Modeling the Dynamics of Poverty Trap and Debt Accumulation

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Abstract

Absolute poverty is all pervasive in most developing countries and particularly in Africa (Gore 2002; Sachs, Mcarthur et al. 2004) and Ghana is no exception. The poverty in developing countries is exacerbated by poor GDP growth. For instance, the growth rate per capita for sub-Saharan Africa was negative in the 1980s, i.e. about -2% per annum and about -1% per annum during the 1990s (Birdsall, Claessens et al. 2002). Most common explanation for why countries fail to achieve economic growth focuses on corrupt leadership, inability to make productive use of loans and culture that impede modern development (Korner, Maass et al. 1987; Sachs 2005). However, in recent years, the idea that poverty itself causes economic stagnation has gain attraction and engages the attention of researchers. In this paper, we developed a system dynamics model based on the system dynamics adaptation of poverty trap and debt overhang theory to establish the causal structural mechanism that explains poverty trap and determine internal poverty trends and its link with public debt accumulation. A generic system dynamics model of a developing economy whose microstructures incorporates basic mechanisms of population, production and public debt accumulation is used as a basis for analysis. We found out that the decline of per worker income in Ghana is attributed to significant reduction of investment, which consequently decreases GDP growth, coupled with high population growth. The policy analysis proposed increasing public investment or savings as the best policy to reduce poverty and public debt accumulation.

Keywords: Poverty trap, Public Debt Accumulation, Modeling and Simulation

1. Introduction

The economic literature on the nature of poverty and the idea that countries might be stuck in an underdevelopment trap was widely discussed by development economist in the 1950s (Nelson 1956; Lieberstein 1957). However, the continuous existence of poverty in many countries in the world after countless attempt to eradicate poverty has renewed the interest in search for causes of poverty trap in many developing countries (Sachs 1989; Gore 2002; Sachs, Mcarthur et al. 2004; Sachs 2005). Absolute poverty is all pervasive in most developing countries and particularly in Africa (Gore 2002; Sachs, Mcarthur et al. 2004) and Ghana is no exception. The poverty in developing countries is exacerbated by poor GDP growth. For instance, the growth rate per capita for sub-Saharan Africa was negative in the 1980s, i.e. about -2% per annum and about -1% per annum during the 1990s (Birdsall, Claessens et al. 2002). Most common explanation for why countries fail to achieve economic growth focuses on corrupt leadership, inability to make productive use of loans and culture that impede modern development (Korner, Maass et al. 1987; Sachs 2005). Jeffrey Sachs in his book "*the end of poverty*" challenged the common explanation for the failure of poor countries to achieve economic growth and ask "*if poverty itself causes economic stagnation*". Sachs concluded that poverty create poverty trap and reinforces itself if steps are not taken to break the cycle. In most poor countries, out of desperation to exit the poverty trap, loans are acquired to increase resources for investment and consumption smoothing (Lindauer and Velenchik 1992; Jha 2001; Ghatak and Sanchez-Fung 2007). As a consequence public debt accumulates causing a heavy debt burden.

The problem situation in Ghana is that Ghanaians are still about as poor as they were in the early 1960s (Easterly 2002) coupled with high per capita public debt that surpass per capita GDP as illustrated in figure 1. We took as a point of departure, the economic performance of Ghana over the years, to understand the link between poverty, low per capita GDP and public debt, i.e., how poverty contributed to the observed per capita GDP and the per capita public debt. Of foremost importance for this paper is to answer the question: what drives Ghana's low GDP per capita and high per capita public debt?

Figure 1 shows the development over time of per capita GDP and per capital public debt in Ghana.

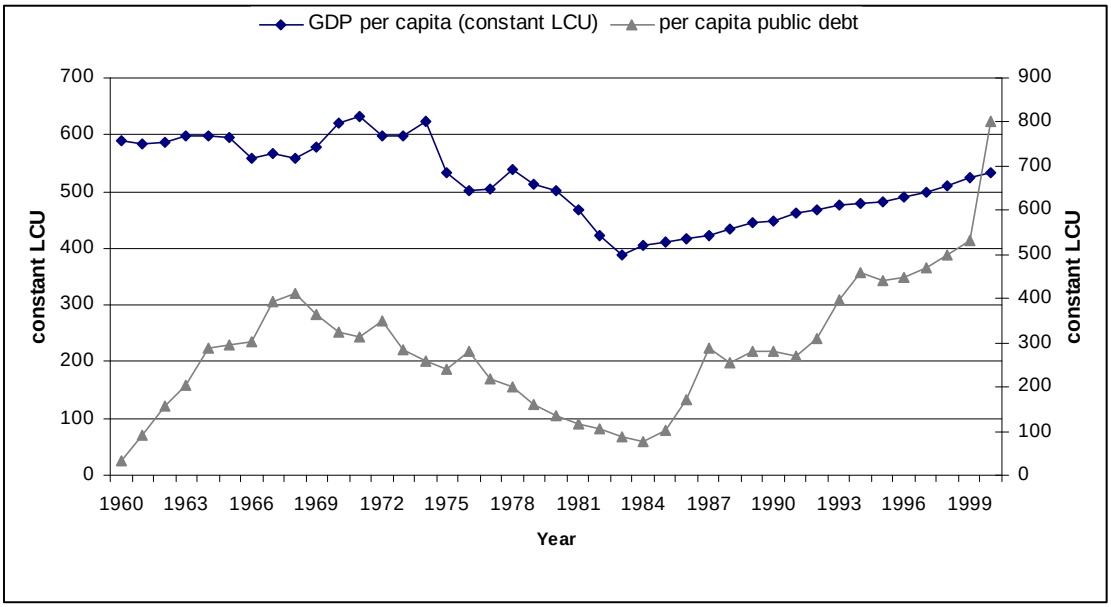

Figure 1: GDP per Capita (left side of y-axis) and per Capita Public Debt (right side of y-axis)

Source: World Bank, World Development Indicators 2002, Ghana Statistical Services

Note: LCU is Local Currency Unit, i.e. Cedi

In this paper, we developed a system dynamics model based on the system dynamics adaptation of poverty trap and debt overhang theory to establish the causal structural mechanism that explains poverty trap in Ghana and determine internal poverty trends and its links with public debt accumulation. A generic system dynamics model of a developing economy whose microstructures incorporates basic mechanisms of population, production and public debt accumulation is used as a basis for analysis.

