The Dynamics of Public Indebtedness in Ghana

John Pastor Ansah
System Dynamics Group, School of Social Sciences
University of Bergen, Norway

Abstract

Purpose - Guided by economic models suggesting that growth can be stepped-up by increasing resources for investment, developing country governments have often resorted to borrowing to supplement revenue hence the accumulation of public debt. The purpose of this paper is twofold. First, it is to develop a dynamic model that identifies the fundamental structure of the public debt accumulation process. Second, it is to identify the *mechanisms* that generate public debt and their relative contribution to public debt accumulation.

Design/methodology/approach – In this paper we developed a dynamic model that consists of the public debt sector linked with the production and household sector of the economy using the System Dynamics method. We use Vensim simulation software to develop the model.

Findings –We identified three mechanisms that generate public debt. They are the *debt creation mechanism* i.e. primary deficit, which is the palpable origin of public debt, the *debt reproduction mechanism* i.e. total interest payments, accrual of interest and foreign debt adjustment and the *debt reduction mechanism* i.e. debt relief, which are the attributes of public debt that contribute to debt accumulation. The conclusion from the analysis is that the *debt creation mechanism* is recognized as the origin of public debt. We establish that the cumulative contribution of the *debt creation mechanism* to public debt accumulation from 1960 to 1999 was 50 percentage points. In addition, we established that the *debt reproduction mechanism* added a cumulative contribution of 50 percentage points to public debt from 1960 to 1999, of which total interest payments contributed 23 percentage points, accrual of interest contributed 6 percentage points and foreign debt adjustment contributed 21 percentage points. The contribution of *debt reduction mechanism* to the accumulation of public debt was insignificant from 1960 to 1999. Lastly, our investigation on the source of debt accumulation establishes that

the inability of the tax authority to collect the expected tax revenue is the main source of the deficit responsible for public debt accumulation.

Practical implications – In this paper, we presents a dynamically robust structural model that helps us understand the public debt accumulation process in developing countries.

Research limitations/implication – Due to lack of comprehensive data, public debt could not be disaggregated into short and long term debt with it implications on fiscal policy.

Originality/value – A dynamic public debt accumulation model that enhances our understanding of the channels through which public debt are formed is a unique feature for this paper. Also, the accounting of the exchange rate effect on debt accumulation is a unique feature of this model. To the best of my knowledge, this is the first System Dynamics model addressing the public debt issue in Ghana.

Key words – Public debt, Modeling, Simulation, Ghana

Paper type - Research paper

1. Introduction

The role of debt in the development process has long been recognised by mainstream development economist (Killick 1978; Easterly 2002). The traditional argument for debt opening derives from the basic macroeconomic identity for a closed economy $AD = C + I + G$ that states that, in equilibrium, aggregate demand (AD) equals the sum of consumption (C), investment (I) and government purchases (G). $I = S$[1] implies equality between investment (I) and domestic savings (S) in the equilibrium situation. Poorer economies have little savings capacity, and thus their growth potential is limited. Consequently, these poorer countries need to attain threshold income levels before they can generate the savings that could stimulate capital accumulation and growth. Alternatively, if expected returns are high but resources are scarce, they can borrow from the local or the international financial markets. The early 1980s and late 1990s was a time of large public debt for many developing countries, prompting concerns that the fiscal policies which led to such outcomes were not only unwise, but also unsustainable (Blanchard, Chouraqui et al. 1990). How do countries get into debt? The answer to this question is the main focus of this research. The purpose of this paper is twofold: First it is to develop a dynamic public debt model that identifies the fundamental structure of the public debt accumulation process. Second, it is to identify the *mechanisms* that generate public debt and their relative contribution to public debt accumulation.

The paper is organised as follows: In section 2 we present the model framework, introduce the modelling approach and provide an exhaustive model description of the public debt, the production sector and the household sector. In section 3 we represent the model validation. Section 4 presents the method for identifying debt accumulation decomposition. We use the method proposed in section 4 to identify the mechanisms of debt accumulation and their relative contributions to debt accumulation. Section 5 represents the sources of debt accumulation. Section 6 is the conclusion.

2. The Model

The model consists of three sectors: public debt, production (labour, capital) and household. The model is inspired by Macro Lab (Wheat 2007). The model captures the feedback process between public debt, public finance, and economic growth. A transparent and integrated

[1] S= AD-(C+G)

modelling approach is required to understand the feedback processes governing the dynamics between public debt, public finance, and economic growth. For that purpose we chose the System Dynamics (SD) method based on its ability to help us; (1) represent a dynamic and long-term perspective, including the delays and the non-linearities involved, and (2) link observable patterns of behaviour of a system to micro level structures and decision making processes (Forrester 1971; Saeed 1993; Yamaguchi 1994; Qudrat-Ullah 2005).

2.1 Conceptual framework

The conceptual framework of the model is an SD-based adaptation of the government budget constraint literature (Christ 1968 ; Blinder and Solow 1973). This literature sets out that the fiscal deficit must equal the sum of domestic borrowing, foreign borrowing and seignorage and considers the impact of deficit financing on output (Islam and Wetzel 1991).

2.2 Public Debt Sector

Guided by the economic models suggesting that growth can be stepped-up by increasing resources for investment, governments of developing countries have often resorted to borrowing to supplement revenue. The borrowed resource is often used for investment purposes and/or consumption smoothing (Campbell 1989). However, due to various reasons, including increased spending resulting from population growth, external shocks, bad economic management, as well as output decline and its slow recovery thereafter, government spending consistently exceed its revenue, hence causing a continued borrowing (Lindauer and Velenchik 1992; Jha 2001; Ghatak and Sanchez-Fung 2007). As a consequence debt accumulates causing a heavy debt burden.

2.2.1 Structure of Public Debt

The public debt model (see figure 1a) demonstrates transparently the mechanisms that generate debt. Public debt disaggregates into domestic and foreign sources. Subscripts[2] are used to

[2] The following variables: (borrowing, borrowing fraction, public debt, total public debt, repayment, debt maturity, interest payments due, interest payments, obligatory interest rate,

separate domestic debt from foreign debt. Principal relief and interest relief in the model are only applicable to foreign debt, and are represented by exogenous variables generated from historical data.

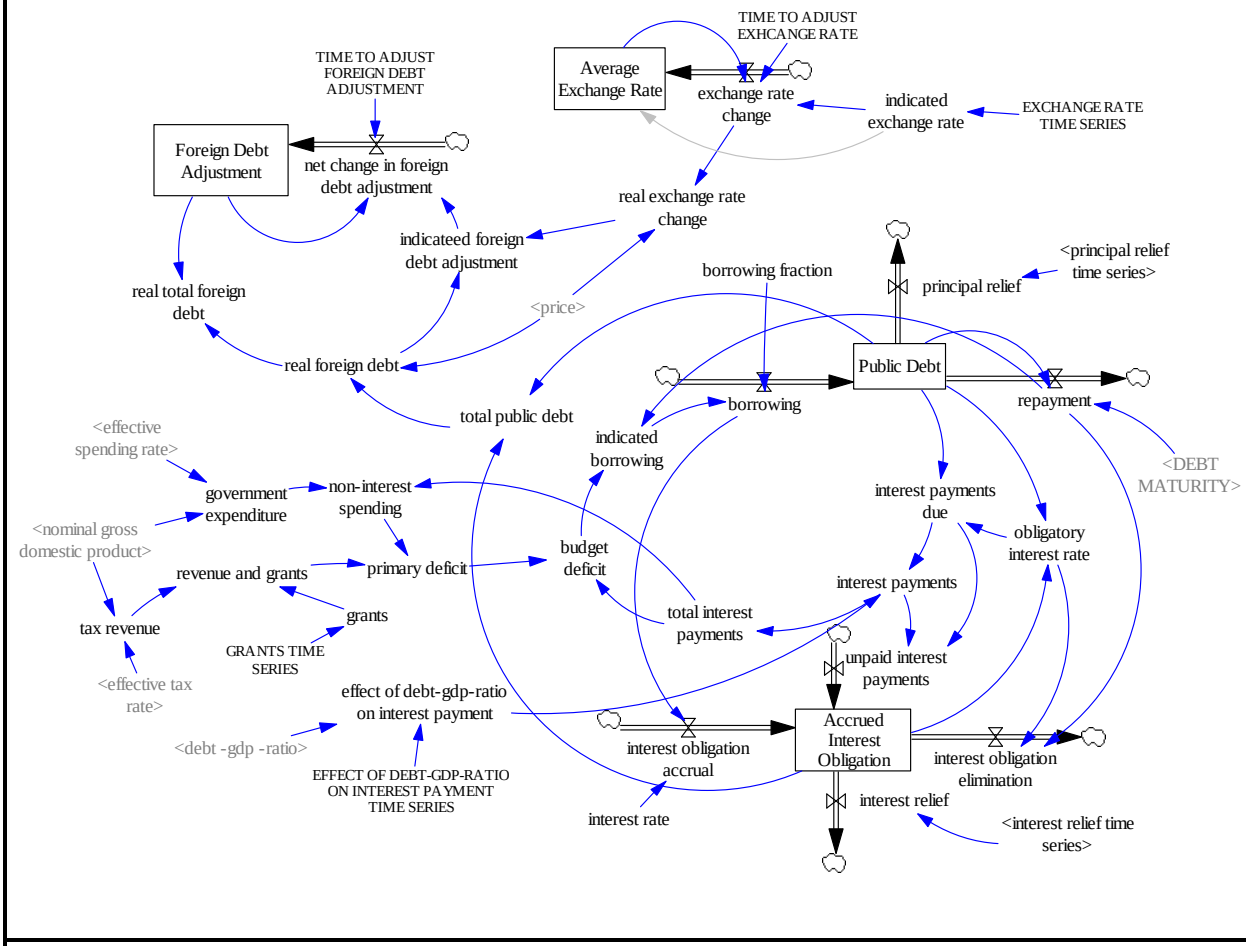

Figure 1a: Stock and Flow Structure of Public Debt

We assume that government finances its budget deficit by borrowing from domestic and foreign sources and depict it as a result of a government budget constraint:

$$pd_t + i_t^{\,d} D^d{}_{t-1} + i_t^{\,f} D^f{}_{t-1} + D^d{}_{t-1}/m^d + D^f{}_{t-1}/m^f = Bd_t = gB_t^{\,d} + gB_t^{\,f} \qquad (1)$$

interest rate, interest addition, accrued interest, interest subtraction) in the public debt model as shown in figure 1a are subscript variables separated into domestic and foreign.

