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Fiscal Response to External Finance: The Case of Sub-Saharan Africa

(Preliminary Draft)

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Abstract:

The importance of capital accumulation for economic growth and hence development was widely recognized long time ago. However, developing countries - especially Sub-Saharan African countries, are still trapped in ‘vicious circle of poverty’ and failed to finance desired level of investment from their own domestic savings. Earlier models of development argued that these countries would come out of stagnation only if they got assistance from the developed world (Rodan 1961, and Chenery and Strout 1966). The two-gap model of Chenery and Strout (1966) showed that these countries are constrained with little domestic savings and foreign exchange earnings. The model predicted that foreign aid is an optimal means to break the circle and solve the two gaps (saving and foreign exchange gaps) simultaneously. However, their results were criticized both theoretically and empirically, and there has been a growing concern that foreign aid can be a substitute for domestic saving (foreign aid displacing domestic savings instead of supplementing it). This was mainly due to its negative impact on governments’ tax collection effort resulting in reduced tax revenue and its allocation for consumption rather than investment.

The purpose of this paper is to empirically investigate the impact of foreign aid inflows on governments’ revenue collection and expenditure behaviors (fiscal response) using pooled data from Sub-Saharan Africa countries. To this effect we extend the neoclassical utility maximization approach of Heller (1975) by treating foreign aid as one of the endogenous variables. The reason we do this is because public policy makers anticipate foreign aid and formulate their policy accordingly. We hypothesize that different types of aid (grants and loans) and aid from different sources (bilateral and multilateral) have different impact on the recipient governments’ revenue collection and expenditure behavior. The structural equations derived from maximization problem of policy-makers’ utility function subject to financing constraints are estimated using 3SLS estimation technique. The finding of this study shows that grants and aid from bilateral sources are pro-consumption and hence have little effect on long run growth. On the other hand, loans and aid from multilateral sources are pro-investment. This research would make contributions to the existing literature as there is no other study made regarding this issue in the context of Sub-Saharan Africa countries.

JEL Classification: F35 – Foreign Aid

I. Introduction

Economic growth is central problem of almost all nations and capital accumulation is at the center of economic growth - especially in less developed countries. Although the importance of capital accumulation was recognized long time ago (see Harrod 1939, Domar 1946, and Lewis 1954), less developed countries have generally failed to finance the desired level of investment out of their own resources (savings). This condition called for foreign aid as an optimal means to break the 'vicious circle of poverty' experienced by these poor countries and fasten the transformation process.

Early 'structural' development models such as Harrod-Domar growth model, two-gap model of Chenery and Strout (1966) showed how foreign aid would enable developing countries to transform their economies. The two-gap model, which can be considered as an extension of Harrod-Domar model has firmly established that foreign aid would assist developing countries by eliminating the two gaps (saving and foreign earning gap) simultaneously. It solves the two gaps when aid coming in the form of hard currencies enables recipient countries to import more capital goods over and above what they would have done from their own earning only (Rodan 1961, and Chenery and Strout 1966).

The practical success of the Marshal Plan of 1948, which enabled the war devastated Western European countries to get out of crisis, was sighted as an evidence to extend the program to developing countries. Since 1960s, aid became one feature of the relationship between developed and developing countries (McGillivray and Morrissey 2001 and Franco-Rodriguez *et al* 1998).

The question to follow is the effectiveness of aid in bringing the desired change. It is difficult to conclude as empirical studies came up with mixed results. Some argued that aid has positive impact when used in good policy environment (see Durbarry *et al* 1998, Ali *et al* 1998, Khan 1998 and Burnside and Dollar 2000) while others argued that aid, at best, has no demonstrable effect at all (see Griffin and Enos 1970, Weisskoff 1972, Dowling and Hiement 1983, Mosley *et al* 1987).

The purpose of this paper is to empirically investigate the impact of foreign aid inflows on governments' revenue collection and expenditure behaviors (fiscal response) using data from Sub-Saharan Africa countries¹. We hypothesize that different types of aid (grants and loans) and aid from different sources (bilateral and multilateral) have different impact on the recipient governments' revenue collection and expenditure behavior. For instance, we expect grants (free resource on which repayment is not expected) are directed towards consumption while loans are channeled towards investment. In addition, foreign aid will not only increase government spending but also reduces governments' revenue collection efforts. To this end, we make use of the neoclassical utility maximization approach of Heller (1975) and extend the model to endogenise foreign aid. Six structural equations derived from policy-makers' utility function subject to financing constraints will be estimated using 3SLS estimation technique. This research would make contributions to the existing literature as there is no other study made regarding this issue in the context of Sub-Saharan Africa countries.

II. Literature Review

2.1 Theoretical Literature

Although empirical studies on aid-growth relation came up with conflicting results, early development models supported the idea that foreign aid promotes growth in recipient countries by augmenting little domestic savings and easing foreign exchange shortage. On fiscal response however, there were no such well-developed theories, which predict the impact of foreign aid inflow on recipient government's revenue collection, expenditure and borrowing behavior. On the revenue side, aid may increase the government's tax collection efforts especially when the aid is tied (to a project) and the government is required to mobilize domestic resource to cover part of the cost of the

¹ The countries are selected purely based on availability of complete data and the study includes twenty one Sub-Saharan Africa countries namely: Benin, Botswana, Burkina Faso, Burundi, Congo Rep., Cote d'Ivoire, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mauritania, Mauritius, Rwanda, Senegal, Seychelles, Swaziland, Togo, Uganda, Zambia

project. The domestic resources counter part of aid could mainly come through increased domestic taxation. Most of the studies in fiscal response, however, hypothesized that inflow of aid may reduce the government's tax collection effort (Griffin and Enos 1970, Heller 1975, Mosley *et al* 1987). Especially weak governments with weak institutional set up may tend to reduce their tax collection efforts when they got some foreign resource especially grant (Griffin and Enos 1970), because foreign resources are an additional resource for the government to finance its expenditures. In that case, foreign resources are driving domestic resource down whose outcome is expected to retard growth (Griffin and Enos 1970, Weisskoff 1972). As Rodan (1961) argued domestic efforts being the principal element in the transition, if inflows of foreign resources create a disincentive - like reducing tax collection effort of the government, it rather becomes inimical to growth. That is why studies that found aid reducing domestic saving argue that aid retards growth (see Griffin 1970, Weisskoff 1972). World Bank (1998) argued that when aid reduces tax 'it encourages incompetence, corruption, misguided policies' which retard growth.

On the expenditure side, aid definitely increases government expenditures for the obvious reason that it increases the availability of resources that helps the government to finance its expenditures assuming that reduction in tax does not offset the inflow of aid. However, the type of expenditure, which increases following aid inflow, may differ from country to country. There is a hypothesis that governments in the recipient countries mostly use the resources to finance consumption like military expenditure, increasing salary of civil servant etc (Heller 1975). Others may use it to finance developmental projects like construction of irrigation schemes, dams etc (Gang and Khan 1991). The growth effect of such uses of foreign resource is obviously different. The growth outcome of foreign resources depends on how it is used and its effect on government tax revenue. There remains a debate as to whether reduction in tax and increased consumption rather than investment has low growth payoff.

Most of the studies reviewed below hypothesized that the effects of different types of aid on both revenues and expenditures of the government of the recipient country differ. The

hypothesis is that grants may be directed to consumption while loans tend to be used in productive areas of capital expenditures. The difference being the first one is not paid while the latter one is paid back implying the existence of incentive problem.