The result from the analysis established that the decline of per worker income in Ghana before the late 1990s was as a result of population growth rate exceeding GDP growth rate. GDP on the average barely increased from 1960 to 1985, whereas from 1985 to 2000 GDP increased from 1.4% to 5.4%. On the other hand, population increased between 2.3% to 2.5% from 1960 to 2000. The poor performance of GDP is attributed to

low investment. According to the analysis, low investment is attributed to three main reasons. First, the gradual decline of per worker income coupled with basic needs consumption increased due to increases in household size as a result of population increase reduced the ability of workers to save. Accordingly, the decline of savings significantly reduced domestic investment which invariably affects investment. Second, the dramatic decline of foreign direct investment during the early 1960s and subsequent disinvestment in the economy contributed significantly to the low investment observed during the simulation period. However, during the early 1990s, foreign direct investments bounce back to the 1960 level. Lastly, the irregular public investment significantly contributed to the observed behavior of investment over the simulation period.

The policy analysis established that increasing public investment or savings is the best policy to reduce poverty and public debt accumulation. The policy analysis indicates that, it is only when the capital base of the country increase significantly, causing production and income to increase, and leading to per worker income significantly higher than basic needs consumption, then, the economy tend to achieve growth.

The paper is organized as follows. Section 2 covers literature review on low level equilibrium trap and poverty trap theory. Section 3 describes the causal structure of poverty trap and debt accumulation while section 4 describes the stock and flow structure and the equations of the model. Section 5 represents the validation of the model. Section 6 represents the base run behavior explanations. Section 7 represents the policy analysis and discussion. Section 8 represents the conclusion.

2. Literature Review

Here, we will discuss two main theories: the low level equilibrium trap theory and poverty trap theory. The low level equilibrium trap theory (Nelson 1956) discusses the relationship between economic growth and demographic transition whereas the poverty

trap theory (Sachs, Mcarthur et al. 2004) demonstrate how poverty causes economic stagnation in poor countries.

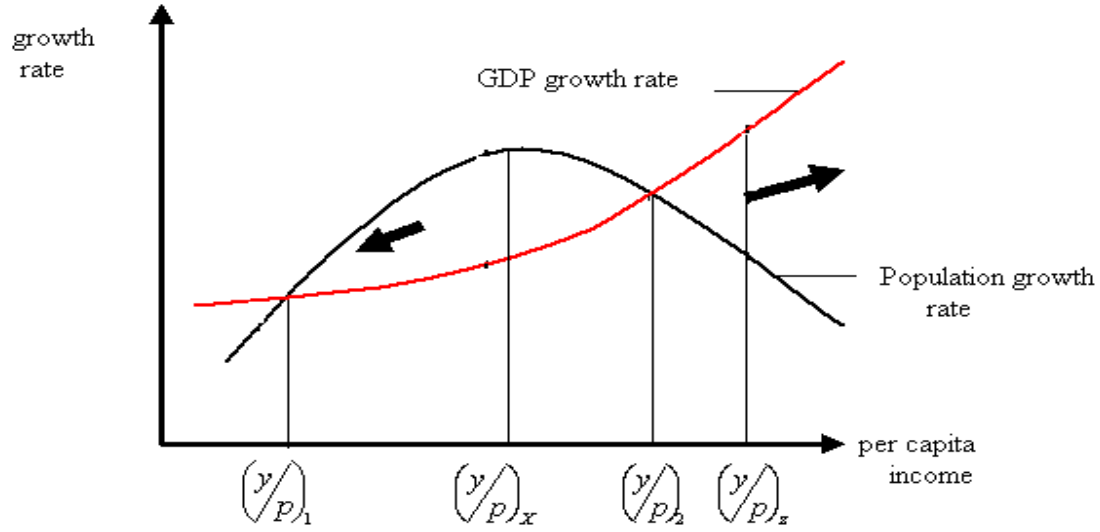

Figure 2: Low Level Equilibrium Trap

Figure 2 shows the graphical model illustrating the low level equilibrium trap. Considering the GDP growth curve for now, figure 2 implies that as per capita income (x-axis of figure 2) increases, the rate of growth of GDP also increases. This is due to the fact that as income increases, savings increases as well which facilitates the accumulation of capital for production. As production increases, income rises which implies greater human capital which further enhances production and income. On the population, the model assumes that up to a certain level of threshold income, household will respond to increased income by having more children. Also, it is hypothesized that as income increases death rate decline further increasing population. But beyond certain level of income $\left(y/p\right)_x$ it is assumed that fertility will fall which consequently reduces population.

From figure 2, the growth rate of per capita income can be estimated by subtracting population growth rate from GDP growth rate. Therefore, per capita income is at equilibrium when population growth rate equals GDP growth rate. Figure 2 shows two

equilibrium states, i.e. $\left(y/p\right)_1$ and $\left(y/p\right)_2$. Assuming per capita income is initially at equilibrium $\left(y/p\right)_1$ and through technology increase and investment, per capita income temporarily increases to $\left(y/p\right)_X$. Over time, if population growth rate exceed GDP growth rate, per capita income will fall until it reaches the initial equilibrium $\left(y/p\right)_1$. However, if the external forces applied to per capita income force it to the new equilibrium $\left(y/p\right)_Z$, the GDP growth rate will surpass the population growth. This will facilitate a period of sustained growth in per capita income.

The fundamental thinking of the poverty trap theory is that the economy grows in per capita terms as long as savings per capita exceeds capital widening[1] (Sachs, Mcarthur et al. 2004). It is postulated that if savings is lower than capital widening the economy experiences a decline in output per capita. According to the poverty trap theory, when capital-labor ratio is very low, marginal productivity of capital also tend to be low because a minimum threshold of capital is needed before modern production process can be started. When the threshold capital is not present, small increments of capital-labor ratio may have little effect. However, the theory hypothesized that once the basic infrastructure and human capital are in place, the marginal productivity of capital may indeed become very high in a low-income country.

[1] Capital widening is the amount of saving per capita that is needed to hold the capital-labor ratio constant in the face of population growth and depreciation.