Where pd_t is primary deficit, $i_t^{\,d}$ is the domestic interest rate, $D^{d}{}_{t-1}$ is the domestic public debt of the previous year, $i_t^{\,f}$ is foreign interest rate, $D^{f}{}_{t-1}$ is the foreign public debt of previous year, m^d is the domestic debt maturity, , m^f is the foreign debt maturity, Bd_t is the budget deficit, $gB_t^{\,d}$ is the domestic borrowing and $gB_t^{\,f}$ is the foreign borrowing.

We express the stock of total public debt (D_t) from the government budget constraint equation and the public debt model in figure 1a as follows:

$$D_t = D^{d}{}_t + D^{f}{}_t \qquad (2)$$

$$D^{d}{}_t = \left[D^{d}{}_{t-1} + (dt)gB_t^{\,d} - (dt)\left(D^{d}{}_{t-1} \Big/ m^d \right) \right] + \left[AI^{d}{}_{t-1} + (dt)Ia^{d}{}_t + (dt)Ui^{d}{}_t - (dt)Is^{d}{}_t \right] \qquad (3)$$

$$D^{f}{}_t = \left[D^{f}{}_{t-1} + (dt)gB_t^{f} - (dt)\left(D^{f}{}_{t-1} \Big/ m^f \right) \right] + \left[AI^{f}{}_{t-1} + (dt)Ia^{f}{}_t + (dt)Ui^{f}{}_t - (dt)Is^{f}{}_t \right] + \left[D^{f}{}_t (X_t - X_{t-1}) \right] - \left[(dt)rD^{f}{}_{t-1} \right] \qquad (4)$$

Here $AI^{d}{}_{t-1}$ is domestic accrued interest obligation of the previous year, $(dt)Ia^{d}{}_t$ is the domestic interest obligation accrual, $(dt)Ui^{d}{}_t$ is the domestic unpaid interest payments, $(dt)Is^{d}{}_t$ is domestic interest obligation elimination, $AI^{f}{}_{t-1}$ is the foreign accrued interest obligation of the previous year, $(dt)Ia^{f}{}_t$ is foreign interest obligation accrual, $(dt)Ui^{f}{}_t$ is foreign unpaid interest payments, $(dt)Is^{f}{}_t$ is foreign interest obligation elimination, X_t is the current average exchange rate per year, X_{t-1} is average exchange rate of the previous year and $(dt)rD^{f}{}_{t-1}$ is the foreign public debt forgiven per year.

Equation (2) demonstrates that total public debt consists of domestic public debt and foreign public debt. Equation (3) defines the domestic public debt, where the first term of the equation represents the integration of domestic borrowing and domestic repayment into the domestic public debt. The second term characterizes the integration of domestic interest obligation accrual, domestic unpaid interest payments and domestic interest obligation elimination into the domestic accrued interest obligation. In equation (4), the first term of the equation represents the integration of foreign borrowing and foreign repayment into foreign public debt. The second term represents the integration of foreign interest obligation accrual, foreign unpaid

interest payments and foreign interest obligation elimination into foreign accrued interest obligation. The third term represents the foreign debt adjustment[3], where the change in currency exchange rate is multiplied by the foreign debt. The last term represents debt relief.

The public debt model adopted the 'co-flow structure' (Sterman 2000) to account for 'accrued interest obligation'. As government borrows, it attracts an interest obligation, which is referred to as 'interest obligation accrual' (see figure 1a). The 'interest obligation accrual' is stored into a stock of 'accrued interest obligation'. 'Accrued interest obligation' represent the total obligatory interest to be serviced per year. On the other hand, when repayment on debt is made, it decreases 'accrued interest obligation' through 'interest obligation elimination'. In sum, the co-flow structure helps us to keep track of 'accrued interest obligation' as an attributes of public debt.

Obligatory interest rate is calculated as accrued interest obligation divided by public debt. Assuming that government is able to service all interest payments due, where interest payments due equals' interest payments. In that situation, 'obligatory interest rate' (as is being referred to in this model) would be known as 'average interest rate'. However, in the model, we postulate that depending on government debt burden (measured by debt-GDP-ratio), interest payments due can be rescheduled for future payment. The addition of unpaid interest payments to the stock of accrued interest obligation create imbalance between public debt and accrued interest obligation, therefore, the average interest rate on public debt is referred to as 'obligatory interest rate'.

Unpaid interest is the difference between interest payments due and interest payments. The model separates interest payments due from interest payments because when government debt burden is high, deficit spending is reduced by rescheduling interest payments which inadvertently reduces borrowing. Interest payments due is calculated as public debt multiplied by obligatory interest rate. Interest payments are defined as interest payment due multiplied by effect of debt-GDP-ratio on interest payments. The non-linear function of the effect of debt-GDP-ratio on interest payment is as shown in figure 2 below. According to figure 2, as debt-GDP-ratio increases, governments' ability to service interest payments is reduced; as a result a fraction of the interest payments due is actually paid.

[3] Foreign debt adjustment is the foreign debt incurred due to changes in exchange rate.

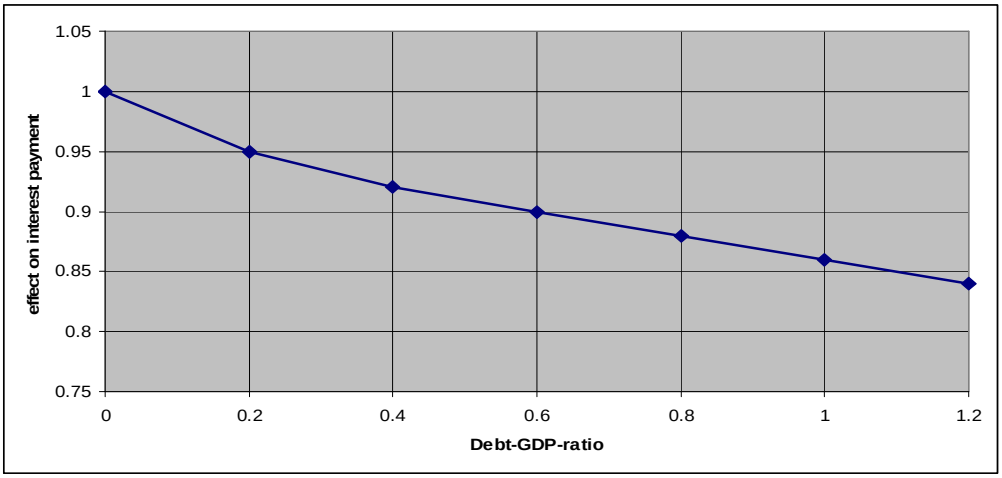

Figure 2: Non-Linear effect of Debt-GDP-Ratio on Interest Payment

The foreign debt adjustment is most often unaccounted for in many studies (Simonsen 1985; Meijdam and Stratum 1989; Saeed 1993; Senhadji 1997; Helbling, Mody et al. 2004). In many developing countries, foreign debt adjustment is a significant debt component that is often not recognised. The foreign debt adjustment in the public debt model captures the debt incurred due to exchange rate changes. The adoption of a Structural Adjustment policy of currency exchange liberalisation and the resulting devaluation, significantly increased the exchange rate in many developing nations, Ghana included, in the 1980s after many years of a fixed exchange rate policy regime (Islam and Wetzel 1991; Konadu-Agyemang 2001). Since foreign loans are contracted in foreign currency, the sudden increase in the exchange rate following the liberalisation of the exchange market significantly increased the foreign debt in local currency equivalence. This is captured in the model to account for the exchange rate effect on foreign debt accumulation. As the exchange rate increases[4], *ceteris paribus* foreign debt is increased by the debt incurred from the exchange rate increase (foreign debt adjustment). It is important to note that foreign debt adjustment arises only when the exchange rate changes. In cases where exchange rate remains stable, there is no foreign debt adjustment.

[4] Exchange rate is the current market price of 1 US dollar to Cedi (Ghanaian currency). An increase in exchange rate is when more cedi is needed to exchange for 1 US dollar. That is to say that the local currency (cedi) has depreciated or the US dollar has appreciated.

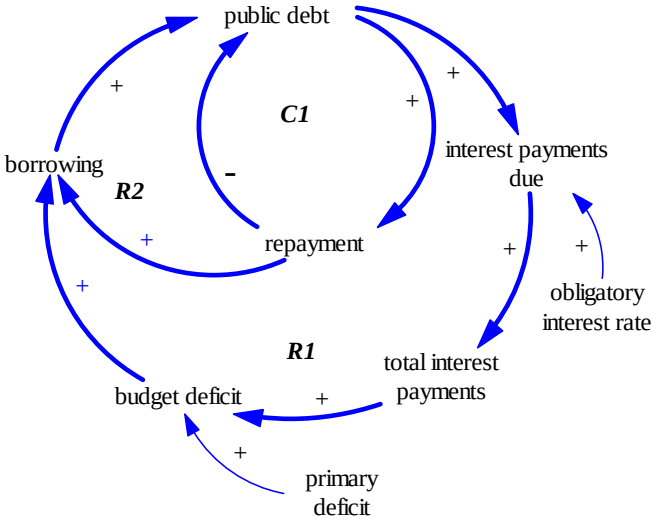

Figure 1b: Feedback Loop Structure of Public Debt

The accumulation of public debt is embodied in the reinforcing feedback loops shown in figure 1b. Government finances its spending by taxing income (income is taken to be equal to GDP); and finances any gap, as is the case in developing countries', by raising public debt through borrowing. We assume that government finances its fiscal balance (budget deficit) by borrowing from domestic and or foreign sources. The feedback loops *R1* and *R2* depicts the *debt trap phenomenon (Saeed 1993)* which represent the basic mechanism responsible for debt accumulation in developing countries. The reinforcing loop *R1* includes the following variables: budget deficit, borrowing, public debt, interest payments due, total interest payments. As the primary deficit increases due to government excess spending over revenue and grants, a budget deficit - financed through borrowing. As borrowing increases, public debt accumulates, - consequently the total interest payments build-up. As interest payments increases, the budget deficit increases. The reinforcing loop *R1* illustrates the deep-seated structure of the debt accumulation process. The reinforcing loop *R2* include: borrowing, public debt and repayment. When borrowing increases, public debt accumulates. As public debt rises, so does the repayment of the principal, further increasing the need for borrowing the following year.

