The Macroeconomic Impact of Ebola Virus Disease (Evd): A Contribution to the Empirics of Growth

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Abstract: The paper addressed the formulation of a macro model to capture the macroeconomic impact of the Ebola Virus Disease (EVD). Previous studies has adopted various models such as the dynamic computable general equilibrium (CGE) model, endogenous model and the LINKAGE model, but there is dire need to generate a step-by-step model which will comprehensively capture how the Ebola Virus Disease (EVD) impacts on macroeconomic variables. Adopting the traditional neoclassical growth model, the model aggregated the various macroeconomic variables as well as captured the epidemic's strain on each of these variables. The paper also empirically shows that the Ebola Virus Disease (EVD) has direct, indirect and deferred indirect cost implications for the economy. Using case studies of countries in Africa, the study evaluated how the Ebola Virus Disease (EVD) has affected the macroeconomic status of selected economies. The findings imply that there is dire need to control the spread of the deadly plague. The paper contribute immensely to empirical studies in the field of macroeconomics.

Keywords: neoclassical growth model; macroeconomic; framework; steady state; computable general equilibrium; Ebola virus disease

JEL Classification: C51; H51; I32

1. Introduction

The Ebola virus has continued to send tremor down the spines of economies not only in Africa, but also in Europe, Asia and the Americas. Its spread has been rapid, defiling preventive measures and moving without constraints across national borders, though the scourge started in West Africa (Guinea). Worst of all, the human death toll has been terrible. OCHA (2014a) reported that as of September 10, 2014, there had been 2,281 recorded deaths out of 4,614 suspected or confirmed cases of Ebola in across Guinea, Liberia, Nigeria, Senegal and Sierra Leone, with fear that these figures were under-reported as in the cases of victims who died in isolation taking treatment in hiding. For instance, there was the case of a medical doctor who died in Port Harcourt, Nigeria of Ebola virus while treating victims of the disease in

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secret. The fatality rate has continued to grow exponentially. The Ebola epidemic currently afflicting West Africa is now a global issue. Macroeconomic effects are now felt in terms of forgone productivity of those directly affected; higher fiscal deficits; rising inflation; lower real household incomes and greater poverty (World Bank, 2014). This trend is expected to linger for a longer duration even after laudable improvement in the eradication of the deadly disease. (*The Economist*, 2015)

A lot of emphasis has been placed on health-related impacts of Ebola Virus Disease (EVD) with little efforts dedicated to the macroeconomic impacts of the Ebola Disease on an economy. The thrust of this paper is to analyze the macroeconomic impacts of the disease using a typical growth model. Following the introductory section, Section 2 develops a macroeconomic model to capture the impacts of the deadly Ebola. Sections 3 and 4 examine empirical findings and concluding remarks respectively.

2. The Model

The theoretical framework of the study is based on the modifications of the Solow-Swan (1956) standard neoclassical growth model. It is expressed below;

$$Y_{it} = R_{it}^{\emptyset} K_{it}^{\varphi} H_{it}^{\theta} [A_{it} N_{it}]^{1-\emptyset-\varphi-\theta-\alpha} \quad (1)$$

Where

Y = measure of output per unit of effective labour

R = measure of Research & Development

K = physical capital

H = health human capital

A = technologies and institutions

N = total population

The exponents θ, φ, α and ϕ represent the factor shares. The subscripts i denotes economy (i) and t implies time.