3. Structure of Poverty Trap and Debt Accumulation

Figure 3 show the fundamental loops that cause poverty and debt accumulation. The conceptual framework of the model incorporates the debt accumulation process theory (Saeed 1993) and the poverty trap theory (Sachs, Mcarthur et al. 2004). The information relationships established in the model are explained below:

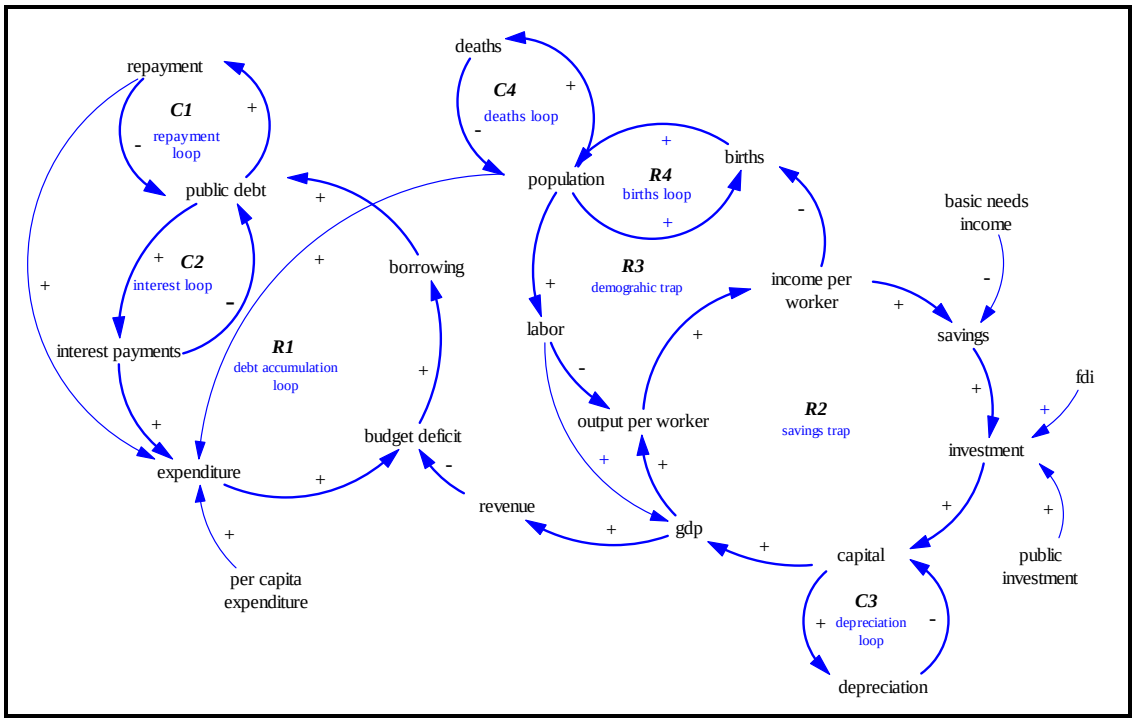

Figure 3: Causal Structure of poverty trap and debt accumulation

3.1 Debt accumulation

The debt accumulation process is embodied in the feedback loops *(R1, C1, and C2)* as shown in figure 3. Public debt increases through borrowing and interest accrual. As debt increases, debt servicing consisting of repayment of principal and interest payments, rises which consequently increases government expenditure. As government expenditure build up without corresponding increase in revenue, budget deficit increases which create the need for more borrowing the next year round. The counteracting loop *C1* and *C2* strives to counteract the growth of public debt. Thus, as public debt increases, repayment of

principal and interest payments increases which then reduces the stock of public debt outstanding.

3.2 Poverty Trap mechanism

The poverty trap mechanism is represented by the interaction of the savings trap *(R2)* and demographic trap *(R3)*. The conceptual framework of the savings traps is the accelerator principle (Hamberg 1971) which posit that investment is a function of rate of change of income. The causal structure of the savings traps and demographic traps are described as follows:

3.2.1 Savings Trap

The conceptual framework of the savings traps is the accelerator principle (Hamberg 1971) which posits that investment is a function of rate of change of income. In poor countries, savings rate can be become very low or even negative when income is low, because impoverished households use all of their income in the struggle to just stay alive (Sachs, Mcarthur et al. 2004). Once basic needs, i.e. personal health, food intake and shelter are met; poor households may save some of the excess income (Sachs 2002). The causal loop *(R2)* demonstrates that low income per worker causes low savings which then decreases investment and capital accumulation. Consequently, output per worker is expected to decrease due to low capital accumulation coupled with high population growth. As output per worker decreases over time, income per worker decreases as well which causes low savings the next year round.

3.2.2 Demographic trap

The demographic trap shows how high population growth, with low capital can push a country into the poverty trap. Based on the assumption that poor countries are characterized by low income, it is proven that high fertility rates in the world are observed among the world's poorest people (Thompson 1928; Kamerschen 1972). With

low income per worker, it is expected that fertility rate will increase causing birth rate to rise. As birth increases, population increases. Population growth causes new entrants to the labor market to increase, which consequently, increases employment, resulting in the decline of capital-labor ratio. In the absence of technological improvement, which is expected to be the case in poor countries, output per worker will decline. As a result income per worker will decrease causing population to grow. It is important to note that as the demographic trap loop becomes stronger over time, it strengthens the savings trap which then reduces investment and capital accumulation further. The strength of the demographic trap can only be counteracted by loop (*C4)* when death surpasses birth to slow the growth of the population.

4. Overview of the Model Structure

This section briefly describes the model structure and the main assumption of the model. The model consists of three parts, i.e. population, production and public debt. Figure 4 shows the stock and flow structure of the model.