The public debt growth is contained by the counteracting feedback loop *C1* striving to reduce the public debt stock and other measures such as debt relief and interest relief that are not represented in the feedback loop structure of this model. As public debt increases, repayment increases which then decreases public debt the next year round.

2.3 Production Sector

The production sector is essentially a representation of the Cobb-Douglas production function. Gross domestic product is generated by inputs to the economic process. These inputs are labour employed and capital. We assume that public and private investment spending occur as capital orders are transformed into a real acquisition of the capital stock. In the model, investments are funds available for acquisition of capital. Hence, investment divided by the unit cost of capital gives capital acquisition. The structure of the factors of production is explained below:

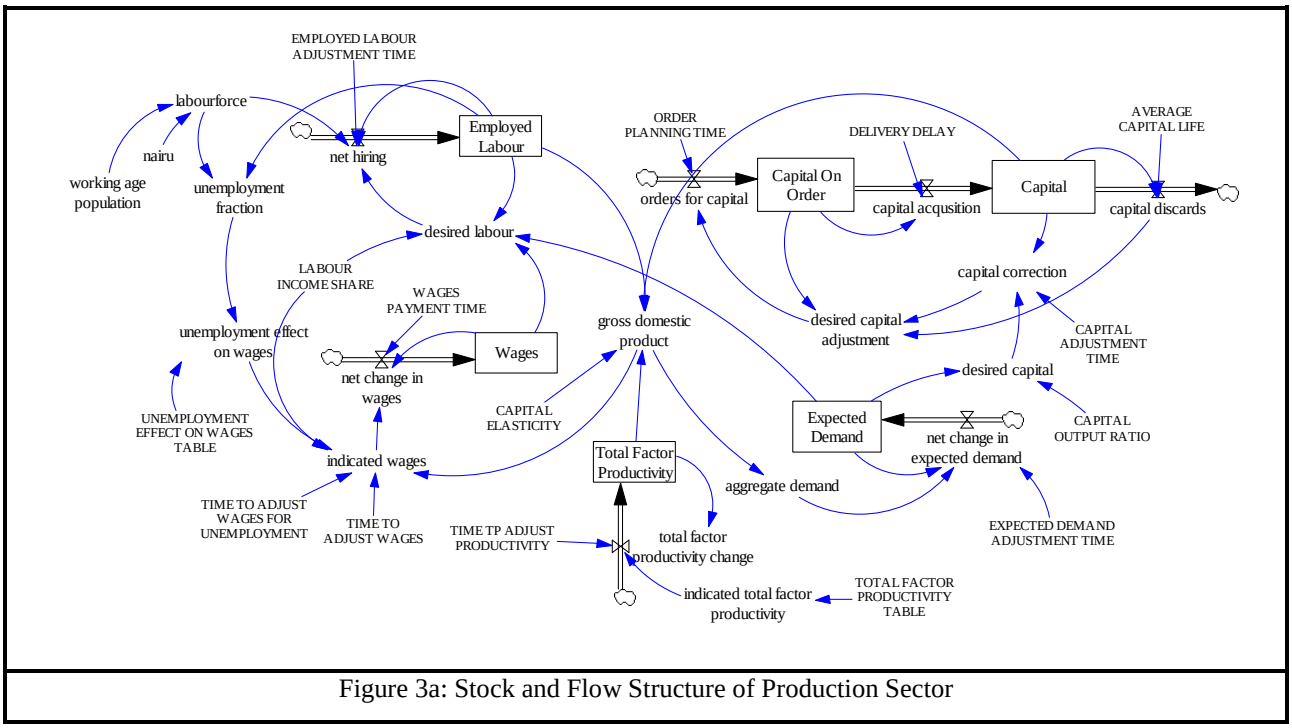

Figure 3a: Stock and Flow Structure of Production Sector

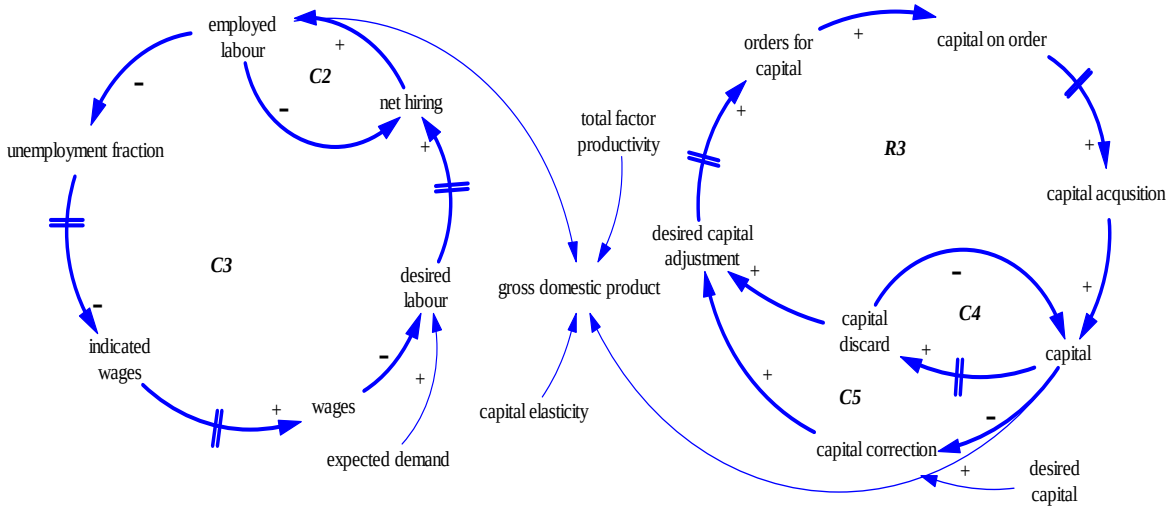

Figure 3b: Feedback Loop Structure of Production Sector

2.3.1 The Labour Component of the Production Sector

Neoclassical economics postulate that labour employed depend on both the supply of and demand for labour. Demand for labour is represented in the model by a variable called “desired labour”. As desired labour changes, employed labour adjusts through net hiring. Desired labour depends positively on expected aggregate demand for goods and services and negatively on wages. In the model, we assume that this equals the supply of good and services; therefore, aggregate demand equals output (i.e. gross domestic product). Net hiring is the difference between desired labour and employed labour divided by the employed labour adjustment time. The supply of labour is referred to as the labour force available. The unemployment is the difference between the available labour and the employed labour. The unemployment fraction is the unemployment relative to the labour force available. Assume unemployment fraction increases unexpectedly. This will push wages downwards, thus keeping wages lower than when in equilibrium (i.e. normal). The effect of the unemployment fraction on wages is represented by the nonlinear function portrayed in figure 4.

Figure 4: Non-linear effect of unemployment fraction on wages

Figure 4 shows that as unemployment fraction increases, wages are adjusted downwards because the unemployed labour would rather work for lower wages than unemployed. We assume that, - decreasing wages will stimulate demand for labour causing an increase in labour employed.

The labour force available is defined as the working age population (age 18-60 years) minus the non-accelerating inflation rate of unemployment (NAIRU) often referred to as “natural

fraction of unemployment". This is the part of the working age population that will not work even if work is available. Wages is the income share of labour (income is taken to be equal to GDP). In the model, wages is formulated by exponential smoothing. Indicated wages are the negotiated wages. The real wages adjusts to its indicated values with a delay (wages payment time). This adjustment time determines how rapidly wages respond to the result of negotiations. In the model, wages payment time is monthly (i.e. 0.08). Indicated (negotiated) wages is a function of gross domestic product and labour income share adjusted by unemployment effect on wages.

The labour component of the production sector in figure 3b is governed by the counteracting feedback loops *C2* and *C3*. The simple feedback loop *C2* include: net hiring and employed labour, whereby as net hiring increases, employed labour increases as well. This will subsequently, decrease net hiring the next year round *ceteris paribus*. The feedback loop *C3* includes desired labour, net hiring, employed labour, unemployment fraction, indicated wages and wages. Assume desired labour increases unexpectedly due to an increase in expected demand. This will induce a labour hiring process that would lead to an increase in employed labour and lower the unemployment fraction. As unemployment fraction decreases, gradually, indicated wages and, subsequently, real-wages would increase. Increased wages will, as a result, -reduce desired labour.

