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Technological Change and Healthcare/Food Interaction Policy in Development Economics

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Abstract This article looks for poverty reduction paths since the conjunction of medicine and agriculture improves sustainability in an economic environment where prevail HIV/AIDS, medical care and food shortages explaining global development crisis. On the basis of Roseinstein-Rodan's coordinate investments proposal, a cooperative unit in charge of some aspects of development where entities goals correlate legitimate coordinate investments policy application conducted by International Donors in Cooperation with Poor Countries' Governments highlighted by relative technological change adoption making medicine and agriculture technologies intercept for a better achievement of the same goal summarized by the link between sustainability improvement and poverty reduction. This economic policy shows-off *multiple poverty reduction paths existence* due to relative technological change and knowledge diffusion movements, the one ensuring the steady state stability exists.

Keywords*: coordinate investment policy, cooperative unit, relative technological change, knowledge diffusion, HIV/AIDS, food shortages*

1. Introduction

As recently asked by the World Bank Chief, *what can be done to end poverty* with respect to the 2015 UN summit goal i.e cutting poverty in half which occurrence time is becoming closer, improvements are observed but still fragile so that discussions should keep being conducted. This article contributes to poverty reduction debate in Sub-Saharan Africa where the relationship between ill health and poverty is complex and works in both directions. Health statistics in Sub-Saharan Africa are alarming such since the appearance of HIV/AIDS in the area where live 68% of the 34 millions of people suffering from HIV/AIDS. In 2010 among the 2,7 millions of new cases of infected people by the HIV virus discovered 1,8 million died. Market failure increased HIV/AIDS prevalence and market volatility increased food shortages in SSA because poor countries do not possess the level of assets (both physical and human capital assets) required to protect themselves from shocks resulting from international markets volatility. Inefficient agricultural and medical technologies caused by inadequate environmental support, sustainability degradation as well as poverty prevent the economy from well-being improvements and stability achievements.

Developing country's economic policies are mostly conducted by international organizations in cooperation with Poor Countries' Governments. Each International Organization has specific goals in poverty reduction and sustainability targets. Health is devoted to WHO (World Health Organization), food is the mission carried by FAO (Food and Agriculture Organization) and poverty is managed by the World Bank. Those organizations try to achieve their targets independently, so that it makes harder for sustainability to reach its optimal path since food and health are linked but economic policies are separately conducted, growth remains unbalanced because of linkages crucial sectors absence [1,2,3]. Therefore, this article promotes the Roseinstein-Rodan seminal paper argument in favor of coordinated investment in poor countries' development and sustainability creative capability [4]. The idea of the model developed is to evidence the existence of an entity in charge of some aspects of International Organization development goals which correlate to establish an interaction of the FAO, the World Bank and the WHO missions in creating a link between food shortages and HIV/AIDS eradication goals in a cooperative policy in order to provide require conditions for global poverty reduction since optimal allocation composed of both food and healthcare provision are carried by a cooperative unit of the International Organizations. The tool used for optimal allocation provision of food and healthcare is agriculture and medicine technological changes interaction which diffusion creates spillovers [5,6,7,8,9] captured in production through a formal development model leading to poverty fight. Whereas medical and agricultural technological changes grow at exponential rates in rich countries, the both sectors grow at arithmetic rates in poor countries. The connection of the both sectors categories to both countries' technology makes knowledge diffuses at a weak exponential way in poor countries. Then the global policy proposed determines optimal food and healthcare allocation allowing the economy reaches its optimal sustainable development path. The results found are: positive relative productivity defines multiple equilibria where growth may be low or higher depending on diffusion parameter value, several development paths with

poverty reduction specificity arise from the model where poverty fight power degree varies according to knowledge spread capability. In contrast, zero or negative relative productivity make the economy remaining kept in poverty trap with no growth so that sustainable development path is unable to be reached.