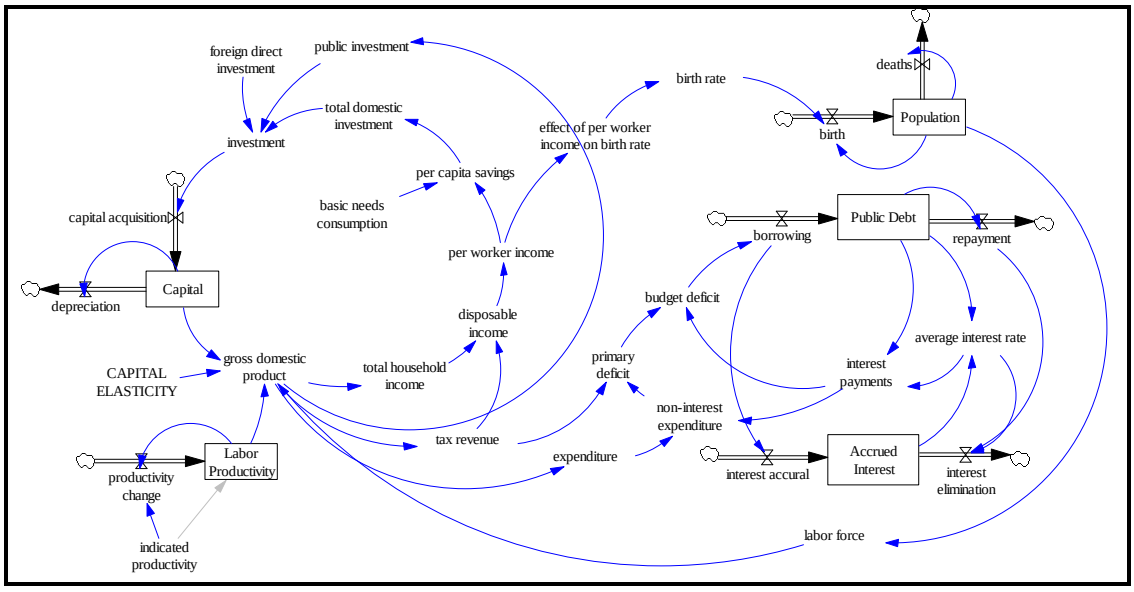

Figure 4: Stock and Flow Structure of the poverty traps and debt accumulation model

In the following paragraphs we describe and briefly discuss the structure of the model.

4.1 Population

The population sector models total population in a simplistic way. The growth of population is determined by the relation between births rates and deaths rates (Meadows, Randers et al. 1972; Szirmai 2005). Here, "births rate" and "deaths rate" are measured in people per year. They represent the total rate at which population is being increased and decreased. The population is represented in the model as:

$$P_t = P_{t-1} + (dt)BR_{t-1} - (dt)DR_{t-1} \qquad (1)$$

Here P_t is the current population, P_{t-1} is the previous year population, BR_{t-1} is the births rate and DR_{t-1} is the deaths rate.

Births rate is determined by births rate normal (BRN), effect of per capita income on births (f (IN)) and previous year population (P_{t-1}). The births rate is called "normal" rate because they correspond to a standard set of conditions at the initial model setting. However, it is expected that income change will cause births rate to rise or fall from their normal values. We assumed generally a negative relationship between per capita income and births rate (Becker 1960). The equation representing births is:

$$BR_t = [BRN * f(IN_{t-1})] * P_{t-1} \qquad (2)$$

Deaths rate is a function of deaths rate normal (DRN_t) and population. The equation representing deaths rate is:

$$DR_t = DRN_t * P_{t-1} \qquad (3)$$

The labor force in the population module is a function of population and working age population fraction. We assume that labor force equals employment. The equation representing labor force is:

$$L_t = Wf_{t-1} * P_{t-1} \quad (4)$$

4.2 Production

The production sector employs Cobb-Douglas production function to represent output. Output depends on factors of production (capital[2] and labor force) and productivity. The Cobb-Douglas production function is represented as:

$$Y_t = K_{t-1}^{\alpha} * (dt) L_{t-1}^{1-\alpha} * A_{t-1} \quad (5)$$

Here, Y_t is the production, K_{t-1} is the previous year capital, α is the capital elasticity, L_{t-1} is the previous year labor force and A_{t-1} is the previous year productivity.

In the production module, capital accumulates through capital acquisition and capital depreciation. Capital acquisition depends on investment. Investment consists of domestic private investment, public investment and foreign direct investment. Capital depreciation is based on perpetual inventory estimation with a common geometric depreciation rate of 4% is assumed (Collins and Bosworth 1996) which gives an average life of capital of 25 years. The capital accumulation equation is represented as:

$$K_t = K_{t-1}(1-\delta_k) + (dt) cK_t \quad (6)$$

Here, K_t is current capital, K_{t-1} is the pervious year capital, δ_k is annual depreciation rate of capital and cK_t is capital acquisition.

[2] Capital is defined as physical and human capital.

In the model, public investment is determined by government decision on public expenditure pattern, i.e. the decision to either invest or consume. Foreign direct investment is an exogenous variable from historical data which is an indication of the attractiveness of the local economy to foreign investors. However, savings is determined in the model based on the assumption that: *Households require a level of minimum real consumption (C) to meet basic needs of personal health, food intake and shelter. When income (N) is above (C), the household saves a constant fraction (ϕ) of the excess (N – C). When income is below (C), household savings is zero, as household consumes as much income as possible in order to come as close as possible to meeting basic needs* (Sachs 2002; Sachs, Mcarthur et al. 2004). Thus, savings (S) is represented as:

$$S = \begin{cases} O & if \quad N < C \\ \phi(N - C) & if \quad N \geq C \end{cases} \qquad (7)$$

In the model, we assume that initial basic needs income will be 700 cedis and basic needs income is expected to increase due to expected increase in household size. We assume further that whenever per capita income is more than basic needs consumption, 40% of the excess income is saved and the 60% is used for consumption smoothing.

4.3 Public Debt

The public debt model demonstrates transparently the mechanisms that generate public debt. We assume that government finances its budget deficit by borrowing and depict it as a result of a government budget constraint:

$$pd_t + i_t\ D_{t-1} + D_{t-1}/m = Bd_t = gB_t \qquad (8)$$

Where pd_t is primary deficit, i_t is the interest rate, D_{t-1} is the public debt of the previous year, *m* is the debt maturity, Bd_t is the budget deficit, gB_t is the borrowing.

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

$$D_t = \left[D_{t-1} + (dt)gB_t - (dt)\left(D_{t-1} \middle/ m \right) \right] + \left[AI_{t-1} + (dt)Ia_t - (dt)Is_t \right] \qquad (9)$$

Here AI_{t-1} is accrued interest of the previous year, $(dt)Ia_t$ is the interest accrual, and $(dt)Is_t$ is interest elimination.

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

5. Model Validation

System dynamic models are causal models and should endogenously generate the right behavior for the right reasons. The validity of system dynamic models means validity of its internal structure which comes from the descriptive knowledge about the system structure (Barlas 1996; Sterman 2000). Greenberger et al. argue that validation is not a general seal of approval but an indication of a level of confidence in the model's behavior under limited conditions and for a specific purpose. Moreover they argued that data provide a tangible link between a model and its reference system, and a means for gaining confidence in the model and its results. Hence, the comparison of the model behavior with data portrays the behavior validity (Greenberger, Crenson et al. 1976).