2.3.2 The Capital Component of the Production Sector

In the capital component of the production sector, desired capital depends on expected demand and the capital output ratio. Expected demand is the perceived aggregate demand for goods and services. Assume that the aggregate demand increases over time; this would increase the expected demand. To achieve the expected demand, the capital stock needs to be adjusted upwards to satisfy the expected demand for goods and services. Therefore, the desired capital is the capital component of the factors of production required to produce the expected demand. Desired capital is defined in the model as the expected demand divided by the capital output ratio. Desired capital adjustment is the sum of capital discards and capital correction, - minus capital on order. Desired capital adjustment originates from the rule of thumb that capital discard should cause replenishment and that the difference between desired and the actual capital stock must be corrected to obtain the capital required to satisfy the expected level of demand. Moreover one must take into consideration (subtract from the desired capital) the

capital on order to avoid over capitalization (Senge 1978; Sterman 2000; Wheat 2007). Capital discard is the depreciated capital and is defined as capital divided by the average capital life. Capital correction is the gap between desired capital and capital, adjusted over time to adjust capital. Orders for capital is desired capital adjustment corrected by order planning time. Capital on order integrates orders for capital and capital acquisition. Capital acquisition is capital on order adjusted by delivery delay. Capital integrates capital acquisition and capital discard. The capital component of the production sector highlights the various time lags involved in the structure of capital. The estimate of the total delay between capital order and capital acquisition is very critical to our understanding of the capital investment process. The model represents four important delays, capital adjustment time, order planning time, delivery delay and average capital life (see figure 3a). Capital adjustment time is a delay associated with administrative, decision making, appropriation, granting permissions and others. Order planning time is the time it takes for placing order for capital purchases. Delivery delay is the time it takes for capital ordered to be executed. Delivery delay can be caused by production, transportation and other kinds of delays. Average capital life is the working life of a capital before it is replaced.

The dynamics of the capital sector are embodied in the reinforcing feedback loop *R3* and the counteracting feedback loops *C4* and *C5* in figure 3b. The feedback loop *R3* includes desired capital adjustment, order for capital, capital on order, capital acquisition, capital and capital discard. A rise in the demand for capital goods causes an increase in the desired capital adjustment. As desired capital adjustment increases, order for capital increases. Consequently, capital on order and capital acquisition increases. As more capital is acquired, the capital stock increases further increasing capital discard and in turn, the desired capital adjustment the next time round. The feedback loop *R3* represents the classical accelerator principle of Samuelson (Remolona, Mangahas et al. 1986; Saeed 1993). The feedback loop *C4* include capital and capital discard. As more capital is accumulated, capital discards increases which in turn decrease the stock of capital. The counteracting feedback loop *C5* includes the following variables: capital, capital correction, desired capital adjustment, order for capital, capital on order and capital acquisition. A rise in desired capital *ceteris paribus* increases capital correction. As a result, desired capital adjustment increases, - further increasing orders for capital, capital acquisition and capital. A rise in capital subsequently reduces the capital adjustment the next time round.

The dynamics of the labour market represents the mechanisms by which employment is created, whereas the capital sector represents the capital accumulation process. Output is represented by the Cobb-Douglas production function. The Cobb-Douglas production function requires that the gross domestic product (*GDP*) must equal the product of total factor productivity (*tfp*), capital (*k*) and employed labour (*l*). The Cobb-Douglas production function is represented in an equation as:

$$GDP = tfp * k^{\alpha} * l^{1-\alpha}$$

where α is the capital share of income (capital elasticity).

2.4 Household Sector

In the household sector, household income is calculated as the sum of income (in this case nominal gross domestic products), private transfers, private factor income and interest payments on domestic debt. Public transfers, public factor income, private factor income, private transfer and foreign direct investment are represented by exogenous variables from historical data. Disposable income is the after-tax income and is defined as total household's income minus the government tax revenues. We assume a consumption decision on the part of the households in the model where households will spend the resources available to achieve a smooth consumption profile and the excess resources will be saved. Therefore, the savings rate equals the disposable income less private consumption. Nominal gross national product is the sum of nominal gross domestic product plus net factor income, where net factor income is the sum of public factor income and private factor income. Nominal gross national income is the sum of nominal gross national products and total net transfer.

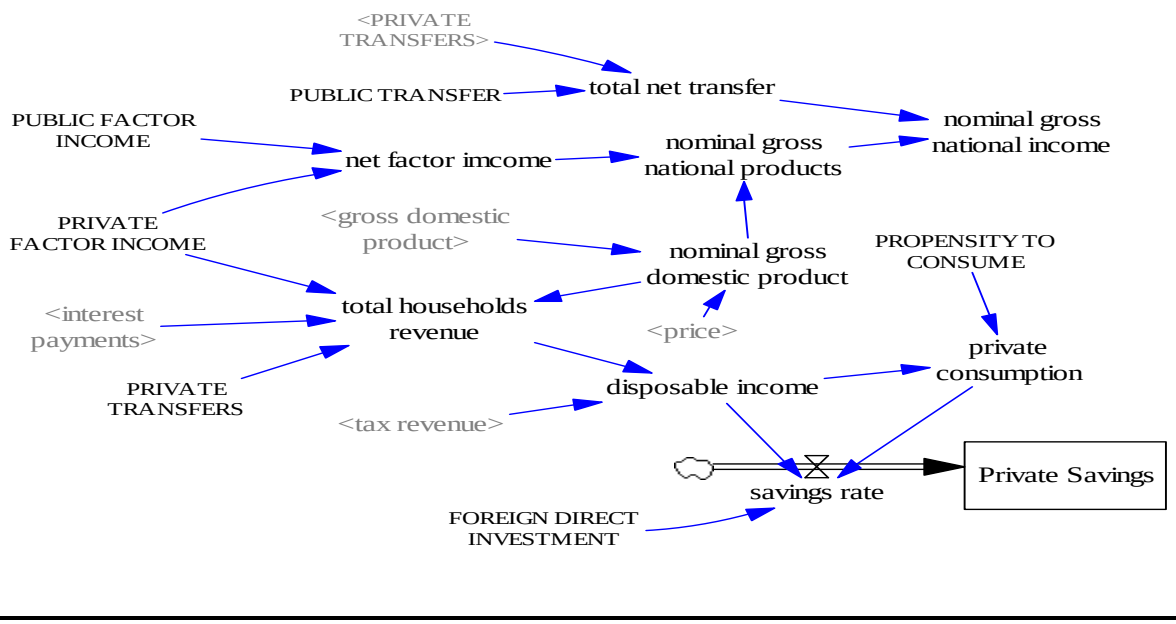

Figure 5: Structure of Household Sector

3. Model validation

Model validation is the process by which we establish sufficient confidence in a model to be prepared to use it for particular purpose (Coyle 1977). Sterman identified a list of validation test to establish confidence in a System Dynamics Model (Sterman 2000). They are dimensional consistency test, structural verification test, extreme condition test, boundary adequacy test, parameter estimation test, sensitivity analysis and behaviour reproduction test. The tests above were conducted with satisfactory results. This allows us to believe that, -the model is useful for our purpose. Below, we report the results of the structural validity test, the structure-behaviour test and the parameter estimation.

3.1 Structural Validity Test

Structural validation is fundamental to an analysis based on a SD model since the structure of the model drives its behaviour. The structural validity of the model originates from the descriptive knowledge about the system structure (Barlas 1989; Barlas 1996; Sterman 2000). The descriptive knowledge of the evolution of public debt, documented in various literature-e.g. (Simonsen 1985; Krugman 1988; Payer 1989; Sachs 1989; Saeed 1993; Senhadji 1997;

Nissanke and Ferrarini 2001; Helbling, Mody et al. 2004; Pattillo, Poirson et al. 2004; Presbitero 2006; Thorbecke 2006) was used to conceptualize the model structure and the causal relationships its represents. We ensured that the model structure is consistent with relevant knowledge, literature and empirical evidence. In the SD model (see figure 1a, 3a and 5) public debt is conceptualized by the stock and flow structure, distilled into causal loop structure (see figure 1b and 2b). When subject to simulation, the model produces the quantitative behaviour that gives rise to validation, analysis and policy design. Moreover, dimensional consistency was checked to ensure that each equation in the model dimensionally corresponds to the real system.

3.2 Parameter Estimation

The model contains fourteen constants. They are: debt maturity, average capital life, capital adjustment time, expected demand adjustment time, delivery delay, order planning time, employed labour adjustment time, time to adjust wages, wage payment time, capital output ratio, time to adjust productivity, capital elasticity, time to adjust nominal tax rate and time to adjust nominal spending rate. These constants were estimated by way of a combination of approaches such as expert estimation elicited by way of interviews, common knowledge, archival studies and optimisation methods.

3.3 Structure-Behaviour Test

The behaviour of any real system is the outcome produced by the mechanisms embedded in the underlying system structure. Correspondingly, the model behaviour results from the structure of the model. Structure-behaviour tests help us understand the structure, including its parameter(s) that governs the behaviour of the model. Figure 6 shows the simulation results for real total foreign debt, real domestic debt, real gross domestic product and real total households' revenue as compared to historical data.