Assumption I

A fundamental assumption underlying equation (1) is that population grows at the economy-specific rate n_i, A_{it} grows at a rate of g_{it} and all capital stocks depreciate at a constant rate of δ. Equation (1) can be written in an intensive form as

$$y_{it} = r_{it}^{\emptyset} k_{it}^{\varphi} h_{it}^{\theta} e_{it}^{\alpha} \quad (2)$$

Where

$$\text{effective output per unit of capital (y)} = \frac{\text{Y}}{\text{AN}}$$

$$\text{physical capital per capita (k)} = \frac{\text{K}}{\text{AN}}$$

$$\text{research \& development capital per capital (r)} = \frac{\text{R}}{\text{AN}}$$

$$\text{education human capital per capital (e)} = \frac{\text{E}}{\text{AN}}$$

$$\text{health human capital per capital (h)} = \frac{\text{H}}{\text{AN}}$$

Assumption II

We assume that the savings in the economy are distributed among physical capital, research and development (R & D), health human capital and education human capital, such that the economy wide savings and investment are distributed among all the capital stocks. This is clearly shown below;

$$s_{it} = s_{it}^{r} + s_{it}^{k} + s_{it}^{h} + s_{it}^{e} = \frac{S_{it}}{Y_{it}} = \frac{I_{it}}{Y_{it}} = \frac{I_{it}^{r} + I_{it}^{k} + I_{it}^{h} + I_{it}^{e}}{Y_{it}} \tag{3}$$

Where

s_{it} = economy wide savings and investment

s^{r}_{it}= saving rate for research and development in economy in economy i at time t.

s^{k}_{it} = saving rate for physical capital in economy in economy i at time t.

s^{h}_{it}= saving rate for health human capital in economy in economy i at time t.

s^{e}_{it}= saving rate for education human capital in economy in economy i at time t.

The rates of research and Development (R & D), physical, education and health capital growth per unit of labour are defined below:

$$\dot{r_{it}} = s_{it}^{r}\dot{y_{it}} - r_{it}(n_{it} + g_{it} + \delta_{it}) \tag{4}$$

$$\dot{k_{it}} = s_{it}^{k}\dot{y_{it}} - k_{it}(n_{it} + g_{it} + \delta_{it}) \tag{5}$$

$$\dot{h_{it}} = s_{it}^{h}\dot{y_{it}} - h_{it}(n_{it} + g_{it} + \delta_{it}) \tag{6}$$

$$\dot{e_{it}} = s_{it}^{e}\dot{y_{it}} - e_{it}(n_{it} + g_{it} + \delta_{it}) \tag{7}$$

Assumption III

The Ebola Virus Disease (EVD) is assumed to be introduced into the neoclassical growth model as a distortion or disturbance to economic growth path. Population growth is allowed to change over time due to EVD-related deaths. If the population growth varies, then we will obtain;

$$\dot{n} = \xi^{n}\left[n_t - \left(n^{*} - a^{n^{*}}\right)\right] - a_{it}^{n} \qquad (8)$$

Where

a_t^n = mortality shock resultant from the initial effect of the Ebola Virus Disease

a_t^{n*} = permanent effect of the epidemic on the population growth

ξ^n = persistent effect of the epidemic on the population growth ($\xi<0$)

(n^* - a^{n*}) = steady state growth reached only in the long run when the epidemic is over.

From equation (8), the impact of the Ebola Virus Disease (EVD) on savings rates and investment as they relate to R & D, education and health capitals can be expressed as:

$$\dot{s}^{k} = \xi^{k}\left[s_t^{k} - \left(s^{k^{*}} - a^{k^{*}}\right)\right] - a_t^{k} \qquad (9)$$

$$\dot{s}^{rd} = \xi^{rd}\left[s_t^{rd} - \left(s^{rd^{*}} - a^{rd^{*}}\right)\right] - a_t^{rd} \qquad (10)$$

$$\dot{s}^{h} = \xi^{h}\left[s_t^{h} - \left(s^{h^{*}} - a^{h^{*}}\right)\right] - a_t^{h} \qquad (11)$$

$$\dot{s}^{e} = \xi^{k}\left[s_t^{k} - \left(s^{k^{*}} - a^{k^{*}}\right)\right] - a_t^{k} \qquad (12)$$

The parameters a_t^k, a_t^{rd}, a_t^h and a_t^e are the shocks of the EVD; a^{k*}, a^{rd*}, $a^{h*}$and a^{e*} are the permanent impact of the disease on each variable while ξ^k, ξ^{rd}, ξ^h and ξ^e are less than zero. Each of them represents EVD persistent shocks on each of the variables of interest. The long run steady state values of savings allotted to physical, health, education and R & D investment are (s^{k*}- a^{k*}), (s^{h*}-a^{h*}), (s^{e*}-a^{e*}) and (s^{rd*}-a^{rd*}) respectively.