The hypotheses mentioned above are based on different assumptions about the behavior of the government in the recipient country. Hence, it will be an empirical issue to investigate which one of the above hypotheses is valid. The earlier model in the fiscal response literature was the Heller (1975) model, which is widely used in the literature on the area (see Mosley *et al* 1987, White 1993, 1994, Gang and Khan 1991, Khan and Hoshino 1992, Khan 1998, Otim 1996, Alemayehu 1996, 2002, Franco-Rodriguez *et al* 1998, Gupta *et al* 2003).

Heller (1975) specified the recipient policymaker's utility function in linear-quadratic form written in deviation of actual from target values of the choice variables (government expenditures and revenues). The utility function is maximized subject to financing constraints, which was disaggregated into two, where the accounting identity total receipts equal total expenditures holds. The utility function specified exhibits diminishing marginal utility and it increases with expenditures and decreases with domestic resources. Although the government tries to minimize the deviations from the target values, it is symmetric (it assumes that the government attach equal weight to overshooting and undershooting of the choice variables).

Although Heller's model was the first and used as a basis for the growing literature in the area of fiscal response, there were attempts, which modified the theoretical settings by changing some of the assumptions used by Heller (1975) (see Mosley *et al* 1987, White 1994, Gang and Khan 1999, Khan 1998 and Franco-Rodriguez *et al* 1998).

In addition to some modifications of the Heller model, Mosley *et al* (1987) extended the fiscal response analysis a step forward to investigate the total impact of foreign capital on output growth that goes through private and public investment. Hence, they specified private investment function in such a way it captures the effect of aid that goes through

change in price. They specified output as a function of public and private capital stock so that the indirect effect of aid, which goes through private and public investment, is captured.

Although Gang and Khan (1991), adopted the Heller's specification in their latter paper conducted in 1999, (Gang and Khan 1999) they argued that the earlier specification by Heller was unrealistic as it assumes that the government attaches equal weights to over and undershooting the target variables. Hence, Gang and Khan (1999) proposed a 'quadratic-ratio loss function' rather than in deviation form. In both cases (earlier specification in 'linear-quadratic function in deviation form' and the latter 'quadratic-ratio') it was assumed that policymaker's tries to minimize the deviation from target values but over and undershooting were weighted differently. The latter specification, 'quadratic-ratio loss function' by Gang and Khan (1999) allowed them to estimate the fiscal response of different types of policymakers who differ by the weight they attach to over and undershooting of target values of different choice variables (see Gang and Khan 1999, and Khan 1998). Finally, they choose among the policymakers using Akaike information criteria and personal observation. To investigate the fiscal response behavior of three Southeast Asian countries Khan (1998) also used the same procedure.

Franco-Rodriguez *et al* (1998) treat aid as an endogenous variable in their quadratic utility function specification. Contrary to the earlier studies, Franco-Rodriguez *et al* (1998) has also allowed domestic borrowing to finance consumption expenditures, which was earlier restricted to financing investment. In the budget constraint, they used inequalities, which is slightly different from earlier studies.

2.2. Empirical Literature

The empirical part of Heller's (1975) study has considered the impact of different types of aid (grant and loan; bilateral and multilateral) on several categories of public expenditures (public expenditure for developmental purposes, civil consumption in the public sector, socio-economic consumption in the public sector), government revenue and

domestic borrowing. Heller (1975) examined this using data from eleven African countries categorized as French and English speaking. He concluded that aid increases both government investment and consumption and reduce taxes and domestic borrowing. It increases total government expenditure because aid inflows increase availability of resource for the government to finance its expenditures. By decomposing aid into grant and loan, Heller (1975) found that grant has a stronger pro-consumption bias while concessional loan has strong pro-investment bias. Therefore, grant directly contributes to increased public consumption and indirectly to private consumption by reducing taxes. Heller estimated the equations by pooling cross-section and time series data.

The 2SLS estimation results of the study by Heller (1975) found that in both samples (French and English speaking) government investment takes 63 to 76 percent of total loans in contrast to 41 to 53 percent of official grant, proving the argument that grants have pro-consumption bias while loans have pro-investment bias. The fact that Heller (1975) find grant to be more pro-consumption while loan to be more pro-investment bias strengthened the suspect that different types of aid have different macroeconomic consequences. The empirical study by Levy (1997) has also showed that there is a difference in utilization of anticipated and unanticipated aid. The result from the estimation of consumption function of sample countries showed that unanticipated aid is fully consumed but more than 40 percent of anticipated assistance is invested.

The impact of foreign financial inflow on growth was not explicitly captured in Heller's model. This was picked up by Mosley et al. (1987) where Heller's model was extended and the impact of aid on output growth is assessed. In the original Heller's model, the target level of public investment was given as a function of lagged output and private investment. In Mosley et al. (1987), first, the private investment is extended to include price effects (by dividing it into tradable and non tradable sectors) of aid inflows and second, output is further redefined as an aggregate production function of private and government capital stock and labor. Their empirical findings from both cross sectional and time series data shows that 'aid in the aggregate has no demonstrable effect on economic growth in recipient countries' both in the 1960's and 1970's. According to their

argument this could arise theoretically, *'if the foreign aid is reallocated into non-productive expenditures in the public sector (fungibility' of aid money) or the transmission of negative price effects in the private sector'*, (Mosley et al.,1987: 623).

Adopting the Heller (1975) model, Gang and Khan's (1991) empirically examined the fiscal behavior of the Indian government to foreign capital inflows using time series data. To investigate the links between aid and development they proposed a two-step procedure. The first step concentrates on the fiscal response aspect of foreign aid while the second step deals with examining the impact of public investment and consumption on developmental variables such as growth and income distribution (Gang and Khan, 1991). Although they employed the framework developed by Heller (1975), they have estimated using non-linear 3SLS estimation technique. Substantively, Gang and Khan (1991) results confirm Heller's initial findings on the tax side but contradict his and other earlier results on expenditure side. The parameters that show the proportion of tax revenues, grants and loans spent on recurrent expenditures (G_c and G_s) are 1.08, -0.79 and -0.03 respectively. The fact that the last two parameters are insignificant show that aid does not statistically affect government consumption but all tax revenues are used to finance consumption. The findings of Gang and Khan (1991) which says aid (both grants and loans) are used to finance investment is different from the findings of Heller (1975) which reported that only 63 to 76 percent of total loans and 41 to 53 percent of official grants goes to public investment. Contrary to the findings of Heller which reported that there is no statistically difference between the two sources of aid (bilateral and multilateral) they found that bilateral aid pulls resources out of government consumption while multilateral aid is used to finance both investment and consumption expenditures. Binh and McGillivray (1993) and White (1994) criticized the Gang and Khan (1991) work on both theoretical and methodological grounds. White argued that Gang and Khan's (1991) conclusion that aid in all goes to investment in India was misinterpretation of their own results. White mentioned the way Gang and Khan generated target values as the main source of the problem as they used the fitted value after regressing actual over some explanatory variables. For White the way Gang and Khan generated the target values are not only inconsistent with budget constraint but also will not be meaningful

when R^2 from the regression is near one or zero. Since such generated values cannot be good proxy variables for target values, which policymakers set, based on economic development objectives, the above critic by White applies to all the studies that followed similar approach.