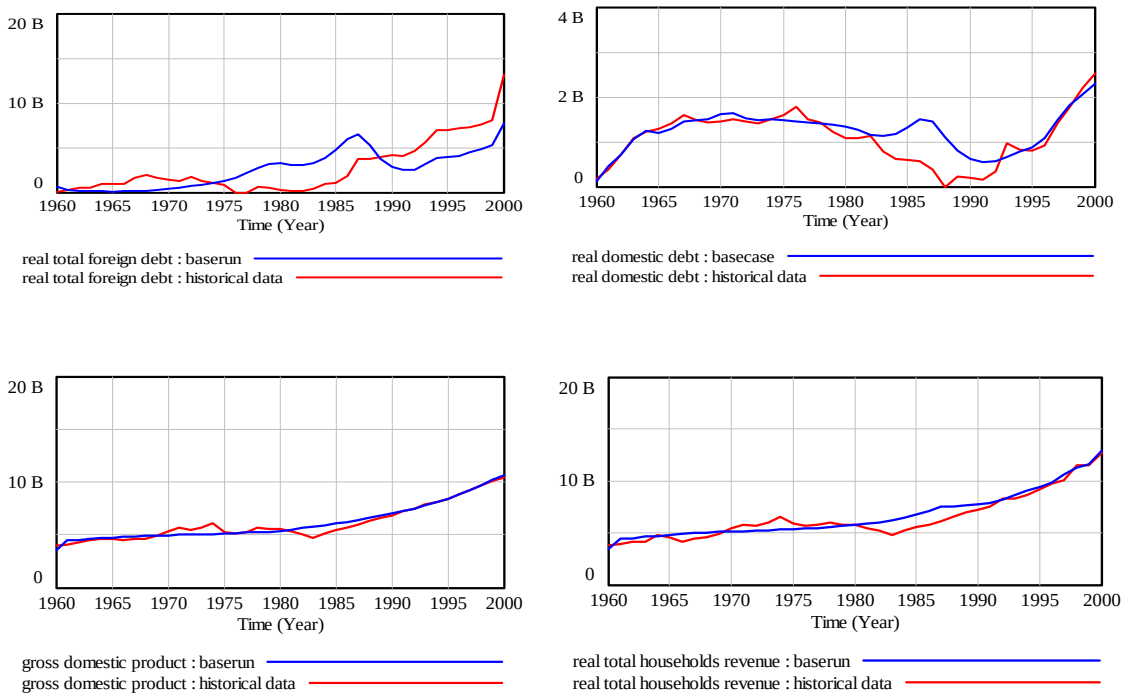

Figure 6: Model behaviour compared to historical data

The simulation result demonstrates that the simulated real domestic debt tracks historical data pretty well. Even though the model does underestimate or overestimate history within certain time intervals. Historical, foreign debt is, however not well reproduced. The foreign debt performs poorly compared to historical data in the 1960s. Then, during the mid 1970s the model consistently overestimates foreign debt and then from the mid 1980s, the simulation result underestimates foreign debt. The Gross domestic product compares favourably with historical data and so does the real total households revenue. A favourable comparison of the model output with historical behaviour is one way among many others to validate the model.

4. Decomposition of Public Debt

4.1 Introduction

We express the stock of total public debt from the government budget constraint equation as follows:

$$D_t = \left[D_{t-1} + (dt)gB_t - (dt)\left(D_{t-1} / m \right) \right] + \left[AI_{t-1} + (dt)Ia_t + (dt)Ui_t - (dt)Is_t \right] + \left[D^f{}_t (X_t - X_{t-1}) \right] - \left[(dt)rD^f{}_{t-1} \right] \qquad (5)$$

Here, D_t is the total public debt, D_{t-1} is the total public debt for the previous year, gB_t is the borrowing, m is the public debt maturity, AI_{t-1} is the accrued interest obligation for the previous year, $(dt)Ia_t$ is the interest obligation accrual, $(dt)Ui_t$ is the unpaid interest payments, $(dt)Is_t$ is the interest obligation elimination, $D^f{}_t$ is the foreign public debt, X_t is the current annual average exchange rate, X_{t-1} is the annual average exchange rate for the previous year and $\left[(dt)rD^f{}_{t-1}\right]$ is the foreign debt forgiven.

Equation (6) demonstrates the equation for the net change in total public debt. The differential equation of total public debt stock is:

$$dD_{t-1,t}/dt = \left[gB_t - D_{t-1}/m\right] + \left[Ia_t + Ui - Is_t\right] + \left[D^f{}_t\left(X_t - X_{t-1}\right)\right] - \left[rD^f{}_{t-1}\right] \quad (6)$$

Equation (6) implies that change in total public debt over a year is accounted for by the difference between borrowing and repayment of the principal, by the accrual of interest, the foreign debt adjustment i.e. the foreign debt change due to exchange rate changes and the debt relief i.e. public debt forgiven by creditors. Equation (6) can be rewritten as:

$$\Delta D_{t-1,t} = \left[pd_t + \left(i_t D_t\right) + D_{t-1}/m - D_{t-1}/m\right] + \left[Ia_t + Ui - Is_t\right] + \left[D^f{}_t\left(X_t - X_{t-1}\right)\right] - \left[rD^f{}_{t-1}\right] \quad (7)$$

Where $pd_t + \left(i_t D_t\right) + D_{t-1}/m = gB_t$ (see figure 1). In equation (7), repayment of the principal, i.e., D_{t-1}/m, increases and decreases total public as shown in the first term of the equation. This is because, in the model (see figure 1a), borrowing equals indicated borrowing, which is defined as the sum of the primary deficit, the total interest payments and repayment of the principal. Hence, the difference between borrowing and repayment $\left[pd_t + \left(i_t D_t\right) + D_{t-1}/m - D_{t-1}/m\right]$ equals the primary deficit and total interest payment $\left[pd_t + \left(i_t D_t\right)\right]$. Thus, the final equation for change in total public debt is:

$$\Delta D_{t-1,t} = [pd_t] + [(i_t D_t) + (Ia_t + Ui_t - Is_t) + (D^f{}_t (X_t - X_{t-1}))] - [rD^f{}_{t-1}] \quad (8)$$

Equation (8) is the public debt decomposition equation, where change in total public debt is characterized by three debt mechanisms namely '*debt creation mechanism*', '*debt reproduction mechanism*' and '*debt reduction mechanism*'. The first term of the equation $[pd_t]$ is the *debt creation mechanism*. Debt is created whenever government non-interest spending exceeds revenue and grants. It is postulated that, the gap is financed by borrowing which, consequently, creates or adds to debt. On the other hand, any time government revenue and grants exceeds non-interest spending, the surplus is used to reduce the existing debt. The second term of the equation $[(i_t D_t) + (Ia_t + Ui_t - Is_t) + (D^f{}_t (X_t - X_{t-1}))]$ is the *debt reproduction mechanism*. This mechanism consists of total interest payments, accrual of interest and foreign debt adjustment. The total interest payments are the actual payment of cost incurred for holding debt while accrual of interest is the accumulation of unpaid interest. Foreign debt adjustment is the foreign debt incurred due to changes in the exchange rate. As long as public debt exists, interest on debt will be incurred. On the other hand, foreign debt adjustment is debt incurred due to an increase in the exchange rate. Since all foreign debt is contracted in foreign currency, any time the average exchange rate increases, foreign debt increases in local currency equivalence. The change in foreign debt due to an exchange rate increase is referred to here as a foreign debt adjustment. It is worth nothing that public debt can increase due to an exchange rate increase besides the well-known flow variables such as primary deficit, interest payments, accrual of interest or debt relief. The last term of the equation $[rD^f{}_{t-1}]$ is the *debt reduction mechanism*. This mechanism is represented by the debt relief which consist of principal relief and interest relief. In many developing countries and Highly Indebted Poor Countries (HIPC), due to the high debt burden and debt servicing difficulties, some creditors (mostly bilateral and multilateral creditors) forgive a fraction of the debt to reduce the debt burden. As debt relief increases, total debt is reduced.

Equation (8) above has two key implications. First, it shows that debt accumulation is driven by primary deficit and total interest payments, - assuming exchange rate and debt relief remains unchanged. The second implication is that debt cannot be stabilised unless the government fiscal policy generate a primary surplus large enough to service the interest on debt *ceteris paribus*.

Table 1 shows the decomposition of the change in total public debt into five year average and the cumulative average contribution of the debt mechanisms to total public debt accumulation in Ghana from 1960 to 1999.

Public Debt Decomposition	*1960-64*	*1965-69*	*1970-74*	*1975-79*	*1980-84*	*1985-89*	*1990-94*	*1995-99*	*Cum. average*
Debt Creation Mechanism									
Primary Deficit	0.86	0.79	0.76	0.76	-0.03**	0.05**	0.38	0.41	***0.50***
Debt Reproduction Mechanism									
Total Interest Payments	0.09	0.15	0.19	0.18	0.71**	0.17	0.14	0.17	***0.23***
Accrual of Interest	0.04	0.05	0.05	0.05	0.11**	0.03	0.04	0.10	***0.06***
Foreign Debt Adjustment	0.00	0.00	0.00	0.01	0.21**	0.75**	0.44**	0.32**	***0.21***
Debt Reduction Mechanism									
Debt Relief	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	***0.00***

Table 1: Decomposition of Change in Total Public Debt from 1960 to 1999

Notes: Figures with the sign (**) indicate sudden trend change which will be explained.

The result from table 1 indicate that with the exception of the period 1980-84 where share of the total interest payments in the change in total public debt exceeded the share of the primary deficit and the periods 1985-89 and 1990-94 where the share of the foreign debt adjustment in the change in total public debt accumulation exceeded the share of the primary deficit, the primary deficit is evidently the most important contributor to the public debt accumulation. The significant reduction in primary deficit in the 1980s and the high total interest payments in 1980-84 were due to combination of factors such as, government spending austerity measures implemented as part of the structural adjustment programme, increased grants from international community and improved tax collection mechanisms put in place (Amoako-Tuffour 1999; Boafo-Arthur 1999).

In the early 1980s, the government of Ghana implemented the Economic Recovery Program and a Structural Adjustment Program imposed by the IMF and the World Bank. Consequently, government expenditure was significantly reduced to enable the government to service its' debt (total interest payments). On the other hand, the high contribution of foreign debt adjustment in 1980-84, 1985-89 and 1990-95 was as a result of the deregulation of the currency market. In the early 1980s, the currency market was liberalised as part of the Structural Adjustment policies. This then increased the foreign debt adjustment significantly. The following section presents a detailed account of the mechanisms governing debt.

4.2 The Debt Creation Mechanism

4.2.1 Primary Deficit

Figure 7 shows a graph of government revenue and grants and non-interest spending as share of GDP on the left hand side and primary deficit as a share of GDP on the right hand side.