The steady state values of the capital stocks for economy i at time t converge to the expression given below;

$$r_{it}^{*} = \left[\frac{(s_i^r)^{1-\varphi-\theta-\alpha}\left(s_i^k\right)^{\varphi}\left(s_i^h\right)^{\theta}(s_i^e)^{\alpha}}{n_i^* - a^{n^*} + g_{it} + \delta}\right]^{\frac{1}{1-\varphi-\theta-\alpha-\phi}} \qquad (13)$$

$$k_{it}^{*} = \left[\frac{(s_i^r)^{\phi}\left(s_i^k\right)^{1-\phi-\theta-\alpha}\left(s_i^h\right)^{\theta}(s_i^e)^{\alpha}}{n_i^* - a^{n^*} + g_{it} + \delta}\right]^{\frac{1}{1-\phi-\theta-\alpha-\varphi}} \qquad (14)$$

$$h_{it}^{*} = \left[\frac{(s_i^r)^{\phi}\left(s_i^k\right)^{\varphi}\left(s_i^h\right)^{1-\phi-\varphi-\alpha}(s_i^e)^{\alpha}}{n_i^* - a^{n^*} + g_{it} + \delta}\right]^{\frac{1}{1-\phi-\varphi-\alpha-\theta}} \qquad (15)$$

$$e_{it}^{*} = \left[\frac{(s_i^r)^{\phi}\left(s_i^k\right)^{\varphi}\left(s_i^h\right)^{\theta}(s_i^e)^{1-\phi-\varphi-\theta}}{n_i^* - a^{n^*} + g_{it} + \delta}\right]^{\frac{1}{1-\phi-\varphi-\theta-\alpha}} \qquad (16)$$

The steady state values of R & D, physical, education human and health human capital expressed in the above equations depict their growth behaviors with implicit implications for a number of factors including n^*, a^{n^*} and y_{it}. The growth behaviors of the capital stocks as shown in equations 13-16 are complex. The complexity of each of the above equations is predicted on the fact that all the other capital stocks' growth behaviors are implicated in the growth behavior of each capital stock. In other words, a distortion or shock to a capital stock is a shock to all. Shocks are automatically transmitted through the general economy. The systematic interrelationship and interdependence among the capital stocks in terms of growth performances in the presence of the deadly disease Ebola is the starting point of the analysis of Ebola Virus Disease macroeconomic impact on an economy.

The steady state values of R & D, physical, education and health capital depicted in equations 13-16 are substituted into equation (2) to obtain the steady state output per capita. The resulting equation is shown below:

$$y_{it}^{*} = \left[\frac{(s_i^r)^{\phi}\left(s_i^k\right)^{1-\phi-\theta-\alpha}\left(s_i^h\right)^{\theta}(s_i^e)^{\alpha}}{n_i^* - a^{n^*} + g_{it} + \delta}\right]^{\frac{1}{1-\phi-\theta-\alpha-\varphi}} \qquad (17)$$

Where

Y_{it}^{*} = steady state output per capita

Equation (17) is a very complex form of the extended neoclassical production function. The equation portrays the impacts of Ebola Virus Disease (EVD) within neoclassical model. EVD is expected to negatively affect output per capita such that its impact reduces savings and investment rates. This effect is contagious since it is automatically felt in the whole economy.

Within the framework of the Solow-Swan neoclassical model, equation (17) is the fundamental framework for understanding the complexity of the macroeconomic impact of the Ebola Virus Disease (EVD) on the growth of an economy.