In 1999, again Gang and Khan investigated whether different sources of aid have different impacts on government revenues and expenditures and the overall fiscal behavior of Indian government using slightly different approach (asymmetric quadratic-ratio utility function). The results from their empirical examination indicate that just like earlier work, bilateral aid is used to finance investment than multilateral aid do. This specification allowed them to estimate the equations for different types of policy makers² from which Gang and Khan (1999) selected non-developmental, fiscal conservative and non-statist based on Akaike's information criteria. Gang and Khan (1999) indicated that for non-developmental, fiscal conservative and non-statist type of policymakers, 40 percent of domestic revenue, 83 percent of bilateral aid and 91 percent of multilateral aid respectively are used to finance consumption (non-developmental) expenditures. This implies that foreign aid is primarily used to finance non-developmental expenditures, which is contrary to their own (1991) work from which they concluded that aid in India is channeled to investment. Nevertheless, with respect to the effect of bilateral and multilateral aid, they have managed to replicate their (1991) result that bilateral aid finances developmental projects than multilateral ones. Finally, they have concluded that the observed shift from bilateral to multilateral aid in India is not desirable, as resources from multilateral sources tend to finance consumption rather than investment.

³ Gang and Khan (1999), and Khan (1998) estimated loss function for different 'type' of policymakers' who differ on the weight they attach to over-or undershooting the target level of the three choice variables; domestic revenues (R), developmental expenditures (D) and non-developmental expenditures (N).
'Developmentalist' gives more weight to undershooting developmental expenditure target than overshooting. The opposite being 'Non-Developmentalist'
'Fiscal liberal' gives more weight to overshooting revenue target than undershooting. The opposite is 'Fiscal conservative'
'Statist' gives more weight to undershooting non-developmental expenditure target than undershooting. The opposite is 'Non-statist'.
By taking different combinations of this, they have estimated loss function for eight types of policymakers. Note that their objective function is minimization of the loss function.

Khan (1998) also used the same procedure (asymmetric quadratic-ratio policymakers utility function) used by Gang and Khan (1999) to empirically examine the macroeconomic impact of aid in three Southeast Asian countries; Indonesia, Malaysia and Thailand. Based on the Akaike's information criteria, the policymaker type in Indonesia was developmental, statist and fiscal liberal. In Khan's study 50 percent of domestic revenue, 33 percent of bilateral and 54 percent of multilateral aid respectively goes to non-developmental expenditures. Khan's (1998) result, like Gang and Khan (1996), proved the superiority of bilateral aid over multilateral ones for the reason indicated mentioned above. Khan concluded that the same results hold for Malaysia and Thailand.

The study by Khan and Hoshino (1992) also examined the fiscal response of recipient governments to foreign aid inflows by taking five sample countries from South and Southeast Asia by adopting the Heller (1975) specification. They have used nonlinear three-stage least square estimation technique from which they found the result that aid affects consumption, investment and taxation similar to Heller (1975). Similar to the Heller's (1975) finding, the parameters that shows the proportion of tax revenues, grants and loans spent on recurrent expenditures (G_c and G_s) are 0.88, 0.48 and -0.21, respectively. Here the estimates of the parameters are comparable to those found by Heller. This indicates that tax is used to finance consumption while relatively grants are more pro-consumption and loans even pull non-loans resources from recurrent consumption to investment. The effect of grants and loans on tax efforts shows that grants tend to reduce taxation while loans tends to increase taxation because policy makers in recipient countries use non-repayable money (grants) to reduce tax burden (Khan and Hoshino 1992). That is the case because in poor countries tax collections have economic costs and political resistance (Heller 1975 and Otim 1996). Similar to Heller (1975), Khan and Hoshino (1992) did not find difference between bilateral and multilateral aid in affecting investment.

McGillivray (1994) has questioned Khan and Hoshino (1992) work in that 'critical hypothesis test and analysis making explicit both the direct and indirect effects of aid in

the model' is missing. McGillivray argued that the parameters for the share of grants and loans allocated to consumption are statistically insignificant. This implies that Khan and Hoshino (1992) conclusion that aid affects both consumption and investment and investment further pull resources away from consumption was wrong. If the indirect effects of aid is included in the model the effect of aid is to reduce consumption and increase investment (McGillivray 1994). White (1993) also tested the impact of aid on government revenue and expenditures by including feedback effects through higher income. Implicitly, White was assuming that aid enhances growth as expected by earlier developments theories, which negate the findings of Griffin (1970) and Weisskoff (1972). White (1993) argued that even the study by Mosley *et al* (1987), which considered the impact of aid on growth through changes in fiscal behavior of the recipient government and prices, did not explore the multiplier and dynamic aspects. By incorporating these effects, White (1993) showed that there is a possibility that aid inflows increases taxes assuming that it crowd in private investment.

Otim (1996) also examined the fiscal behavior of three South Asian countries using the Heller (1975) model. Most of the findings of Otim (1996) confirm the results of Heller (1975), and Khan and Hoshino (1992) that grants are pro-consumption while loans are pro-investment (as Otim got 34.4 percent of grants and 18.7 percent of loans finance consumption expenditures). However, the finding that inflow of aid increases recipient country's tax collection effort and 'in the presence of aid tax pulls resources out of consumption' contrasts with earlier findings. Otim also found that multilateral aid to be more productive than bilateral ones and this also contradicts with the findings of Heller (1975), Khan and Hoshino (1992) who concluded that there is no different between the two, and Gang and Khan (1991, 1996) and Khan (1998) who concluded that bilateral aid is more productive.

To wrap-up the discussion on the empirics of fiscal response, let us consider the following table and briefly discuss the main findings and policy implications of fiscal response literature. The following table presents the estimated values of parameters,

which measure the proportion of domestic revenue (interpreted as tax) (ρ_1), grants (ρ_2) and loans (ρ_3) allocated to consumption (recurrent) expenditures respectively.

Table 1: Summary of the results of some earlier studies

	Heller (1975) Pooled sample	Gang and Khan (1991) [for India]	Khan and Hoshino (1992) Pooled sample	Otim (1996) Pooled sample	Gang and Khan (1996) [for India]	Franco-Rodriguez <i>et al</i> (1998) [for Pakistan]
ρ_1	0.83	1.08	0.88	-0.371	0.4563	0.85
ρ_2	0.38	-0.79	0.48	0.344	0.8323	0.51
ρ_3	-0.39	-0.03	-0.21	0.187	0.9153	0.54

Note: *For Gang and Khan (1996), ρ_2 and ρ_3 show the proportion of bilateral and multilateral aid allocated to consumption expenditures.

** For Franco-Rodriguez *et al* (1998), ρ_2 and ρ_3 shows the proportion of foreign aid (grants plus loans) and domestic borrowing allocated to consumption expenditures.

The above table shows that, the results are mixed, but some general skeptical conclusions could be drawn out of it. The parameter, which measure the proportion of tax allocated to consumption, got positive value, which is closer to one except for Otim (1996) implying that domestic revenue is mainly used to finance consumption expenditures. The proportion ranging from 45 percent for Gang and Khan (1996) to 100 percent for Gang and Khan (1991). Most of the studies also indicated that loans are more pro-investment than grants as the government in the recipient countries tends to use loans (on which repayment is expected) wisely than grants, which are free resources. This result is intuitive as loan has incentive element to use it efficiently than the free resource grant. The policy implication of this is donors should provide loans rather than grants to promote growth in developing countries. Yet, this comes at cost, especially when the resources are used to finance consumption and inefficient investment projects from which repayment at full scale is not expected. This leads to the growing problem of debt crisis from which less developed countries are suffering from. The fiscal burden of debt accumulation discourages private investment, which may offset the positive impacts.