The purpose of this model is to identify the causal structure of poverty trap and debt accumulation and design alternative policies to reduce poverty and public debt accumulation. The poverty trap theory (Sachs, Mcarthur et al. 2004), debt accumulation process theory (Saeed 1993) and accelerator principle (Hamberg 1971) provided the theoretical, empirical and logical grounding of our approach to model the causal structure of poverty trap and debt accumulation. This is the basis for the structural validity of the model. Moreover, the formulation of the stock and flow structure of the model is dimensionally consistent and performs as expected for the extreme condition test, another validation measures (Barlas 1989; Barlas 1996; Ford 1999; Sterman 2000). On behavior validity, the main variable in the model, i.e. gross domestic product correspond with the historical data well with r-square of 0.874. The error analysis of the gross domestic product shows RMSE[3] of 14% which is a strong indication that the model endogenously tracks historical data quite well. The breakdown RMSE attributed 17.3% of the error to bias, 37.3% to unequal variance and 45.4% to unequal covariance. The error analysis indicates that major part of the error is with the covariation component as compared to bias and unequal variance which are relatively small. This clearly shows that simulated variable tracks the underlying trend well, but diverges by point-by-point. This might indicate that the majority of the error is unsystematic with respect to the purpose of the model, and it should not therefore be rejected for failing to match the data points.

6. Base run Analysis

The base run simulation shows the behavior of production, investment and savings and public debt.

6.1 Production

The behavior of the production sector is evident in the simulation in figure 5.

[3] Root-square mean error

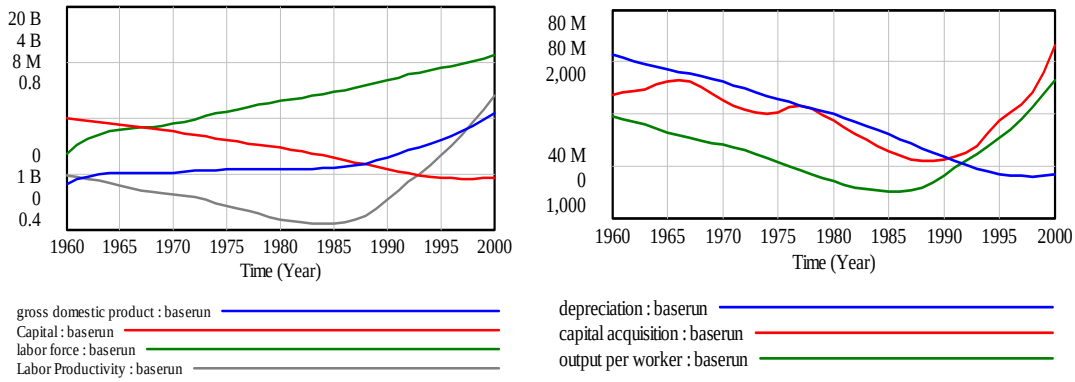

Figure 5: Base run behavior of production sector

Gross domestic product remained relatively stable from 1960 to 1985 after which it started increasing. The graph on the left hand side shows the behavior over time of gross domestic product, capital, labor force and labor productivity. While labor force increased consistently over the simulation period, capital stock declined significantly over the simulation period. Since capital stock integrates capital acquisition and capital depreciation, it is palpable that whenever capital is decreasing, it is as a result of excess capital depreciation over capital acquisition. The graph on the right hand side, of figure 5 shows capital depreciation, capital acquisition and output per worker. From 1960 to 1990, capital depreciation surpassed capital acquisition, accordingly, capital stock declined. However, from 1990 to 2000, capital acquisition increased significantly to slow the decline in capital stock. The significant increase in capital acquisition during the 1990s is attributed to investment increase which will be discussed later. Labor productivity decreased from 1960 to 1985. During the 1990s, the decreasing trend of labor productivity reversed and surpassed the levels observed in the 1960s. The observed behavior of labor productivity correlates with the observed behavior of output per worker. The decline of capital stock and the corresponding output stabilization in the midst of increasing labor force from 1960 to the 1980s, caused output per worker to decrease. However, during the 1990s output increased significantly above the growth in labor force causing output per worker to increase. As output per worker increased, lobor productivity increased accordingly.

It is apparent from the discussion that the poor performance of the gross domestic product from 1960 to 2000 can be attributed to low capital base of the Ghanaian economy. The decline of capital stock due to low capital acquisition as a result of inadequate investment is the main cause of the poor performance of gross domestic product.

6.2 Investment and Savings

Figure 6 shows on the left hand side investment and the various components of investment i.e. total domestic investment, public investment and foreign direct investment and population. On the right hand side of figure 6, the graph shows per worker income, basic needs consumption and per worker savings.

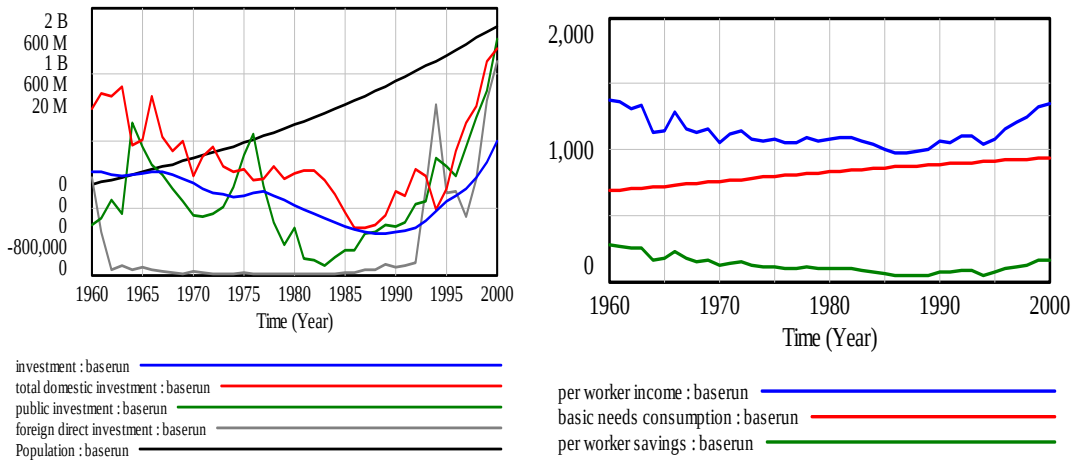

Figure 6: Base run behavior of investment and savings

From 1960 to 1990, investment decreased in general amidst some fluctuations. The decrease in investment is attributed to decline in savings, irregular public investment due to government fiscal policy and dramatic decline of foreign direct investment. During the 1990s, investment as shown in figure 5 increased substantially mainly due to significant increase in foreign direct investment, public investment and relative increase in savings. The graph on the right hand side of figure 6 shows that over the simulation period, per