In order to accommodate the impact of EVD on specific economies (such as Sub Saharan Africa, Europe etc) there is need to transform the Solow-Swan neoclassical function levels into growth model using the process given by Mankiw, Romer and Weil (1992).

Taking the logs of equations 13-16, we arrive at the following;

$$\ln r_{it}^{*} = \frac{1}{(1-\phi-\varphi-\alpha-\theta)}\Big[\ln\Big((s_i^r)^{1-\varphi-\theta-\alpha}(s_i^k)^{\varphi}(s_i^h)^{\theta}(s_i^e)^{\alpha}\Big) - \ln\big(n_i^{*} - a^{n^{*}} + g_{it} + \delta\big)\Big] \quad (18)$$

$$\ln k_{it}^{*} = \frac{1}{(1-\phi-\varphi-\alpha-\theta)}\Big[\ln\Big((s_i^r)^{\phi}(s_i^k)^{1-\phi-\theta-\alpha}(s_i^h)^{\theta}(s_i^e)^{\alpha}\Big) - \ln\big(n_i^{*} - a^{n^{*}} + g_{it} + \delta\big)\Big] \quad (19)$$

$$\ln h_{it}^{*} = \frac{1}{(1-\phi-\varphi-\alpha-\theta)}\Big[\ln\Big((s_i^r)^{\phi}(s_i^k)^{\varphi}(s_i^h)^{1-\phi-\varphi-\alpha}(s_i^e)^{\alpha}\Big) - \ln\big(n_i^{*} - a^{n^{*}} + g_{it} + \delta\big)\Big] \quad (20)$$

$$\ln e_{it}^{*} = \frac{1}{(1-\phi-\varphi-\alpha-\theta)}\Big[\ln\Big((s_i^r)^{\phi}(s_i^k)^{\varphi}(s_i^h)^{\theta}(s_i^e)^{1-\phi-\varphi-\theta}\Big) - \ln\big(n_i^{*} - a^{n^{*}} + g_{it} + \delta\big)\Big] \quad (21)$$

Substituting equation 18-21 into the augmented steady state of output per capita depicted in equation (17) gives;

$$ln\, y_{it}^{*} = \frac{\phi}{(1-\phi-\varphi-\alpha-\theta)} ln(s_i^r) + \frac{\varphi}{(1-\phi-\varphi-\alpha-\theta)} ln(s_i^k) + \frac{\theta}{(1-\phi-\varphi-\alpha-\theta)} ln(s_i^h) + \frac{\alpha}{(1-\phi-\varphi-\alpha-\theta)} ln(s_i^e) - \frac{\phi+\varphi+\theta+\alpha}{(1-\phi-\varphi-\alpha-\theta)} ln(n_i^* - a^{n^*} + g_{it} + \delta) \quad (22)$$

In equation (22), s_i^r, s_i^k, s_i^h and s_i^e represent the proportion of savings rates deployed to R & D, physical capital, health capital and education capital. If equation (22) is linearised, then we will obtain;

$$\frac{d \ln y_{it}}{dt} = \mu(\ln y_{it}^{*} - \ln y_{it}) \quad (23)$$

Where

$\mu = (n_i^* - a^{n^*} + g_{it} + \delta)(1-\phi-\varphi-\alpha-\theta)$ and y_{it} is representative of the level of output per capita in economy i at time t.If the differential equation is solved, the equation below is expressed:

$$\ln y_{it} = (1 - exp^{-\mu t}) \ln y_{it}^{*} + exp^{-\mu t}\, ln\, y_{i0} \quad (24)$$