III. The Model

The basic problem facing the government is to allocate revenue in different expenditure categories given the budget constraint. Following the arguments by Heller (1975), Mosley *et al* (1987), White (1993, 1994), Gang and Khan (1991, 1996), and Franco-Rodriguez *et al* (1998) we assume that government expenditure is mainly divided in to recurrent (G) and capital (I_g) expenditure. Recurrent expenditure is further subdivided into government consumption expenditure for socio-economic ends (G_s – such as expenditure on education and health) and government consumption expenditure for political purposes (G_c – such as expenditure for military and security purposes or wage payments made to civil servants, etc). The revenue side includes domestic and foreign sources namely: Domestic revenue (T), Domestic Borrowing (B) and Foreign aid inflows (grants (A_1) and loans (A_2)). All variables are in real terms. The utility function of the public sector can therefore be represented as: $U = f(I_g, G_c, G_s, T, B; A_1, A_2)$.

The policy makers are assumed to set a target for each revenue and expenditure categories and attempt to attain that. Based on Heller (1975), we represent the policy makers' utility function in linear - quadratic form. In addition to that, we assume that recipient governments anticipate aid inflow and incorporate that into their revenue collection and expenditure decisions.

$$\begin{aligned}
 U = & \alpha_0 + \alpha_1(I_g - I_g^*) - \frac{\alpha_2}{2}(I_g - I_g^*)^2 - \alpha_3(T - T^*) - \frac{\alpha_4}{2}(T - T^*)^2 + \alpha_5(G_c - G_c^*) - \frac{\alpha_6}{2}(G_c - G_c^*)^2 \\
 & + \alpha_7(G_s - G_s^*) - \frac{\alpha_8}{2}(G_s - G_s^*)^2 - \alpha_9(B - B^*) - \frac{\alpha_{10}}{2}(B - B^*)^2 + \alpha_{11}(A_1 - A_1^*) - \alpha_{12}(A_1 - A_1^*)^2 \\
 & + \alpha_{13}(A_2 - A_2^*) - \alpha_{14}(A_2 - A_2^*)^2
 \end{aligned} \tag{1}$$

Where $\alpha_i > 0, \forall i$.

Variables with asterisk (*) are target values for the choice variables. The target variables are derived from the following regression:

$$I_g^* = \alpha_{15} + \alpha_{16}Y_{t-1} + \alpha_{17}I_p + \alpha_{18}I_{g,t-1} \tag{2}$$

$$T^* = \alpha_{19} + \alpha_{20}Y + \alpha_{21}M + \alpha_{22}T_{t-1} \tag{3}$$

$$Gc^* = \alpha_{23} + \alpha_{24}Gc_{t-1} + \alpha_{25}Y \quad [4]$$

$$Gs^* = \alpha_{26} + \alpha_{27}P + \alpha_{28}Y + \alpha_{29}Gs_{t-1} \quad [5]$$

$$B^* = 0 \quad [6]$$

$$A_1^* = \alpha_{30} + \alpha_{31}A_{1,t-1} \quad [7]$$

$$A_2^* = \alpha_{32} + \alpha_{33}A_{2,t-1} \quad [8]$$

Equation 2, which estimates the target value of public investment, is based on ‘accelerator principle’ and it also allows capturing the relationship between private (I_p) and public investment (I_g). The target value of domestic revenue (T^*) depends on overall economic activity (Y) and one period lagged value of imports. The target value of ‘civil’ consumption in public sector (Gc^*) is a function of its one period lag value and economic activity. The target for socio-economic expenditures (Gs^*) is specified as a function of population and output. As Heller (1975) and others who used his specification like Mosley *et al* (1987), Gang and Khan (1991), Khan and Hoshino (1992), Otim (1996) argued *ex ante* the target for domestic borrowing is assumed to be zero. Hence, there is no behavioral equation for estimating domestic borrowing. That is the case because domestic borrowing comes as the last option to finance expenditure as the costs involved following it like higher rates of inflation, crowding out private investment, etc are severe (Heller 1975). Finally, the target aid for this period is assumed to depend on its lagged values.

Since expenditures are subject to financing constraints, the accounting identity that all expenditures should be equal to all receipts holds here.

$$I_g + G_s + G_c = T + B + A_1 + A_2 \quad [7]$$

The above accounting identity is categorized into two between investment (capital expenditure) and consumption (recurrent expenditure) based on the assumption that governments in developing countries do not finance consumption out of domestic

borrowing while inflows of foreign capital and domestic revenues are used to finance both consumption and investment (Heller, 1975).

$$I_g = B + (1-\rho_1)T + (1-\rho_2)A_1 + (1-\rho_3)A_2 \quad [8]$$

$$G_c + G_s = \rho_1T + \rho_2A_1 + \rho_3A_2 \quad [9]$$

ρ_1 , ρ_2 and ρ_3 are parameters that measure the proportion of domestic revenue; grants and loans respectively allocated to government consumption (G_c and G_s), while the remaining $1 - \rho_i$ ($i = 1, 2$ and 3), proportion are used to finance investment expenditures (I_g).

The Lagrange function of the above utility function was specified by introducing two Lagrange multipliers λ_1 and λ_2 for the two budget constraints.

$$\begin{aligned} \text{Max } L = & \alpha_0 + \alpha_1(I_g - I_g^*) - \alpha_2/2 (I_g - I_g^*)^2 - \alpha_3(T - T^*) - \alpha_4/2 (T - T^*)^2 + \alpha_5(G_c - G_c^*) \\ & - \alpha_6/2 (G_c - G_c^*)^2 + \alpha_7(G_s - G_s^*) - \alpha_8/2 (G_s - G_s^*)^2 - \alpha_9(B - B^*) - \alpha_{10}/2 (B - B^*)^2 \\ & + \alpha_{11}(A_1 - A_1^*) - \alpha_{12}/2(A_1 - A_1^*)^2 + \alpha_{13}(A_2 - A_2^*) - \alpha_{14}/2(A_2 - A_2^*)^2 \\ & + \lambda_1 \{I_g - B - (1 - \rho_1)T - (1 - \rho_2) A_1 - (1 - \rho_3) A_2\} + \lambda_2 \{G_s + G_c - \rho_1T - \rho_2A_1 \\ & - \rho_3A_2\} \end{aligned} \quad [10]$$

Optimization requires taking the first order derivatives of the lagrangian function with respect to the seven choice variables (including the two-lagraingian multipliers λ_1 and λ_2). The first order conditions are:

$$\partial U / \partial I_g = \alpha_1 - \alpha_2(I_g - I_g^*) + \lambda_1 = 0 \quad [11]$$

$$\partial U / \partial T = -\alpha_3 - \alpha_4(T - T^*) - \lambda_1(1 - \rho_1) - \lambda_2\rho_1 = 0 \quad [12]$$

$$\partial U / \partial G_c = \alpha_5 - \alpha_6(G_c - G_c^*) + \lambda_2 = 0 \quad [13]$$

$$\partial U / \partial G_s = \alpha_7 - \alpha_8(G_s - G_s^*) + \lambda_2 = 0 \quad [14]$$

$$\partial U / \partial B = -\alpha_9 - \alpha_{10}(B - B^*) - \lambda_1 = 0 \quad [15]$$

$$\partial U / \partial A_1 = \alpha_{11} - \alpha_{12}(A_1 - A_1^*) - \lambda_1(1 - \rho_2) - \lambda_2 \rho_2 = 0 \quad [16]$$

$$\partial U / \partial A_2 = \alpha_{13} - \alpha_{14}(A_2 - A_2^*) - \lambda_1(1 - \rho_3) - \lambda_2 \rho_3 = 0 \quad [17]$$

$$\partial L / \partial \lambda_1 = I_g - B - (1 - \rho_1)T - (1 - \rho_2)A_1 - (1 - \rho_3)A_2 = 0 \quad [18]$$

$$\partial L / \partial \lambda_2 = G_s + G_c - \rho_1 T - \rho_2 A_1 - \rho_3 A_2 = 0 \quad [19]$$