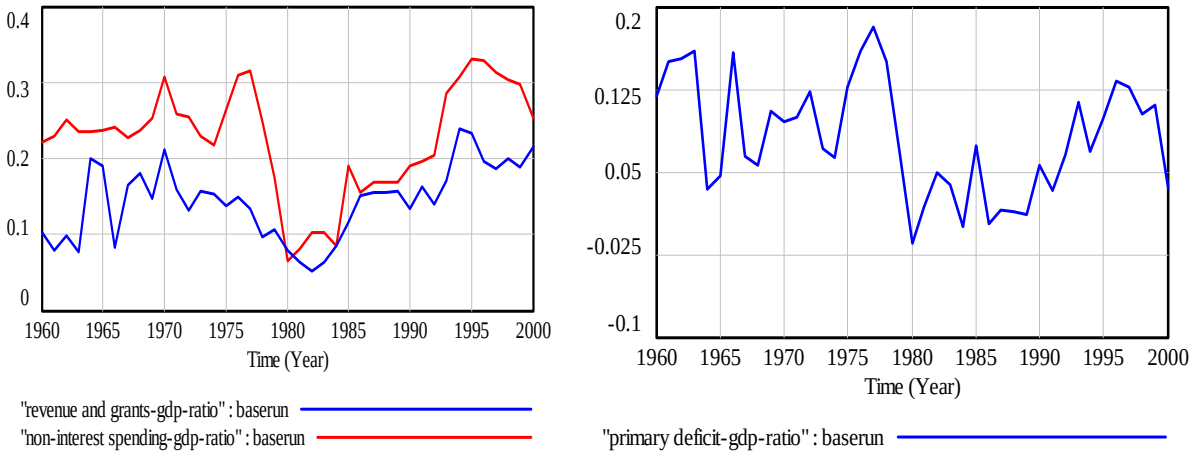

Figure 7: Government spending, Revenue and Primary deficit as percentage of GDP

Primary deficit is the excess of non-interest spending over revenue and grants. Ghana government revenue derives from taxes on international trade (e.g. import duties and export taxes on cocoa), domestic indirect taxes such as sales and petroleum taxes, and domestic direct taxes such as corporate taxes and individual income taxes. In addition, the government generate non-tax revenue from income and fees, and recently from divestiture receipts[5]. Ghana also derives income from programme grants, project grants and project aid from foreign bilateral and multilateral donors (Amoako-Tuffour 1999). Non-interest expenditure includes public sector wages and salaries, pensions, transfer payment and capital investment. We see from figure 7 that revenue and grants have not been sufficient to cover spending. From figure 7, we see that non-interest spending averaged approximately 0.2 of GDP from 1960 to 1970. The 1960s were the era immediately after Ghana's independence where industrialisation implied development is and constitute the economic strategy of the government. The economic policy was one of planned 'restructuring' of the economy through massive public investment, with the aim of reaching the status of an industrial society (Krassowski 1974; Killick 1978; Frimpong-Ansah 1991; Islam and Wetzel 1991; Ayittey 1992). Consequently, government non-interest

[5] Revenue generated from the sale of government assets such as companies.

spending was higher than the revenue and grants available. This caused a substantial accumulation of public debt over the period 1960-70. Non-interest spending dropped sharply from 1976 reaching a trough of 0.07 of GDP in 1980 because access to external borrowing prior to 1984 was limited (Islam and Wetzel 1991). With the implementation of the Economic Recovery Programme and the Structural Adjustment Programme called upon by the IMF and the World Bank, external borrowing increased, - allowing the government to increase spending (Islam and Wetzel 1991). Consequently, from 1985, non-interest spending increased, peaking at 0.3 of GDP in the late 1990s. In contrast, government revenue and grants have varied considerably over time. Revenue and grants peaked around 0.2 of GDP in 1964, and then dropped sharply over the nest two years only to return to a second peak in 1970 at 0.2 of GDP. Revenue and grants declined sharply over the next couple of years reaching a trough in 1982 of 0.06 of GDP. From 1983 revenue and grants turned once more and have since increased with some fluctuation up to around 0.23 of GDP in 1994. According to Islam and Wetzel (1991), the increase in revenue before the 1990s coincided with the increased cocoa production. Cocoa is the major cash crop for the economy of Ghana and any income increase from cocoa increases government revenue.

The primary deficit as shown in figure 7 is a summary measure of the impact of government fiscal policy on total public debt accumulation. The fiscal sustainability theory postulates that for a fiscal policy to be sustainable, a government which has debt outstanding must anticipate sooner or later to run primary surpluses (Blanchard, Chouraqui et al. 1990). Figure 7 clearly demonstrates that the government fiscal policy was not sustainable due to consistent deficit spending. The cumulative contribution of primary deficit to the change in total public debt is calculated to be 0.50 on the average over the period of 1960 to 1999. This indicates that the primary deficit contributed significantly to the total public debt accumulation and can be described as the principal contributor to the total public debt in Ghana.

4.3. The Debt Reproduction Mechanism

4.3.1 Total Interest Payments

Figure 8 illustrates the obligatory interest rate on the left hand side and total interest payments on the right hand side, both as a share of GDP.

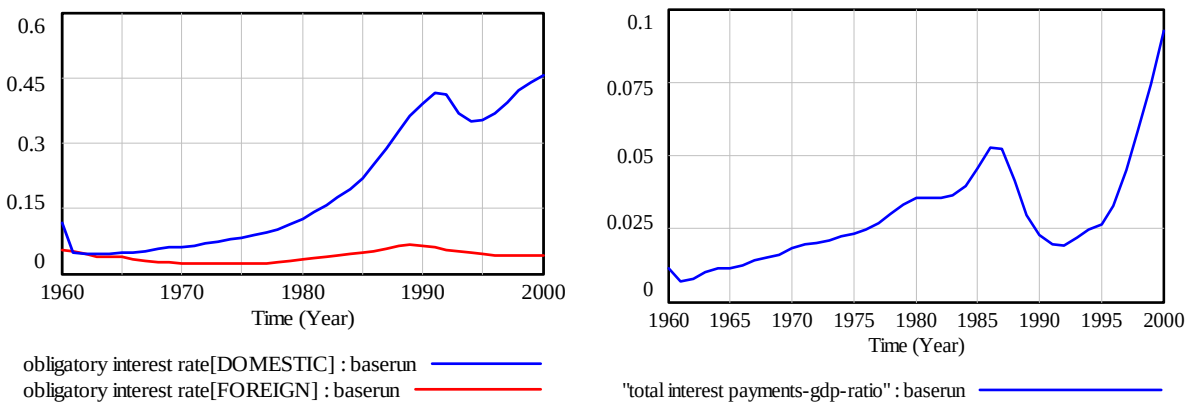

Figure 8 Total Interest payments

The obligatory interest rate is separated into that for domestic debt and that associated with foreign debt. The domestic obligatory interest rate dropped sharply from 0.11 in 1960 to 0.04 in 1961. From 1961 to 1980, the domestic obligatory interest rate increased gradually from 0.04 to 0.12. The 1960s to 1980 was the era where the financial sector in Ghana was characterised by a fixed ceiling on interest rates, credit guidance for different sectors and fixed ceiling on credits. Interest rate controls ensures that the government governs the interest rate. This explains, perhaps, the slow increase in interest rate from 1960 to 1980 (Mensah 1997) regardless of the high inflation rate in the economy, - well over the interest rate. The domestic obligatory interest rate then increased sharply from 0.12 in 1980 to 0.41 in 1992. This sharp increase is attributed to the significant accrual of interest in the early 1980s and the high interest rate charge on domestic borrowing. From 1980, the domestic interest rate increased from 0.10 to 0.24 in 1992. The interest rate rose due to the gradual deregulation of the financial sector when the Financial Sector Structural Adjustment Program (FINSAP) was adopted (Mensah 1997). As a result, the interest rate increased towards the market conditions. From 1992, the domestic obligatory interest rate briefly reduced until it increased once more and peaked at 0.45.

On the other hand, foreign obligatory interest rate decreased from 0.05 in 1960 to 0.02 in 1976. This reduction of the foreign obligatory interest rate is attributed to the shift of government borrowing from private financial market to concessional loans from bilateral and multilateral sources. The relatively low interest rate on concessional loans compared to private supplier credit, thus far accepted by the government, ensures that the obligatory interest rate decreases during the period (Krassowski 1974; Killick 1978). The foreign obligatory interest rate

increased significantly during the period 1977 to 1990, from 0.02 to 0.06. The increase in the foreign obligatory interest rate from 1977 to 1990 is ascribed to the combined effect of an increase in the interest rate on concessional loans and increase in accrual of interest. The interest rate on concessional foreign borrowing increased during the period 1977 to 1990 from 0.02 to 0.03 as a response to the rise in the interest rate worldwide. Moreover, the increase in accrual of interest stepped up the accumulation of accrued interest which invariably increased the foreign obligatory interest rate. The foreign obligatory interest rate decreased slightly from the 1991 level of 0.06 to 0.04 in 2000. This follows the reduction of interest rate on concessional loans.

Total interest payments as a fraction of GDP decreased significantly from 0.01 of GDP in 1960 to approximately 0.006 in 1961 and increased steadily to 0.05 of GDP in 1987. Total interest payments as a fraction of GDP decreased immediately after 1987, reaching a trough of 0.019 in 1992 before peaking at 0.09 in 2000.

The cumulative contribution of total interest payments to debt accumulation in Ghana from 1960 to 1999 is estimated to be 0.23. We establish that total interest payments are the second highest contributor to public debt accumulation in Ghana after the primary deficit. Table I estimates shows that during the period 1960-64, the share of public debt accumulation constituting total interest payments was 0.09. The significant interest payments component of the debt accumulation was due to increased government borrowing. From 1965-69 to 1970-74, total interest payments contribution to debt accumulation was 0.15, which increased further to 0.19. The total interest payments contribution to debt accumulation decreased slightly from the 1970-74 level of 0.19 to 0.18 in 1975-1979. Nevertheless, the total interest payments contribution to the accumulation of debt peaked in 1980-84 at 0.71. The sharp increase to 0.71 from 1980-84 highlights the high debt burden during the early 1980s that prompted the assistance of the International Financial Institutions in solving the debt problem. Hence, the implementation of the Structural Adjustment Programme to restructure the economy and government fiscal policy. From 1985 to 1999, the total interest payments share to the debt accumulation decreased significantly from 0.62 to 0.17, and then decreased further to 0.14 before increasing slightly to 0.17 by the end of the millennium.