The departure point of growth literature is back to Solow model [10] which concludes to poor economies' development potentiality compare to rich economies. However empirical attempts to validate that finding fail. The literature identifies human capital [11,12] and technological change [13] as the main factors causing economic dynamics of countries and poverty traps, the resulting effect of human capital and technological change investment absence. Thereby turn out to be industrialization requirement conditions in poor economies but since the 1990s, sustainability problems or equivalently, health disaster and food shortages increased, thus retarded development and creates a crisis where industrialization is no more the main growth source and goal. Health and food must be sustainable because their weight is now higher than historical industrialization dilemma of the development theories pioneers. In parallel, health in growth models was originally built in three directions which are *the rise in obesity* due to food excess consumption [14,15,16], *aging effects on productivity* [17,18] and *pension funds provision due to aging* [19,20] extended to development economics through HIV/AIDS impact on growth [21-29] and those models assume technology to be the major engine of improvements in health terms which scientifically can be called medicine. However, studying how individuals are able to escape poverty still a central issue of economic development theory in which the literature of poverty reduction contains both its advocates [30,31,32,33] for whom it is possible to eliminate poverty through a particular kind of economic growth policy and its non advocates [34] for whom it is not possible to end poverty but urgent to encourage the world's poor and marginalized communities to enhance their lives to create and adopt alternatives to this hegemonic model because agricultural growth is essential for fostering economic development and feeding growing populations in most less developed countries [35]. Agriculture is a part of growth sustainability in development models guided with technological change [36]. Indeed, because both medicine and agricultural are not assumed together in a formal development model as sustainable tools, this analysis does it in order to look for poverty reduction paths when technological change conjugates rural (agriculture) and urban (medicine or health) growth to determinate the sustainable steady state. The model shows-off *multiple poverty reduction paths existence* due to relative technological change and knowledge diffusion movements, the one ensuring the steady state stability exists.

Section II presents the basic model, section III provides the optimal solution, section IV presents the results and the discussions and section V concludes on the analysis.

2. The Model

Consider a world of two countries where one is developed and the other is not. The leader country possesses two AK endogenous technological change sectors and the follower country possesses two Solow exogenous technological change sectors, the two production sectors in the both countries are medicine and agriculture.

2.1. The Production

In the leading economy, technological change in both the medical and the agricultural sectors grow at an exponential way i.e

$$H^{M}{}_{t+1} - H^{M}{}_{t} = H^{M}{}_{t} e^{\mu^{M} t} \tag{2.1}$$

$$H_{t+1} - H_{t} = H_{t} e^{\mu t} \tag{2.2}$$

Where H_t and H_t^{M} are the respective current human capital stocks in agricultural and in medical sectors, μ^M and μ are the respective productivities in medical and in agricultural sectors. In contrast, the poor country's technological change in medical and in agricultural sectors grow at an arithmetic way expressed by equations (2.3) and (2.4) i.e

$$h^{M}{}_{t+1} - h^{M}{}_{t} = \mu^{M} h^{M}{}_{t} \tag{2.3}$$

$$h_{t+1} - h_{t} = \mu h_{t} \tag{2.4}$$

In order to capture the rich country's technological change, we introduce the diffusion parameter in the two previous production functions, then (2.3) and (2.4) can be expressed such that (2.5) and (2.6) i.e:

$$h^{M}{}_{t+1} - h^{M}{}_{t} = \mu^{M} h^{M}{}_{t}{}^{1-\theta^{M}} H^{M}{}_{t}{}^{\theta^{M}} \tag{2.5}$$

$$h_{t+1} - h_{t} = \mu h_{t}^{1-\theta} H_{t}^{\theta} \tag{2.6}$$

Therefore, the rich country's technology diffuses in the poor country according to $i=\theta^M$ and $j=\theta$. Replacing the country's human capital stock H in (2.5) by its value given by (2.1) and doing the same thing for H^M in (2.6) by its value given by (2.2), we obtain the poor country's technological changes absorption with respect to the agriculture and the medicine i.e $v(t,h,H)$ and $v^M(t,h^M,H^M)$ expressed by (2.7) and (2.8) i.e

$$v^{M}\left(t, h^{M}\right) = \mu^{M} h_{t}^{M\,1-\theta} e^{-\theta \mu^{M} t} \tag{2.7}$$

$$v\left(t, h\right) = \mu h_{t}^{1-\theta} e^{-\theta \mu t} \tag{2.8}$$

Therefore technological change interaction between medicine and agiculture v_t is expressed such that

$$\bar{v}_{t} = \bar{\mu} k_{t}^{\bar{\theta}} e^{\bar{\mu} t} \tag{2.9}$$

Where $\bar{\mu} = \mu^{M} / \mu$ and $k = h^{M} / h$ as well as $\bar{v}$ =vM/v and $\bar{\theta} = 1 - \theta$ is knowledge diffusion parameter. Equation (2.8) expresses the required link between agriculture and medicine needed to be specifically managed by a Cooperative unit of the donors in order to allow the poor economy achieve sustainable development.