Assuming $B^* = 0$, substituting out the λ s and rearranging the above first-order condition, we obtain the following behavioral equations³

$$G_s = \beta_0 - (1 - \beta_1)G_c^* + \beta_1 G_s^* + (1 - \beta_1)\rho_1 T + (1 - \beta_1)\rho_2 A_1 + (1 - \beta_1)\rho_3 A_2 + \varepsilon_1 \quad [20]$$

$$G_c = -\beta_0 + (1 - \beta_1)G_c^* - \beta_1 G_s^* + \beta_1 \rho_1 T + \beta_1 \rho_2 A_1 + \beta_1 \rho_3 A_2 + \varepsilon_2 \quad [21]$$

$$T = \frac{\beta_2}{\beta_3} + \frac{\rho_1 \alpha_6}{\beta_3} (G_c^* - G_c) + \frac{\alpha_4}{\beta_3} T^* + \frac{\alpha_{10}}{\beta_3} \{(1 - \rho_1)(I_g - (1 - \rho_2)A_1 - (1 - \rho_3)A_2)\} + \varepsilon_3 \quad [22]$$

$$I_g = \frac{(\alpha_1 - \alpha_9)}{(\alpha_{10} + \alpha_2)} + \frac{\alpha_2}{(\alpha_{10} + \alpha_2)} I_g^* + \frac{\alpha_{10}}{(\alpha_{10} + \alpha_2)} \{(1 - \rho_1)T + (1 - \rho_2)A_1 + (1 - \rho_3)A_2\} + \varepsilon_4 \quad [23]$$

$$A_1 = \frac{\beta_4}{\beta_5} + \frac{\rho_2 \alpha_8}{\beta_5} (G_s^* - G_s) + \frac{\alpha_{12}}{\beta_5} A_1^* + \frac{\alpha_{10}}{\beta_5} \{(1 - \rho_2)[I_g - (1 - \rho_1)T - (1 - \rho_3)A_2]\} + \varepsilon_5 \quad [24]$$

$$A_2 = \frac{\beta_6}{\beta_7} + \frac{\rho_3 \alpha_8}{\beta_7} (G_s^* - G_s) + \frac{\alpha_{14}}{\beta_7} A_2^* + \frac{\alpha_{10}}{\beta_7} \{(1 - \rho_3)[I_g - (1 - \rho_1)T - (1 - \rho_3)A_1]\} + \varepsilon_6 \quad [25]$$

Where

$$\beta_0 = \frac{(\alpha_7 - \alpha_5)}{(\alpha_8 + \alpha_6)}, \quad \beta_1 = \frac{\alpha_8}{(\alpha_8 + \alpha_6)},$$

$$\beta_2 = \rho_1 \alpha_5 - \alpha_3 + \alpha_9(1 - \rho_1)$$

$$\beta_3 = \alpha_4 + \alpha_{10}(1 - \rho_1)^2$$

$$\beta_4 = \rho_2 \alpha_7 + \alpha_9 + \alpha_{11}$$

$$\beta_5 = \alpha_{12} + \alpha_{10}(1 - \rho_2)^2$$

³ Derivations of the structural equations are given in the appendix.

$$\beta_6 = \rho_3 \alpha_7 + \alpha_9 + \alpha_{13}$$

$$\beta_7 = \alpha_{14} + \alpha_{10}(1 - \rho_3)^2$$

We can put cross equation parameter restriction and avoid bulky presentation of the structural equations. Hence, we estimate the following four structural equations.

$$G_s = \beta_0 - (1 - \beta_1)G_c^* + \beta_1 G_s^* + \rho_1(1 - \beta_1)T + \rho_2(1 - \beta_1)A_1 + \rho_3(1 - \beta_1)A_2 + \varepsilon_1 \quad [20a]$$

$$G_c = -\beta_0 + (1 - \beta_1)G_c^* - \beta_1 G_s^* + \rho_1 \beta_1 T + \rho_2 \beta_1 A_1 + \rho_3 \beta_1 A_2 + \varepsilon_2 \quad [21a]$$

$$T = \beta_8 + \rho_1 \beta_9 (G_c^* - G_c) + \beta_{10} T^* + \beta_{11}(1 - \rho_1)I_g - \beta_{11}(1 - \rho_1)(1 - \rho_2)A_1 - \beta_{11}(1 - \rho_1)(1 - \rho_3)A_2 + \varepsilon_3 \quad [22a]$$

$$I_g = \beta_{12} + \beta_{13} I_g^* + (1 - \beta_{13})(1 - \rho_1)T + (1 - \beta_{13})(1 - \rho_2)A_1 + (1 - \beta_{13})(1 - \rho_3)A_2 + \varepsilon_4 \quad [23a]$$

$$A_1 = \beta_{14} + \rho_2 \beta_{15} (G_s^* - G_s) + \beta_{16} A_1^* + \beta_{17}(1 - \rho_2)I_g + \beta_{17}(1 - \rho_1)(1 - \rho_2)T + \beta_{17}(1 - \rho_2)(1 - \rho_3)A_2 + \varepsilon_5 \quad [24a]$$

$$A_2 = \beta_{18} + \rho_3 \beta_{19} (G_s^* - G_s) + \beta_{20} A_2^* + \beta_{21}(1 - \rho_3)I_g + \beta_{21}(1 - \rho_1)(1 - \rho_3)T + \beta_{21}(1 - \rho_2)(1 - \rho_3)A_1 + \varepsilon_6 \quad [25a]$$

Where

$$\begin{aligned} \beta_8 &= \beta_2/\beta_3, & \beta_9 &= \alpha_6/\beta_3, & \beta_{10} &= \alpha_4/\beta_3, & \beta_{11} &= \alpha_{10}/\beta_3, & \beta_{12} &= (\alpha_1 - \alpha_9)/(\alpha_2 + \alpha_{10}), \\ \beta_{13} &= \alpha_2/(\alpha_2 + \alpha_{10}), & \beta_{14} &= \beta_4/\beta_5, & \beta_{15} &= \alpha_8/\beta_5, & \beta_{16} &= \alpha_{12}/\beta_5, & \beta_{17} &= \alpha_{10}/\beta_5, & \beta_{18} &= \beta_6/\beta_7 \\ \beta_{19} &= \alpha_8/\beta_7, & \beta_{20} &= \alpha_{14}/\beta_7, & \beta_{21} &= \alpha_{10}/\beta_7 \end{aligned}$$

IV. Data and Estimation Results

Annual data are obtained from World Bank World Development Indicators (WDI), Penn World Tables and OECD International Development Statistics online database. All variables are expressed in real terms after dividing them by the corresponding country's GDP deflator. The government expenditure on socioeconomic purposes is approximated only by expenditure on education (due to lack of data on other aggregates such as expenditure on health). Data on government and private investment are obtained from Penn World Tables while all information on foreign aids is obtained from OECD. The rest are from WDI.