4.3.2 Foreign Debt Adjustment

Figure 9 reports the change in exchange rate on the left hand side and foreign debt adjustment on the right hand side as a share of GDP.

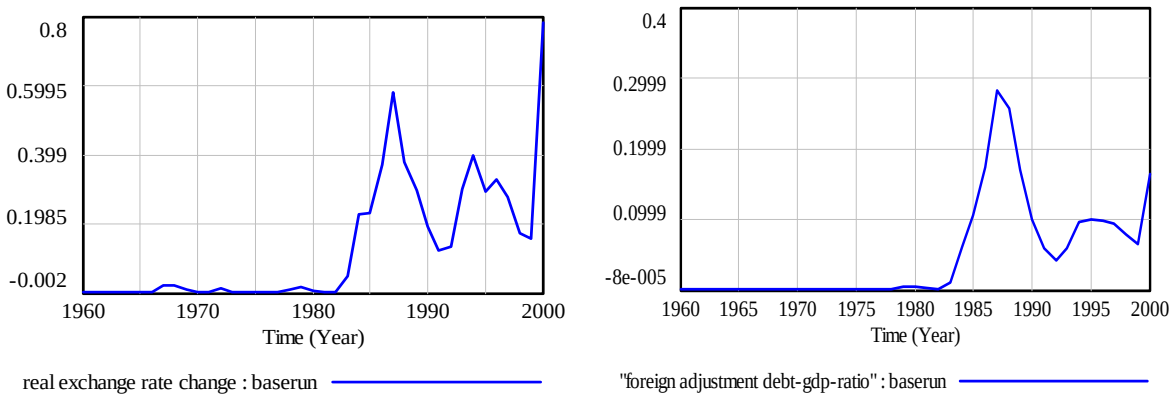

Figure 9: Foreign Debt Adjustment

The graph in figure 9 shows that from 1960 to 1980, the change in the real exchange rate was negative. This is due to the implementation of a fixed currency exchange regime (Islam and Wetzel 1991; Boafo-Arthur 1999). From 1980, the change in the real exchange rate become positive and then increased sharply between 1983 and 1986. This sharp increase is attributed to the deregulation of the currency exchange market during the Structural Adjustment era (Boafo-Arthur 1999). Subsequently the exchange rate adjusted to the market rate as a result of the deregulation amidst some fluctuations after 1990, - based on the strength of Ghana's balance of payment.

The five year average contribution of the foreign debt adjustment to the debt accumulation during the period 1960 to 1979 as shown annually in table 1 are 0.00, 0.00, 0.00 and 0.01. The insignificant foreign debt adjustment from 1960 to 1979 implies that the currency exchange policy implemented by the government during that period did not contribute significantly to public debt accumulation. From a modest contribution of 0.01 to public debt accumulation in 1975-79, the foreign debt adjustment increased significantly in 1980-85, contributing 0.21 to public debt accumulation, and peaked at 0.75 in 1985-89 before declining gradually to 0.44 in 1990-94 and 0.32 in 1995-99. We establish that the 1980s was the period that the distortion in the currency exchange market was corrected to ensure relative stability in the exchange market, - consequently the high debt accumulation from the adjustment of the exchange rate. The cumulative contribution of foreign debt adjustment as a share of debt accumulation is

calculated to be a total fraction of 0.21 from 1960 to 1999. Foreign debt adjustment is the third highest contributor to public debt accumulation in Ghana from 1960 to 1999.

4.4. The Debt Reduction Mechanism

4.4.1 Debt Relief

Figure 10 shows the share of debt relief as a fraction of GDP.

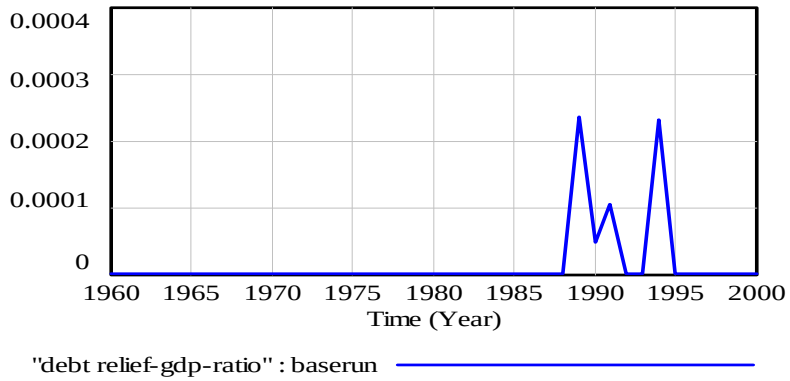

Figure 10: Debt Relief as a share of GDP

We observe from figure 10 that from 1960 to the late 1980s, the government of Ghana did not receive debt relief from its creditors. Moreover, from 1988 to 1995 the government received insignificant debt relief relative to GDP from its creditors. The contribution of debt relief to debt accumulation from 1960 to 1989 is therefore either zero or insignificant. The only period where debt relief contributed to reducing debt was 1990-94 where the debt relief share of the total debt accumulation was 0.0011. It is worth noting that debt relief negatively affect debt accumulation. That is, as debt relief increases, public debt decreases. The cumulative share of debt relief to debt accumulation from 1960 to 1999 is very small implying that debt relief did not play significant role in determining the development of public debt in Ghana.

5. The source of Debt Accumulation

5.1 Introduction

The source of public debt creation is the fiscal policy of the government. Assume that initially there is no public debt and that the government balanced budget every time period so that no debt accumulates. However, debt accumulates if government spending exceeds government revenue and grants. The default assumption is here that, whenever government spending exceeds government revenue and grants, the gap is closed by borrowing from either a domestic and or a foreign source. So, in the course of the first period, debt will equal to government spending minus government revenue and grants. However, if government spending continues to be higher than revenue and grants as is common in developing countries, resulting in a primary deficit, over the next period debt will not only consist of the difference between government spending and revenue and grants, but will also include interest on debt as well as repayment of some fraction of the principal. We identified in our modelling process that the inability of the tax authorities to collect the tax revenue expected is responsible for low tax revenue which, consequently affect the primary deficit. Table 1 established that primary deficit had a cumulative contribution of 0.50 as a share of the change in public debt from 1960 to 1999. This indicates that a significant portion of public debt accumulation from 1960 to 1999 can be explained by understanding the government fiscal policy.

5.1 Fiscal policy

The fiscal policy refers to the decision rules by the government that are designed to influence the direction of the economy through changes in government taxes and spending. The two main instruments of fiscal policy are government taxation and government spending. Figure 11 shows the structure of the government taxation on the left hand side and the structure of government spending on the right hand side.

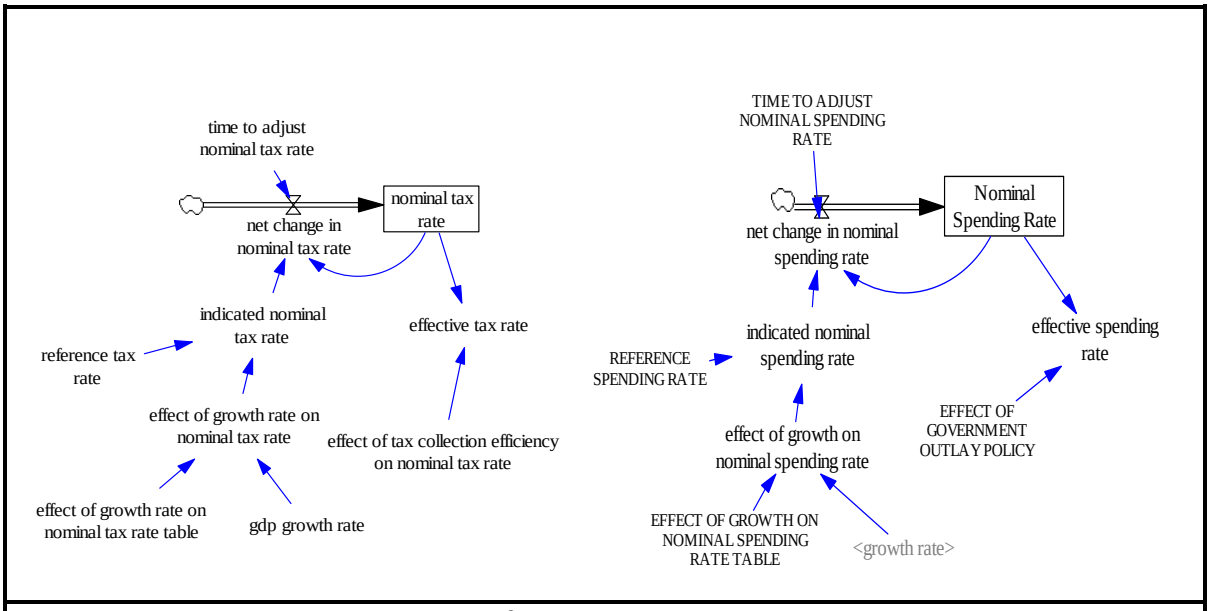

Figure 11: Structure of Government Tax and Spending Rate

We assume that a simple, adjustable tax policy is in place; where the nominal tax rate is determined by a "reference tax rate" and an effect of growth rate on nominal tax rate. According to the simple adjustable tax policy, the nominal tax rate will increases as GDP increases and, in times of low growth, stagnation or recession where GDP decreases, the nominal tax rate will be reduced to stimulate the economy. Figure 12 below illustrates the non-linear function of the effect of GDP growth on- the nominal tax rate.