worker income decreased until the 1990s when the trend was reversed while basic needs consumption increased gradually over time, consequently, savings per worker declined. We realized that per worker income in 2000 is at the same level as per capita income in 1960. The decline in income per worker is attributed to high growth rate in labor force relative to the growth rate in disposable income. The rise of basic needs consumption is understood to be caused by the increase in household size due to population growth. As population increases, the dependency ratio (age-population ratio of those typically not in the labor force, i.e. the dependent, and those typically in the labor force, i.e. the working age) of workers increase, subsequently, more income is required to meet the basic needs of the increased household size. As basic needs consumption increases given declining per worker income, savings automatically decreases causing total domestic investment to decrease below what is should have been, which, in turn decreases investment. As investment decreases, capital accumulation is negatively affected which then causes production to decrease. Production decrease causes disposable income to decrease, as well as, per worker income. As per worker income decreases, it is hypothesized that population increases due to the negative relationship between income and births rate. As population increases, labor force increases, causing output per worker to decrease due to lack of investment as a result of low savings. As output per worker decreases, productivity is expected to decrease which negatively affect production.

In summary, we established a dynamic relationship between savings and investment. As savings increases, investment increases over time creating the possibility for capital accumulation and production increase. As production increases *ceteris paribus* per worker income increases. This then causes savings to increase further the next year round. In Ghana, the observed decline in savings was caused by increased basic needs consumption due to household size increase emanating from population growth. The rise in investment was due to increased government expenditure and increased foreign direct investment which stimulated the economy to increase production causing per worker income as well as savings to increase.

6.3 Public Debt

The simulation result of the public debt accumulation is evident in figure 7.

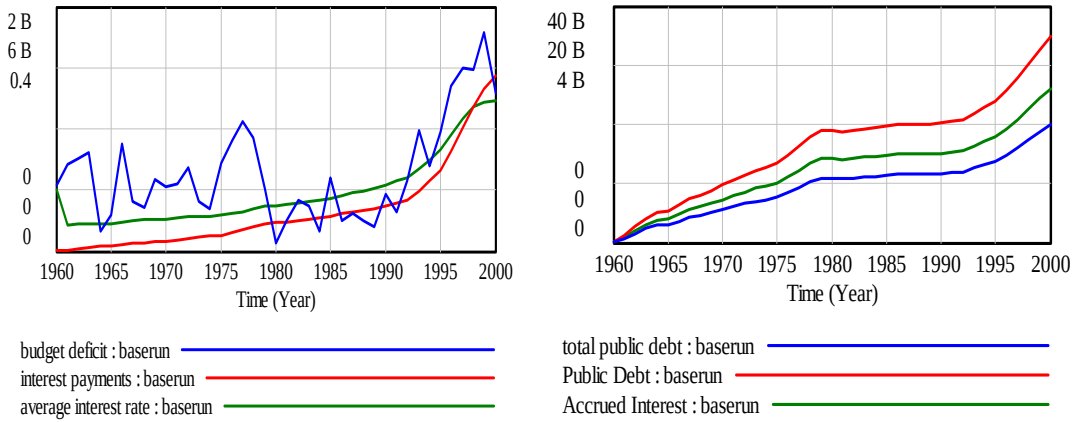

Figure 7: Base run behavior of population and public debt

The behavior of the budget deficit indicates that government expenditure exceeded revenue and grants over the simulation period. As budget deficit increases, public debt is accumulated. Total public debt increased shapely from 1960 to 1980. The growth of public debt slowdown during the 1980s then increased shapely again in the 1990s. The shape increase in public debt is attributed to government budget deficit. Interest payments shows increasing trend over the simulation period due to increasing public debt and interest rate charge on public debt. It is expected that as public debt increases over time, interest payments will increase concurrently, causing government expenditure to increase. As government expenditure increases mainly as a result of high public debt burden, more resources are channeled to debt servicing which affect public investment. As public investment decreases, production is expected to decrease which then decrease per worker income and savings *ceteris paribus*. This scenario brings us back to the vicious cycle of decreasing per worker income to low savings further decreasing income and savings the next year round.

To summarize, we established that the decline of per worker income in Ghana before the late 1990s was as a result of population growth rate exceeding GDP growth rate. GDP on

the average barely increased from 1960 to 1985, whereas from 1985 to 2000 GDP increased from 1.4% to 5.4%. On the other hand, population increased between 2.3% to 2.5% from 1960 to 2000. The poor performance of GDP is attributed to low investment due to three main factors; first, the gradual decline of per worker income coupled with basic needs consumption increase due to increase in household size as a result of population increase reduced the ability of workers to save. The decline in savings significantly reduced domestic investment which invariably affected investment. Second, the dramatic decline of foreign direct investment during the early 1960s and subsequent disinvestment in the economy contributed significantly to the low investment observed during the simulation period. It was during the early 1990s that foreign direct investment picked up again to the levels at the 1960. Lastly, the irregular public investment significantly contributed to the observed behavior of investment over the simulation period.

7. Policy Analysis and Discussion

7.1 Policy Simulation Setup and Description

The purpose of the policy analysis is to experiment and prescribe a policy or set of policy initiatives to reduce poverty and public debt accumulation. The result from the policy analysis is expected to help decision makers in choosing the best policy to reduce poverty and public debt accumulation in Ghana. We tested six policies and evaluated their impact on income, savings and public debt. Table 1 shows the six policies.