Equations 20a to 25a are estimated simultaneously with the cross parameter restrictions. The major problem with system estimation techniques relate to misspecification of a single equation in the system that will contaminate the estimates of all the parameters as they are generated simultaneously. Nevertheless, if the system involves cross equation parameter restrictions and that equations are nonlinear with respect to ρ and β parameters (as is the case for our system), they can be handled with a more efficient estimation techniques. Owing to the importance of cross equation parameter restrictions and relative inefficiency of limited information estimation techniques, we opted for 3SLS, which is a full information estimation technique. This technique is more efficient than 2SLS and what it effectively does is to take the ‘residuals from second stage regression of 2SLS to apply generalized least square in the third stage’ (Mukherjee *et al* 1998). Statistically, linearity requires the model to be linear with respect to parameters and it could or could not be linear with respect to the explanatory variables (Gujarati 1995, Greene 2000). Therefore, non-linear model is a model which is nonlinear with respect to the parameters. As can be seen form equations 20a to 25a, all the equations are linear with respect to the explanatory variables but not with respect to parameters ρ_s and β_s . Hence, we estimated the system using nonlinear least square, specifically nonlinear three stage least squares (nonlinear 3SLS). In practical estimation, the order condition for identification is equivalent to saying the number of instrumental variables must be at least as many as the number of coefficients in the equations. Since nonlinear 3SLS estimation procedure yields only estimates of $\rho_1, \rho_2, \rho_3, \beta_0, \beta_1$ and β_8 through β_{21} estimates of the structural equations which show the total effects of change in the regresand to changes in one of the regressors can be calculated using these estimated parameters.

These parameters, which are directly obtained from the estimation, are presented in tables 1 and 2. Table 1 shows estimate of the parameters when aid is categorized by Type (grants (A1) and loan (A2)) and table 2 shows when aid is categorized by source (bilateral (BLT) and multilateral (MLT)). This classification allows us to examine how different types of aid and aid from different sources affect governments’ fiscal behavior.

Table 1: Estimates of Structural Equation Parameters

[When Aid is categorized by Type: Grants (A_1) vs. Loans (A_2)]

Parameter	Estimate	t-Statistic
C(1) [= β_0]	-29148.8	-0.39
C(2) [= β_1]	0.986***	59.21
C(3) [= ρ_1]	0.490***	28.83
C(4) [= ρ_2]	0.856***	75.48
C(5) [= ρ_3]	0.424***	58.17
C(6) [= β_8]	-420158.5	-1.26
C(7) [= β_9]	0.069	0.85
C(8) [= β_{10}]	0.973***	58.20
C(9) [= β_{11}]	0.011***	4.31
C(10) [= β_{12}]	-124684.0	-1.04
C(11) [= β_{13}]	-0.007	-0.77
C(12) [= β_{14}]	206179.7	0.51
C(13) [= β_{15}]	-7.805***	-11.76
C(14) [= β_{16}]	0.943***	89.13
C(15) [= β_{17}]	-0.075***	-4.18
C(16) [= β_{18}]	432767.2	1.53
C(17) [= β_{19}]	10.207***	14.14
C(18) [= β_{20}]	1.073***	40.39
C(19) [= β_{21}]	0.048***	4.87

*** Significantly different from zero at 1 percent level of significance

Table 2: Estimates of Structural Equation Parameters

[When Aid is categorized by Source: Bilateral (BLT) vs. Multilateral (MLT)]

Parameter	Estimate	t-Statistic
C(1) [= β_0]	82185.35	1.17
C(2) [= β_1]	0.977***	63.3
C(3) [= ρ_1]	0.371***	20.62
C(4) [= ρ_2]	0.707***	44.75
C(5) [= ρ_3]	0.193***	3.19
C(6) [= β_8]	-285869.7	-1.05
C(7) [= β_9]	-5.14	-0.20
C(8) [= β_{10}]	1.006***	74.03
C(9) [= β_{11}]	-0.004***	-10.20
C(10) [= β_{12}]	-8459.48	-0.07
C(11) [= β_{13}]	-0.004	-0.83
C(12) [= β_{14}]	110685.4	0.29
C(13) [= β_{15}]	-1.071	-1.27
C(14) [= β_{16}]	0.974***	101.3
C(15) [= β_{17}]	0.078***	9.93
C(16) [= β_{18}]	-48588.17	-0.29
C(17) [= β_{19}]	1.371***	12.69
C(18) [= β_{20}]	1.041***	66.35
C(19) [= β_{21}]	-0.002***	-7.02

*** Significantly different from zero at 1 percent level of significance

The parameters of the budget constraint: ρ_1 , ρ_2 , and ρ_3 show allocation of domestic revenue (T) and aid between government consumption expenditures (G_c and G_s) and public investment (Ig). The estimates of the ρ_1 , ρ_2 , and ρ_3 are 0.49, 0.86 and 0.42, respectively when foreign aid is considered by type: grants vs. loans. The parameters are significantly different from zero at 1 percent level of significance. With respect to the allocation of grants (A_1) and loans (A_2), $\rho_2 = 0.86$ and $\rho_3 = 0.42$ indicates that both grants and loans are allocated between consumption and investment. However, 86 percent of grants are allocated to consumption while only about 42 percent of loan goes to consumption expenditure. Hence, comparing these two types of foreign aid: grants and loans, we can conclude that loans are pro-investment compared to grants.

From Table 2 the estimate of ρ_1 , ρ_2 , and ρ_3 shows the proportion of domestic revenue (T), bilateral aid (BLT) and multilateral aid (MLT) went to consumption as they are obtained when the structural equations are estimated by classifying aid by source. The estimate of ρ_1 , ρ_2 , and ρ_3 are 0.37, 0.71 and 0.19, respectively. All are significantly different from zero at one percent level. These results imply that most of aid from bilateral sources are fungible (or pro-consumption) like grants while multilateral aid is mainly used to finance investment. Surprisingly, the result also indicates that the governments use most of their domestic revenue for investment purposes.

Table 3: Estimates of Total Impacts of Revenue Variables

[When Aid is categorized by Type; Grants (A₁) vs. Loans (A₂)]

Impact	Mechanism	Estimate
A ₁ on T	$-\beta_{11}(1 - \rho_1)(1 - \rho_2)$	0.001
A ₁ on G _c	$\rho_2\beta_1$	0.844
A ₁ on G _s	$\rho_2(1 - \beta_1)$	0.012
A ₁ on I _g	$(1-\beta_{13})(1-\rho_2)$	0.145
A ₂ on T	$-\beta_{11}(1-\rho_1)(1-\rho_3)$	0.003
A ₂ on G _c	$\rho_3\beta_1$	0.418
A ₂ on G _s	$\rho_3(1 - \beta_1)$	0.006
A ₂ on I _g	$(1-\beta_{13})(1-\rho_3)$	0.580

Table 4: Estimates of Total Impacts of Revenue Variables

[When Aid is categorized by Source; Bilateral (BLT) vs. Multilateral (MLT)]

Impact	Mechanism	Estimate
BLT on T	$-\beta_{11}(1 - \rho_1)(1 - \rho_2)$	0.001
BLT on G _c	$\rho_2\beta_1$	0.691
BLT on G _s	$\rho_2(1 - \beta_1)$	0.016
BLT on I _g	$(1-\beta_{13})(1-\rho_2)$	0.294
MLT on T	$-\beta_{11}(1-\rho_1)(1-\rho_3)$	0.002
MLT on G _c	$\rho_3\beta_1$	0.188
MLT on G _s	$\rho_3(1 - \beta_1)$	0.004
MLT on I _g	$(1-\beta_{13})(1-\rho_3)$	0.807

From table 3 and 4 we can see the structural parameters estimates. The estimates of these parameters would help us determine the impact of foreign aid on the government revenues and expenditures decisions in more details. Whether aid is classified by type or by source, there is a slight positive impact of foreign aid on recipient governments' domestic revenue.