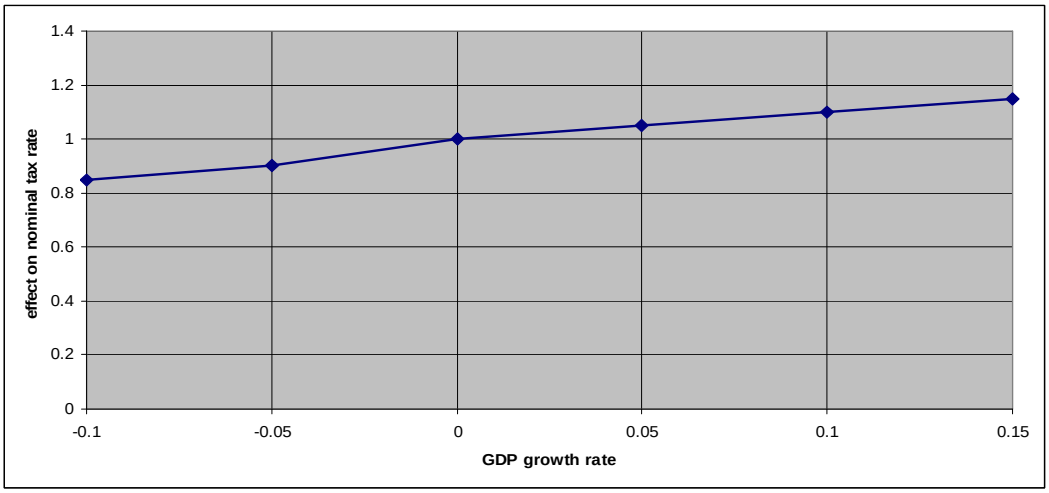

Figure 12:Non-linear function of the effect of GDP on nominal tax rate

In developing countries where a significant segment of the economy is informal, the effectiveness of the tax authority to collect the nominal tax revenue is very crucial. Based on

tax revenue data and the simulated nominal tax rate from the model, we estimate the effect of tax collection efficiency on the nominal tax rate. The effective tax rate is a function of the nominal tax rate and the effect of tax collection efficiency on the tax rate.

Concerning the spending policy (see figure 11), the default assumption is that the government has a default 'reference spending rate' which is adjustable, based on the health of the economy. As GDP increases, it is assumed that revenue from taxes will increase, and, as a result, spending will increase to match revenue. On the other hand, as GDP decrease during recession, it is assumed that spending will increase by 5 percentage points to stimulate the economy. The spending increase during a recession period will originate from government borrowing. Empirical evidence shows that the development agenda of governments at certain times cause spending to increase beyond what it should have been, and Ghana is no exception. Accordingly, the 'government outlay policy effect' on the nominal spending rate is estimated in the model to define the effective spending rate. The effective spending rate is a function of the nominal spending rate and the 'government outlay policy effect'.

Figure 13 shows the effective and nominal spending rate on the left hand side and effective and nominal tax rate on the right hand side, both as a share of GDP. The effective spending rate of the government fluctuated around the nominal spending rate from 1960 to 2000. From 1960 to 1968, the government effective spending rate approximately equals the nominal spending rate, while the 1970s generally saw effective spending higher than nominal spending. The 1980s to the early 1990s saw government effective spending significantly lower than nominal spending and the later part of 1990s to 2000 witness effective spending significantly above nominal spending. Likewise, the government effective tax rate was consistently lower than the nominal tax rate. The early 1980s recorded the lowest effective tax rate which was significantly lower than 0.1 of GDP

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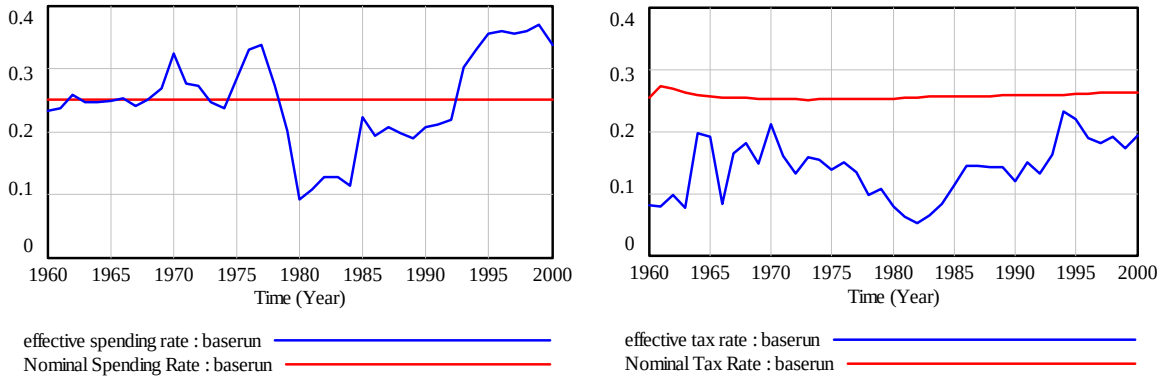

Figure 13: Effective and Nominal spending and tax rate

To understand the effect of government fiscal policy on total debt, we move beyond the factual description to construct counterfactuals (Cunha, Heckman et al. 2004). The counterfactual simulation help us determine what the total debt would have been if the government fiscal policy outcome (effective tax rate and effective spending rate) were different than historically observed one. We have tested the following scenarios;

Scenario 1: The Tax authority collects the nominal tax revenue.

Scenario 2: The government spending adheres to the nominal spending.

Scenario 3: The tax authority collects the nominal tax revenue and government spending adheres to the nominal spending.

Figure 14 shows the results of the scenario analysis compared with the base case scenario.

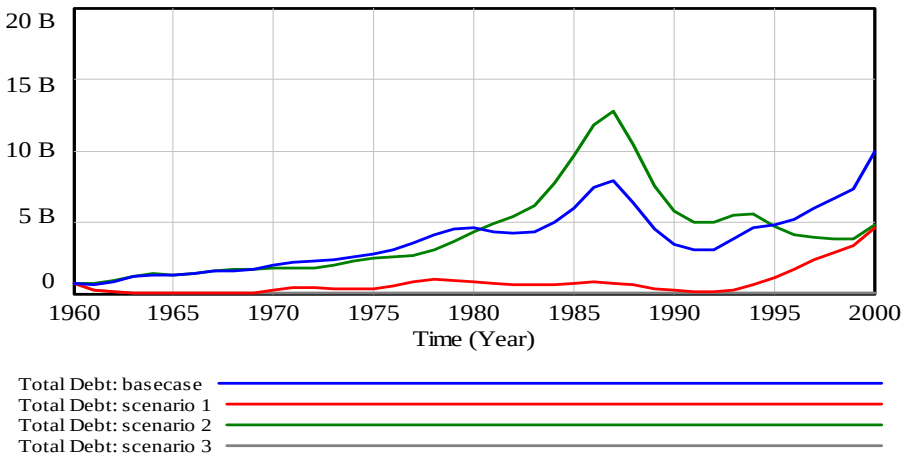

Figure 14: Scenario Analysis of Total Public Debt

5.1.1 Scenario 1

Under this scenario we analyse what total debt would have been should all nominal tax revenue be collected by the tax authority? We implemented this scenario by assuming that the effect of tax collection efficiency on the nominal tax rate is one (1). For that reason, effective tax rate equals the nominal tax rate. The result from the scenario analysis point out that, as the tax revenue increases under scenario 1 *ceteris paribus*, primary deficit reduces. Consequently, the total debt decreases compared to the base case scenario. We therefore conclude that the inefficient tax collection system is the main source of debt accumulation in Ghana (see figure 13). The inability of the tax authority to develop ingenious ways of tax collection in an economy with sizeable informal sector is denying the government vital resources to finance badly needed spending. Implementing a better system for tax collection will help the government to effectively collect tax revenue and reduce total debt.

5.1.2 Scenario 2

In this scenario we analyse what total debt would have been if the government effective spending was equal to nominal spending. In a simplistic way to do this we ensure that the effective spending rate equals the nominal spending rate. As a result, the government outlay policy effect on the spending rate is taken as one (1) *ceteris paribus (*see figure 11*)*. The result of scenario 2 as shown in figure 14 indicates that total debt would have been much higher compared to the base case scenario and scenario 1. The outcome indicates that effective spending alone is not responsible for the debt accumulation. Scenario 2 implies that the government outlay policy contributed to excess effective spending over nominal spending in the 1970s and late 1990s while contributing to spending reduction from 1975 to 1998.

5.1.3 Scenario 3

Under this scenario we analyse the combined effect of scenario 1 and 2 on total debt. The result from scenario 3 shows less total debt compared to scenario 2 and the base case scenario. However, the total debt from scenario 3 is comparable to scenario 1, except from 1985 to 1990 where total debt from scenario 3 is higher than scenario 1 and from 1995 to 2000 where total debt from scenario 1 is larger than scenario 3. We can infer from the analysis that had the government implemented tax policies that ensured maximum tax collection and also spent prudently i.e. government spending equals nominal spending, debt accumulation would have

been drastically reduced and the total debt burden would haven been much less than it currently is.

6. Conclusion

Within the confines of the objectives of this paper, we developed a dynamic model that identifies the fundamental structure of public debt accumulation, the *mechanisms* that generate public debt and their relative contribution to public debt accumulation. The synthetic data from the model was used to estimate the contribution of the *debt mechanisms* to public debt accumulation. The identified debt mechanisms are the *debt creation mechanism*, the *debt reproduction mechanism* and the *debt reduction mechanism*. The conclusion from the analysis is that the *debt creation mechanism* i.e. primary deficit is recognized as the main cause of public debt. We establish that the cumulative contribution of the *debt creation mechanism*, i.e. the primary deficit to public debt accumulation from 1960 to 1999 was 50 percentage points. Moreover, we established that the *debt reproduction mechanism* added a cumulative contribution of 50 percentage points to public debt from 1960 to 1999, of which the total interest payments contributed 23 percentage points, accrual of interest contributed 6 percentage points and foreign debt adjustment contributed 21 percentage points. The contribution of the *debt reduction mechanism* i.e. debt relief to the accumulation of public debt was insignificant from 1960 to 1999. Lastly, our investigation on the source of debt accumulation establishes that the inability of the tax authority to collect the expected tax revenue is the main source of the deficit responsible for public debt accumulation.

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