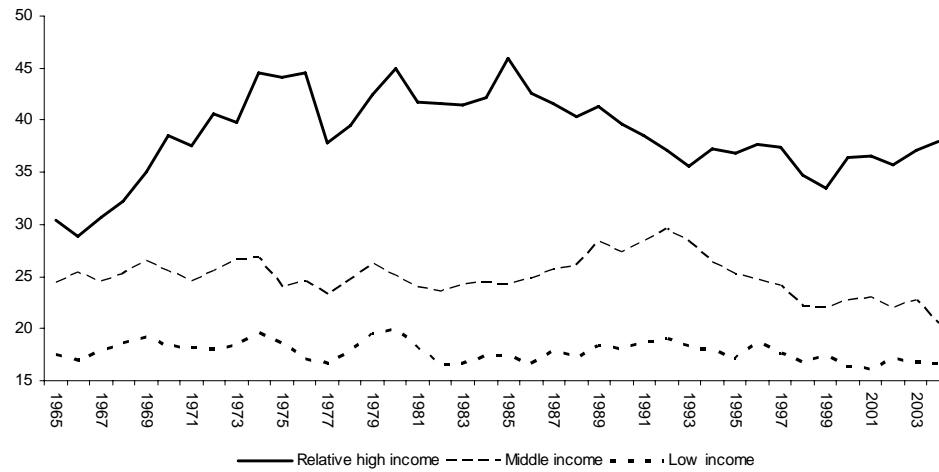
**Share of Services (in % of GDP)**



**Share of Primary Sector (in % of GDP)**



**Share of Industry (in % of GDP)**



## Table 1 - Annex

Table - GDP Per Capita (in constant 2000 US\$)

	1970-1979	1980-1989	1990-2003	AVERAGE 1970-2003	Median 1970-2003	Standard deviation 1970-2003
<i>Relatively high income</i>						
Botswana	808	1710	2850	1789	1830	924
<b>Gabon</b>	4888	4364	4036	4429	4143	908
Mauritius	...	1898	3305	2601	2696	836
Namibia	...	1798	1749	1774	1770	91
South Africa	3314	3364	3020	3233	3174	209
<b>GROUP AVERAGE</b>	<b>3003</b>	<b>2627</b>	<b>2992</b>	<b>2765</b>	<b>2723</b>	<b>594</b>
<i>Middle income</i>						
Cameroon	523	786	581	630	596	126
Cape Verde	299	749	1070	706	867	329
<b>Comoros</b>	...	428	380	404	406	30
Cote d'Ivoire	963	825	663	817	775	145
Kenya	315	353	357	342	350	27
Nigeria	396	319	336	350	335	40
<b>Senegal</b>	453	428	434	438	434	24
<b>Swaziland</b>	503	524	1322	783	599	410
<b>Zambia</b>	550	434	345	443	413	91
<b>Zimbabwe</b>	582	575	565	574	576	49
<b>GROUP AVERAGE</b>	<b>499</b>	<b>577</b>	<b>564</b>	<b>549</b>	<b>535</b>	<b>127</b>
<i>Low income</i>						
Burundi	122	139	118	126	127	17
Central African Republ	347	299	250	299	286	42
Congo, Dem. Rep.	309	242	120	224	239	87
Ethiopia	...	99	95	97	98	8
Gambia	303	333	315	317	323	19
Malawi	148	149	158	152	152	11
Niger	278	227	178	227	205	49
Sierra Leone	281	279	171	244	270	62
Togo	331	326	290	316	313	29
<b>GROUP AVERAGE</b>	<b>265</b>	<b>233</b>	<b>188</b>	<b>222</b>	<b>224</b>	<b>36</b>
<b>TOTAL</b>	<b>1256</b>	<b>1145</b>	<b>1248</b>	<b>881</b>	<b>384</b>	<b>190</b>

## Table 2 - Annex

### Table - Investment Uncertainty (lagged values) and Growth

	Average Investment Uncertainty			Correlation between lagged value of investment uncertainty and GDP growth			Correlation between lagged value of investment and GDP growth		
	Public	Private	Total	Public	Private	Total	Public	Private	Total
	investment	investment	investment	investment	investment	investment	investment	investment	investment
<i>Relatively high income</i>									
Botswana	5.347	1.498	3.069	0.739	0.559	0.671	0.205	0.107	0.311
Gabon	20.896	6.401	30.605	0.020	-0.231	-0.304	-0.276	-0.571	-0.512
Mauritius	3.351	0.545	2.659	0.473	0.234	0.407	-0.015	-0.275	-0.152
Namibia	3.911	4.733	5.146	0.073	-0.416	0.276	0.367	-0.564	-0.142
South Africa	0.905	0.612	1.249	0.159	0.159	-0.193	-0.224	-0.004	-0.085
<b>GROUP AVERAGE</b>	<b>6.882</b>	<b>2.758</b>	<b>8.546</b>	<b>0.293</b>	<b>0.061</b>	<b>0.172</b>	<b>0.012</b>	<b>-0.261</b>	<b>-0.116</b>
<i>Middle income</i>									
Cameroon	2.719	1.380	5.660	0.298	-0.364	0.164	0.052	-0.363	-0.160
Cape Verde	8.238	28.000	39.375	0.141	0.135	0.372	-0.167	0.472	0.411
Comoros	0.474	6.281	7.146	-0.104	0.257	0.227	-0.255	0.265	0.245
Cote d'Ivoire	3.478	0.999	2.379	0.214	0.104	0.054	-0.395	-0.238	-0.316
Kenya	1.143	1.727	3.789	0.238	0.100	-0.239	0.342	0.173	0.339
Nigeria	10.450	5.345	9.450	-0.462	-0.431	0.174	0.395	-0.371	-0.242
Senegal	0.227	0.506	0.940	-0.296	0.133	0.522	0.233	0.315	0.300
Swaziland	14.789	6.265	11.232	0.154	0.042	0.106	0.020	-0.004	0.015
Zambia	3.669	2.607	3.023	0.030	-0.302	0.220	0.010	0.332	0.217
Zimbabwe	4.706	1.143	4.370	-0.322	-0.408	-0.174	0.138	0.093	0.143
<b>GROUP AVERAGE</b>	<b>4.989</b>	<b>5.425</b>	<b>8.736</b>	<b>-0.011</b>	<b>-0.073</b>	<b>0.142</b>	<b>0.037</b>	<b>0.067</b>	<b>0.095</b>
<i>Low income</i>									
Burundi	0.582	4.183	6.425	-0.204	-0.101	0.358	0.109	0.256	0.264
Central African Republic	3.042	3.158	7.116	-0.205	0.305	-0.157	0.118	-0.295	-0.080
Ethiopia	1.610	1.757	4.809	-0.245	0.333	-0.066	0.185	-0.103	-0.038
Gambia	4.161	2.444	4.542	-0.038	0.345	0.116	0.113	-0.136	-0.029
Malawi	5.027	3.725	10.592	-0.071	-0.309	0.034	0.315	-0.020	0.211
Niger	0.969	1.993	2.888	0.058	-0.253	-0.146	0.033	-0.185	-0.152
Sierra Leone	4.682	3.033	11.647	0.271	0.153	0.295	0.070	0.090	0.089
Togo	5.187	2.725	6.436	0.063	-0.088	0.012	-0.087	-0.207	-0.339
<b>GROUP AVERAGE</b>	<b>3.158</b>	<b>2.877</b>	<b>6.807</b>	<b>-0.046</b>	<b>0.048</b>	<b>0.056</b>	<b>0.107</b>	<b>-0.075</b>	<b>-0.009</b>