On the expenditure side, grants and aid from bilateral sources are channeled towards government civil consumption (G_c – expenditure on non-developmental purposes such as military expenditure or payments of wages for civil servants). Governments' social consumption as approximated by expenditure on education is not affected much by aid inflow. On the capital expenditure side, we found that most of the aid inflow from multilateral sources and aid in the form of loans are channeled towards investment. The findings from the estimates of the structural parameters reinforce that of budget constraint parameters.

V. Conclusion

Although the importance of capital accumulation for economic growth and hence development was recognized long time ago, Sub-Saharan Africa countries are still trapped in 'vicious circle of poverty' and failed to finance desired level of investment from their own domestic savings. Earlier models of development revealed that such countries would come out of stagnation only if they got assistance from developed world. The two-gap model of Chenery and Strout (1966) showed that these countries are constrained with little domestic savings and foreign exchange earnings. The model predicted that foreign aid is an optimal means to break the circle and solve the two gaps simultaneously.

Although it was convincing and appears interesting, empirical studies on the effectiveness of aid came up with mixed results. The first critic to the 'optimist' view of 1950s and 1960s came from Griffin and Enos (1970) who argued that foreign aid rather contributes negatively to growth, as it is substitute for domestic savings by reducing

government revenue collection effort and increasing consumption. Following that, many empirical studies were conducted on aid-growth relation but they were with inconclusive results. The main problem with single equation based aid-saving/investment or aid-growth studies, however, had serious problems as they fail to recognize that aid is mainly channeled through the public sector and its net affect depends on how it is used in this sector and/or how this sector responds to inflows of foreign aid.

This paper examined the fiscal response of recipient governments to inflows of foreign aid using pooled data of twenty one Sub-Saharan Africa countries between 1986 and 2001. Using a model similar to Heller (1975), which is built on optimization of policymakers' utility function and extending it to endogenize foreign aid, we estimate the budget constraint and structural equation parameters. These estimates give information on how the government uses the resources and how it responds to the foreign financial inflows. The budget constraint parameters: ρ_1 , ρ_2 , and ρ_3 shows the proportion of domestic revenue, grants, and loans respectively used to finance government consumption expenditures. The estimated high value of ρ_2 when aid is categorized both by type and source indicates that, aid in the form of grant and aid from bilateral sources are mainly allocated to consumption. On the other hand, the low estimated value of ρ_3 indicates that loans and aid from multilateral sources are mainly channeled towards investment. The same kind of analysis is derived from the estimates of structural parameters.

Therefore, comparing the two types of aid and the two sources of aid we can say loans and aid from multilateral sources are pro-investment while grants and aid from bilateral sources are pro-consumption.

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Appendix: Derivation of the Structural Equations

Based on Heller (1975), the utility function of policymakers in aid recipient country is given as: $U = f(I_g, G_s, G_c, T, B; A_1, A_2)$. Where government investment (I_g), socio-economic consumption in public sector (G_s), ‘civil’ consumption in the public sector (G_c), domestic revenue (T) and domestic borrowing (B) are decision variables. We also assume grants (A_1) and loans (A_2) are endogenous as the recipient governments can anticipate it and formulate their budget accordingly. The utility function can formally be specified as deviations of the ‘decision’ variables from their target values (variable with asterisk) in linear-quadratic form, which can be represented as

$$\begin{aligned}
 U = & \alpha_0 + \alpha_1(I_g - I_g^*) - \frac{\alpha_2}{2}(I_g - I_g^*)^2 - \alpha_3(T - T^*) - \frac{\alpha_4}{2}(T - T^*)^2 + \alpha_5(G_c - G_c^*) - \frac{\alpha_6}{2}(G_c - G_c^*)^2 \\
 & + \alpha_7(G_s - G_s^*) - \frac{\alpha_8}{2}(G_s - G_s^*)^2 - \alpha_9(B - B^*) - \frac{\alpha_{10}}{2}(B - B^*)^2 + \alpha_{11}(A_1 - A_1^*) - \alpha_{12}(A_1 - A_1^*)^2 \quad [1] \\
 & + \alpha_{13}(A_2 - A_2^*) - \alpha_{14}(A_2 - A_2^*)^2
 \end{aligned}$$

Policymakers maximize the function by minimizing the deviation between actual and target values of the decision variables. Policymakers maximize the function subject to financing constraint, which says total expenditures should be equal to all receipts

$$I_g + G_s + G_c = T + B + A_1 + A_2$$

To analyze the behavior of policymakers the budget constraint is classified into two. Hence, decision makers maximize the above utility function subject to the following financing constraints:

$$I_g = B + (1-\rho_1)T + (1-\rho_2)A_1 + (1-\rho_3)A_2 \quad [2]$$

$$G_c + G_s = \rho_1T + \rho_2A_1 + \rho_3A_2 \quad [3]$$

Constructing the lagrangian function (L) for the utility function and finding the first order derivative with respect to decision variables: I_g , G_c , G_s , T and B and the lagrangian multipliers: λ_1 and λ_2

$$\begin{aligned}
\text{Max } L = & \alpha_0 + \alpha_1(I_g - I_g^*) - \alpha_2/2 (I_g - I_g^*)^2 - \alpha_3(T - T^*) - \alpha_4/2 (T - T^*)^2 + \alpha_5(G_c - G_c^*) \\
& - \alpha_6/2 (G_c - G_c^*)^2 + \alpha_7(G_s - G_s^*) - \alpha_8/2 (G_s - G_s^*)^2 - \alpha_9(B - B^*) - \alpha_{10}/2 (B - B^*)^2 \\
& + \alpha_{11}(A_1 - A_1^*) - \alpha_{12}/2(A_1 - A_1^*)^2 + \alpha_{13}(A_2 - A_2^*) - \alpha_{14}/2(A_2 - A_2^*)^2 \\
& + \lambda_1 \{I_g - B - (1 - \rho_1)T - (1 - \rho_2) A_1 - (1 - \rho_3) A_2\} + \lambda_2 \{G_s + G_c - \rho_1 T - \rho_2 A_1 \\
& - \rho_3 A_2\} \tag{1a}
\end{aligned}$$

FOCs

$$\partial U / \partial I_g = \alpha_1 - \alpha_2(I_g - I_g^*) + \lambda_1 = 0 \tag{4}$$

$$\partial U / \partial G_c = \alpha_5 - \alpha_6(G_c - G_c^*) + \lambda_2 = 0 \tag{5}$$

$$\partial U / \partial G_s = \alpha_7 - \alpha_8(G_s - G_s^*) + \lambda_2 = 0 \tag{6}$$

$$\partial U / \partial T = -\alpha_3 - \alpha_4(T - T^*) - \lambda_1(1 - \rho_1) - \lambda_2 \rho_1 = 0 \tag{7}$$

$$\partial U / \partial B = -\alpha_9 - \alpha_{10}(B - B^*) - \lambda_1 = 0 \tag{8}$$

$$\partial U / \partial A_1 = \alpha_{11} - \alpha_{12}(A_1 - A_1^*) - \lambda_1(1 - \rho_2) - \lambda_2 \rho_2 = 0 \tag{9}$$

$$\partial U / \partial A_2 = \alpha_{13} - \alpha_{14}(A_2 - A_2^*) - \lambda_1(1 - \rho_3) - \lambda_2 \rho_3 = 0 \tag{10}$$

$$\partial L / \partial \lambda_1 = I_g - B - (1 - \rho_1)T - (1 - \rho_2)A_1 - (1 - \rho_3)A_2 = 0 \tag{11}$$

$$\partial L / \partial \lambda_2 = G_s + G_c - \rho_1 T - \rho_2 A_1 - \rho_3 A_2 = 0 \tag{12}$$

The FOCs from (4) and (12) are solved together to obtain the structural equations to be estimated.