Policy Alternatives	Value
1. Increasing public investment (P1)	12% of GDP by 2050
2. Increasing foreign direct investment (P2)	100% increase of FDI by 2050
3. Increasing spending rate (P3)	40% of GDP spending rate by 2050
4. Increasing effective tax rate (P4)	30% of GDP effective tax rate by 2050
5. Increasing savings (P5)	60% savings rate by 2050
6. Decreasing population (P6)	1% population increase by 2050

Table 1: Policy Simulation Setup

7.1.1 Increasing Public Investment: This policy ensures that government increase public investment to 12% of GDP by 2050. The assumption is that, at certain stage of the economic growth, increases in public investment create the necessary human and physical capital for economic growth to take off (Rostow 1990). High investment is expected to aid accumulation of capital to facilitate production which will then increase income to reduce poverty. This policy is implemented in the policy experimentation by increasing the government decision variable, i.e. public investment fraction from 8.5% of GDP in 2000 to 12% by 2050.

7.1.2 Increasing Foreign Direct Investment: With this policy, we speculate that foreign direct investment will double by 2050. This policy is based on the assumption of the economic convergence (Barro and Sala-i-Martin 1991; Sachs and Warner 1995) at play in the world economy such as the potential for capital inflows into capital-scarce countries. This policy will ensure that the government creates the necessary enabling environment for foreign investors to invest in the country. The policy is implemented in the policy experimentation by increasing foreign direct investment from 1.17e+012 in 2000 to 2.34E+12 by 2050.

7.1.3 Increasing Spending Rate: The spending increase policy guarantees that government expenditure increase as a result of increasing spending rate as a percentage of income to 40% by 2050. It is hypothesized that as government expenditure increases, public investment, capital accumulation and production will increase as well. On the flip side, this policy is likely to increase budget deficit if government revenue remains unchanged. This policy is implemented in the policy experimentation by increasing government decision variable spending rate from 33.7% in 2000 to 40% by 2050.

7.1.4 Increasing Effective Tax Rate: The policy of tax increase is expected to increase the effective tax rate to 30% of income by 2050. It is expected that as effective tax rate increases, tax revenue generated by government will increase to enable government finance all expenditure from government revenue to reduce public debt build up. Moreover, as tax revenue increases, government expenditure is expected to increase

concurrently; therefore, public investment is expected to increase creating the possibility for the accumulation of human and physical capital to stimulate growth and economic prosperity. The downside of this policy is that, as tax revenue increases, disposable income available to the households will decrease, consequently, per worker income will decline causing private savings and domestic investment to decrease. This policy is implemented in the policy experimentation by increasing the effective tax rate from 19% of income in 2000 to 30% by 2050.

7.1.5 Decrease Population: Population increase without corresponding income increase, is seen as one of many factors responsible for poverty (Sachs, Mcarthur et al. 2004). This policy will ensure that government implement strategies to reduce population over time by decreasing fertility rate. We assume that by implementing this policy, birth rate will reduce to 1%. The policy is implemented in the policy experimentation by reducing birth rate normal from 2.5% in 2000 to 1% by 2050.

7.2 Results and Discussion

The outcome of the policy experimentation and simulation is presented in table 2. Three main indicators are used to assess the success and impact of the policies on poverty and public debt. The indicators are; per worker income, per worker savings and debt-GDP ratio. Figure 8 shows the behavior over time of the policy analysis.

Policy Alternatives	Per worker income	Per worker savings	Debt-GDP Ratio
1. Increasing public investment (P1)	2626**	410	3
2. Increasing foreign direct investment (P2)	2470	348	3
3. Increasing spending rate (P3)	2444	337	4
4. Increasing effective tax rate (P4)	2007	163	1**
5. Increasing savings (P5)	2586	592**	3
6. Decreasing population (P6)	2261	264	4