In equation (24), y_{i0} denotes initial income in the economy (i). The change in income from the initial time (t) is obtained by subtracting y_{i0} from both sides of equation (24) and substituting into the equation for steady state output per capita. The resultant equation is shown below;

$$\boldsymbol{ln\, y_{it} - ln\, y_{i0} = (1 - exp^{-\mu t}) \frac{\phi}{1-\phi-\varphi-\alpha-\theta} lns_i^k + (1 - exp^{-\mu t}) \frac{\alpha}{1-\phi-\varphi-\alpha-\theta} lns_i^e + (1 - exp^{-\mu t}) \frac{\theta}{1-\phi-\varphi-\alpha-\theta} lns_i^h + (1 - exp^{-\mu t}) \frac{\varphi}{1-\phi-\varphi-\alpha-\theta} lns_i^{rd} - (1 - exp^{-\mu t}) \frac{\phi+\varphi+\alpha+\theta}{1-\phi-\varphi-\alpha-\theta} \ln(n_i^* - a^{n^*} + g_{it} + \delta) - (1 - exp^{-\mu t}) lny_{i0}} \quad \mathbf{(25)}$$

Equation (25) thus constitutes the macroeconomic framework on which the impact of Ebola Virus Disease (EVD) can be accessed in an economy.

3. Empirical Findings

Various studies have attempted to analyze the macroeconomic impact of the Ebola Virus Disease. Such a task is not easy. However, there are majorly four contributions in this regard. (World Bank, 2014; UNECA, 2014; UNDP-RBA, 2014; and UNDP-RBA, 2015)

In general, the Ebola Virus Disease epidemic will affect the economy via three channels. (World Bank, 2014) These channels are direct, indirect and deferred indirect costs. World Bank (2014) opined that the direct costs are mostly medical expenditures which are incurred due to the disease at the macro level. For instance, if a family is struck by the virus, the use of family savings for health care is considered a direct cost. Savings meant for family day-to-day economic activities are expended on the victim(s) leaving the family impoverished as seen in many households affected by the disease.

Indirect costs are closely related to economic productivity. Losses in economic activities due to reduction of productivity caused by deaths of some dramatis personae in an economy. While, deferred indirect costs are the costs that households or the general economy will have to pay in the absence of external aid. In with this, OCHA (2014) stated that the financial resources involved has four strategic objectives; stop the outbreak, treat the infected, ensure essential services, and preserve stability. Such a situation will shake in no small measure the economic structure of the economy due to its capital implications.

The World Bank using a dynamic computable general equilibrium (CGE) model estimated the medium term impacts of Ebola Virus Disease in growth rates in Liberia, Guinea and Sierra Leone. The estimated result shows that Liberia is the most affected country in terms of poverty. Prior to the Ebola Virus Disease outbreak is already at 83.3 percent in 2011. (World Bank, 2014) However, in 2014, the poverty rate is estimated to have been 5.46 percent higher in the low Ebola scenario and 5.89 percent higher in the high Ebola scenario, both relative to the baseline (no Ebola). The results showed that the poverty rate in Guinea in 2014 increased from 2.25 to 2.65 percent relative to the baseline for the low and high Ebola scenarios, respectively. In spite of economic policy thrusts employed 2015 to revamp the economy, the economy of Guinea still remains incapacitated to reduce poverty. The disease also critically affected poverty in Sierra Leone. (UNDP, 2015)

It is noteworthy to stress that the above estimates are tentative and with the souring and exponential increase in the outbreak of the epidemic, the financial requirements must have exploded drastically. The situation is complicated with economic burdens of bearing up foreign medical teams, medical evacuation, human resources (technical and operational staff) and material supports in terms of relief materials. There is thus an urgent need to curb the virus spread and reestablish stability and confidence.

4. Concluding Remarks

The analysis so far has established the fact that the Ebola Virus Disease (EVD) has adversely affected the macroeconomic status of various economies. Ranging from its impact on investments on infrastructural project to savings, the disease has and will continue to ravage societies even those in advanced nations. There is thus urgent need to address the situation and curb the menacein order to reestablish confidence through eradication of macroeconomic misalignments.

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