From equation (12)

$$G_s = \rho_1 T + \rho_2 A_1 + \rho_3 A_2 - G_c \tag{12a}$$

From equations (5) and (6) we can solve from λ_2

$$\lambda_2 = \alpha_6 G_c - \alpha_6 G_c^* - \alpha_5 \quad [5a]$$

$$\lambda_2 = \alpha_8 G_s - \alpha_8 G_s^* - \alpha_7 \quad [6a]$$

From equations (5a) and (6a)

$$\lambda_2 = \lambda_2$$

$$G_c = \frac{\alpha_8 G_s + \alpha_6 G_c^* - \alpha_8 G_s^* + \alpha_5 - \alpha_7}{\alpha_6} \quad [13]$$

$$G_s = \frac{\alpha_6 G_c - \alpha_6 G_c^* + \alpha_8 G_s^* + \alpha_7 - \alpha_5}{\alpha_8} \quad [14]$$

Substituting equation (13) into (12a)

$$G_s = \beta_0 - (1 - \beta_1) G_c^* + \beta_1 G_s^* + (1 - \beta_1) \rho_1 T + (1 - \beta_1) \rho_2 A_1 + (1 - \beta_1) \rho_3 A_2 \quad [15]$$

Where

$$\beta_0 = \frac{(\alpha_7 - \alpha_5)}{(\alpha_8 + \alpha_6)}$$

$$\beta_1 = \frac{\alpha_8}{(\alpha_8 + \alpha_6)} \quad \text{This implies that } (1 - \beta_1) = \frac{\alpha_6}{(\alpha_8 + \alpha_6)}$$

From equation (10)

$$G_c = \rho_1 T + \rho_2 A_1 + \rho_3 A_2 - G_s \quad [12b]$$

Substituting equation (15) into (12b)

$$G_c = -\beta_0 + (1 - \beta_1) G_c^* - \beta_1 G_s^* + \beta_1 \rho_1 T + \beta_1 \rho_2 A_1 + \beta_1 \rho_3 A_2 \quad [16]$$

From equations (4) and (8) we can solve for λ_1

$$\lambda_1 = \alpha_2 I_g - \alpha_2 I_g^* - \alpha_1 \quad [4a]$$

$$\lambda_1 = -\alpha_9 - \alpha_{10} B - \alpha_{10} B^* \quad [5a]$$

From equations (4a) and (5a); equating the expression for λ_1 in the two equations and assuming $B^* = 0$

$$B = \frac{(\alpha_1 - \alpha_9) + \alpha_2 I_g^* - \alpha_2 I_g}{\alpha_{10}} \quad [17]$$

From equation (11)

$$I_g = B + (1 - \rho_1)T + (1 - \rho_2)A_1 + (1 - \rho_3)A_2 \quad [11a]$$

Substituting equation (17) into (11a)

$$I_g = \frac{(\alpha_1 - \alpha_9)}{(\alpha_{10} + \alpha_2)} + \frac{\alpha_2}{(\alpha_{10} + \alpha_2)} I_g^* + \frac{\alpha_{10}}{(\alpha_{10} + \alpha_2)} \{(1 - \rho_1)T + (1 - \rho_2)A_1 + (1 - \rho_3)A_2\} \quad [18]$$

From equation (11)

$$T = \frac{\{I_g - (1 - \rho_2)A_1 - (1 - \rho_3)A_2 - B\}}{(1 - \rho_1)} \quad [11b]$$

From equation (8) assuming $B^* = 0$

$$B = \frac{-(\alpha_9 + \lambda_1)}{\alpha_{10}} \quad [8a]$$

From equation 5

$$\lambda_2 = \alpha_6(G_c - G_c^*) - \alpha_5 \quad [5a]$$

Substituting equation (5a) into (7)

$$\lambda_1 = \frac{-\alpha_3 - \alpha_4 T + \alpha_4 T^* - \rho_1 \alpha_6 (G_c - G_c^*) + \rho_1 \alpha_5}{1 - \rho_1} \quad [19]$$

Substituting equation (19) into (8a)

$$B = \frac{-\alpha_9(1 - \rho_1) + \alpha_3 + \alpha_4 T - \alpha_4 T^* + \rho_1 \alpha_6 (G_c - G_c^*) - \rho_1 \alpha_5}{\alpha_{10}(1 - \rho_1)} \quad [20]$$

Substituting equation (20) into (11b)

$$T = \frac{\beta_2}{\beta_3} + \frac{\rho_1 \alpha_6}{\beta_3} (G_c^* - G_c) + \frac{\alpha_4}{\beta_3} T^* + \frac{\alpha_{10}}{\beta_3} \{(1 - \rho_1)(I_g - (1 - \rho_2)A_1 - (1 - \rho_3)A_2)\} \quad [21]$$

Where

$$\beta_2 = \rho_1 \alpha_5 - \alpha_3 + \alpha_9(1 - \rho_1)$$

$$\beta_3 = \alpha_4 + \alpha_{10}(1 - \rho_1)^2$$

From equation (11) we also have

$$A_1 = \frac{\{I_g - (1 - \rho_1)T - (1 - \rho_3)A_2 - B\}}{(1 - \rho_2)} \quad [22]$$

Substituting equation (6a) into (9) and solving for λ_1

$$\lambda_1 = \frac{\alpha_{11} - \alpha_{12}(A_1 - A_2^*) - \rho_2 \alpha_8 (Gs - Gs^*) + \rho_2 \alpha_7}{1 - \rho_2} \quad [23]$$

Substituting equation (23) into (8a)

$$B = \frac{-\alpha_9 - \alpha_{11} + \alpha_{12}(A_1 - A_1^*) + \rho_2 \alpha_8 (Gs - Gs^*) - \rho_2 \alpha_7}{\alpha_{10}(1 - \rho_2)} \quad [24]$$

Substituting (24) into (22) and simplifying

$$A_1 = \frac{\beta_4}{\beta_5} + \frac{\rho_2 \alpha_8}{\beta_5} (Gs^* - Gs) + \frac{\alpha_{12}}{\beta_5} A_1^* + \frac{\alpha_{10}}{\beta_5} \{(1 - \rho_2)[I_g - (1 - \rho_1)T - (1 - \rho_3)A_2]\} + \varepsilon_5 \quad [25]$$

Where:

$$\beta_4 = \rho_2 \alpha_7 + \alpha_9 + \alpha_{11}$$

$$\beta_5 = \alpha_{12} + \alpha_{10}(1 - \rho_2)^2$$

Similarly, using a parallel argument made for A_1 , it is straight forward to show that:

$$A_2 = \frac{\beta_6}{\beta_7} + \frac{\rho_3 \alpha_8}{\beta_7} (Gs^* - Gs) + \frac{\alpha_{14}}{\beta_7} A_2^* + \frac{\alpha_{10}}{\beta_7} \{(1 - \rho_3)[I_g - (1 - \rho_1)T - (1 - \rho_3)A_1]\} + \varepsilon_6 \quad [26]$$

Where:

$$\beta_6 = \rho_3 \alpha_7 + \alpha_9 + \alpha_{13}$$

$$\beta_7 = \alpha_{14} + \alpha_{10}(1 - \rho_3)^2$$

Therefore, the structural equations to be estimated are (15), (16), (18), (21), (25) and (26).