Table 2: Result of Policy Simulation

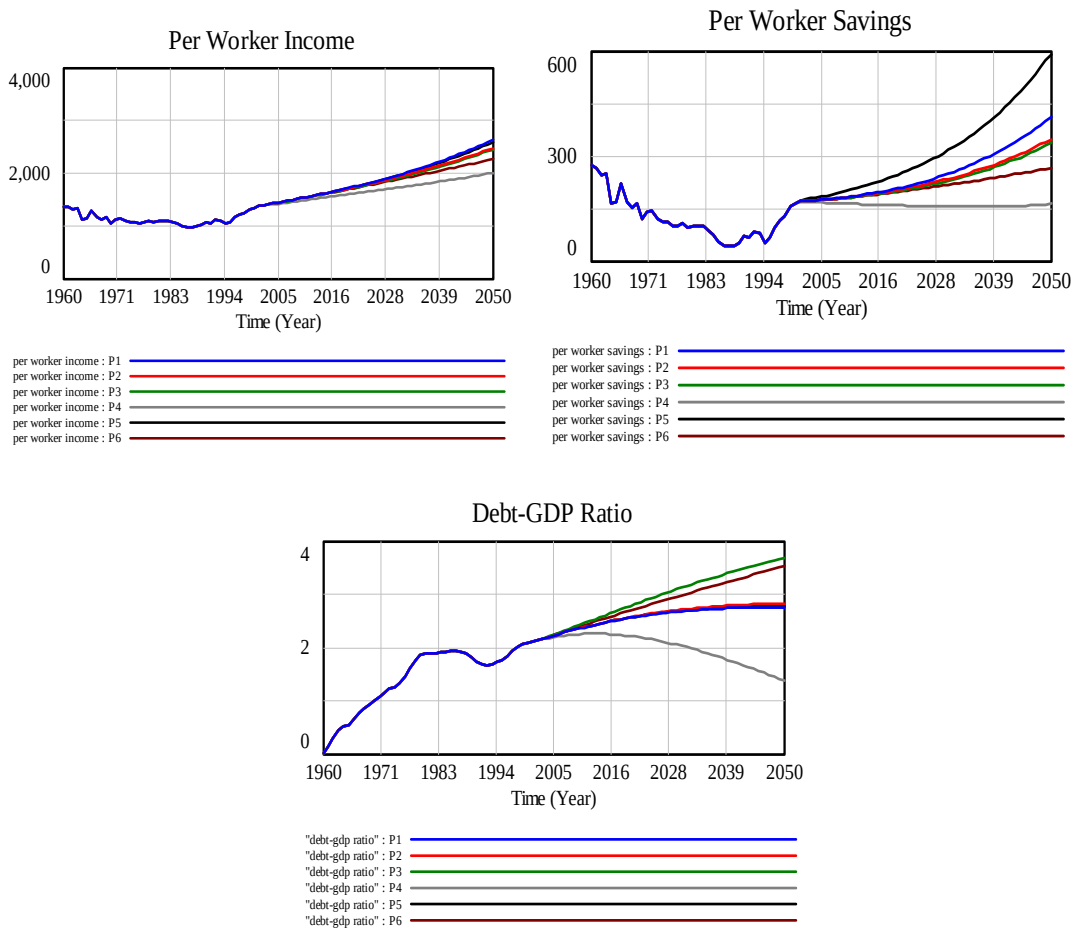

Figure 8: Policy Simulation result for Income, Savings and Public debt

The policy analysis established that, the policy to increase public investment (P1) is the policy option that gives the highest sustainable per worker income over the simulation period compared to the other policies. The underlying mechanism that explains the results obtained from P1 is, as public investment increases over time, capital is accumulated to facilitate production which in turn generates prosperity, i.e. income. As income increases *ceteris paribus*, savings increases as well, which further enhance the ability to invest and accumulate capital and technology to boost production. Also, policy P1 is the second preferred policy to increase per worker savings and reduce public debt compared to the other policies.

The policy simulation analysis indicates that foreign direct investment policy (P2) is the third favorable policy to increase per worker income and per worker savings. However, concerning public debt reduction, policy P2 is comparable to the results obtained for P1 and P5, which demonstrate that P2 is among the second best policies to reduce public debt given the current condition. The foreign direct investment policy, i.e. (P2), attracts the scarce capital unavailable in the local economy to increase investment and capital accumulation. The performance of (P2) clearly indicates that, doubling the foreign direct investment currently available in Ghana will not be as effective as P1 and P5 to reduce poverty. However, this policy can be implemented along side other policies to pull together investment opportunities for the economy to take off to the path of sustained economic growth and prosperity.

We established that the policy to increase government expenditure (P3) in the fourth favorable policy to increase per worker income and per worker savings. On public debt, P3 is the third and least favorable policy to reduce debt-GDP ratio. The underlying mechanism of P3 is that, by implementing this policy, government expenditure is significantly increased to stimulate the economy to the path of growth. However, when expenditure increases, budget deficit increases as well due to excess spending over revenue. Deficit spending builds up public debt, which, consequently, increase interest payments and repayments that takes significant portion of government expenditure, as a result, decreasing non-interest expenditure available for spending and investment. The outcome of the policy analysis indicates that, increasing government spending is not necessarily the best policy to reduce poverty and public debt.

The policy analysis result establishes that, the policy to increase government revenue through increasing effective tax (P4), is the least favorable policy to increase per worker income and per worker savings. Nonetheless, P4 is the most effective policy to reduce public debt. The mechanism underlying P4 is that, increasing effective tax reduces per worker income and savings because as tax revenue increases, disposable income available to the household's decreases, concurrently, as a result, per worker income decreases *ceteris paribus*. As per worker income decreases ceteris paribus, savings is

expected to decrease which in turn decreases investment, capital, production and disposable income to household's the next year round. On the other hand, as effective tax increses, government revenues rise; this then reduces budget deficit and public debt accumulation.

The policy to increase savings (P5) is evidently the most successful policy to increase per worker savings. Also, we found that P5 is the second favorable policy to increase per worker income and reduce public debt. The mechanism underlying P5 is explained as follows: as savings increases over time, investment increases, this then facilitate the accumulation of capital for production. As production increases, income to households increases causing disposable income to rise further creating the condition for more savings. On the flip side, increases in production are accompanied by income increases which then increase government tax revenue. Increases in government revenue enable the government to reduce deficit spending *ceteris paribus*. As deficit spending declines, public debt reduces below what it would have been.

The policy analysis shows that decreasing population (P6) is the second least favorable policy to increase per worker income and savings. Moreover, P6 is the least favorable policy to reduce public debt. The result indicates that the expected decrease in population from the implementation of P6 is not significant enough to increase income and savings. Moreover, the decline in population from implementing P6 is not significant enough to reduce government spending, which will consequently, reduce public debt.

Based on the results from the policy analysis, we established that, the best policy(s) to reduce poverty and public debt accumulation is: to increase public investment (P1) or to increase savings (P5). P1 yields the highest per worker income and is the second best policy to increase per worker savings and reduce public debt. On the other hand, P5 yields the highest per worker savings and is the second best policy to increase per worker income as well as reduce public debt.

In summary, we established that, when an economy begins with a low capital base, low GDP growth, and high population growth, both capital stock and per worker savings tend to decline over time. Lack of capital accumulation coupled with population growth further erodes the income base. The outcome of the policy analysis confirms that it is only when capital base of the country increase above a certain threshold which leads to per worker income significantly higher than basic needs consumption then the economy tend to achieve growth.

8. Conclusion

The system dynamics model presented in this paper represent an integration of poverty trap and public debt accumulation, to clarify the dynamic mechanisms underlying observed trends and project the trends into the future under variety of policies to assess their impact on poverty and public debt.

We established that the decline of per worker income in Ghana before the late 1990s was as a result of population growth rate exceeding GDP growth rate. GDP on the average barely increased from 1960 to 1985, whereas from 1985 to 2000 GDP increased from 1.4% to 5.4%. On the other hand, population increased between 2.3% to 2.5% from 1960 to 2000. The poor performance of GDP is attributed to low investment due to three main reasons; first, the gradual decline of per worker income coupled with basic needs consumption increase due to increase in household size as a result of population increase reduced the ability of workers to save. The decline in savings significantly reduced domestic investment which invariably affected investment. Second, the dramatic decline of foreign direct investment during the early 1960s and subsequent disinvestment in the economy contributed significantly to the low investment observed during the simulation period. It was during the early 1990s that foreign direct investment picked up again to the levels at the 1960. Lastly, the irregular public investment significantly contributed to the observed behavior of investment over the simulation period.

The policy analysis proposed increasing public investment or savings as the best policy to reduce poverty and public debt accumulation. This is for the reasons that, when an economy begins with a low capital base, low GDP growth, and high population growth, both capital stock and output per worker tend to decline over time. Lack of capital accumulation coupled with population growth further erodes the income base. The outcome of the policy analysis confirms that it is only when capital base of the country goes above a certain threshold which leads to per worker income significantly higher than basic needs consumption then the economy tend to achieve growth.

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