2.2. The Intertemporal Utility Function

The intertemporal utility function is defined over *per-capita* food and health state i.e

$$U(a_t, x_t) = \ln(a_t) - \alpha \ln(x_t) \qquad (2.10)$$

Where a_t is *per-capita* food consumption and -x_t is *per-capita* HIV/AIDS. Equation (2.9) means that HIV/AIDS hurt the agent utility whereas food increases it.

2.3. The Most Efficient Optimal Path

In order to provide optimal sustainable development path, strong linkages between health and food production sectors are established i.e *per-capita* HIV/AIDS, x_t moves according to drug stock absence, D_t^{-1} such that

$$x_{t+1} - x_t = x_t D_t^{-1} \qquad (2.11)$$

Hunger, a_{t+1} -a_t moves according to food shortages, F^{-1} i.e

$$a_{t+1} - a_t = F^{-1}{}_t a_t \qquad (2.12)$$

Therefore, aggregate HIV/AIDS food shortages move such that

$G_t = x_t D_t^{-1} + a_t F_t^{-1}$. Finally, the interaction between technological change and healthcare/ food establishes income at $Y_t = v_t - G_t$ expressed by equation (2.13) i.e

$$Y_t = x_t D_t^{-1} + a_t F_t^{-1} - \bar{\mu} k_t^{\bar{\theta}} e^{\bar{\mu} t} \qquad (2.13)$$

3. The Results

Proposition 1:

Cooperative international organizations economic policy determines optimal per-capita healthcare and food provision leading to sustainable development and poverty reduction expressed by equations (3.1) and (3.2) i.e

$$a^* = \left(\frac{F}{1-\alpha}\right)^{\bar{v}} \qquad (3.1)$$

$$-x^* = \left(\frac{\alpha D}{1-\alpha}\right)^{\bar{v}} \qquad (3.2)$$

Proposition 2:

Optimal healthcare and food allocation defines sustainable development path expressed by equation (3.3) i.e

$$g^* = \left(\frac{1+\alpha}{1-\alpha}\right)^{\bar{v}} \qquad (3.3)$$

PROOF

The optimal program can be written such that

$$\Omega = [\ln(a_t) - \alpha \ln(x_t)] + \lambda Y_t$$

Where $Y_t = x_t D_t^{-1} + a_t F_t^{-1} - \bar{\mu} k_t^{\bar{\theta}} e^{\bar{\mu} t}$

The first order conditions of the optimal program provide *optimal allocation expressed by optimal per-capita food and optimal per-capita healthcare provision* in function of appropriate technological change i.e

$$a^* = \left(\frac{F}{1-\alpha}\right)^{\bar{v}}$$

and

$$-x^* = \left(\frac{\alpha D}{1-\alpha}\right)^{\bar{v}}$$

Using equation (4.1) and (4.2), we determinate the respective healthcare and food growth rates depending on appropriate technological change i.e:

$$g_a{}^* = \left(\frac{1}{1-\alpha}\right)^{\bar{v}}$$

and

$$g_x{}^* = \left(\frac{\alpha}{1-\alpha}\right)^{\bar{v}}$$

Therefore, aggregate growth rate is the sum of agriculture and medicine growth rates i.e $g=g_a+g_x$. Applying the previous formula, we obtain equation (3.3)

5. Discussions

Therefore if cooperative investment policy is engaged, relative technological change $\bar{v}$ is positive and then its absorption efficiency depends on the mechanics of sustainable development which are: relative productivity, $\bar{\mu}$ and knowledge diffusion parameter, $\bar{\theta}$ action through relative human capital, *k*

The steady state is the set $D \subseteq R_+^2$ such that $D=\{(k^*, \bar{\theta}) \epsilon D(\bar{\mu})$ where $0<k^*<k<\infty$ and $0 \leq \bar{\theta} \leq 1\}$ and therefore the subset $D(\bar{\mu})=\{(k,g)$ such that $k \geq 0$ and $0<g<\infty\}$ is defined. Then for a fixed $\bar{v}>0$ if $\bar{\mu}>0$ there exist three paths highlighted in the steady state such that: (k*, $\bar{\theta}$=-1), (k*, $\bar{\theta}$=1) and (k*, $\bar{\theta}$ inside the open ball (0,1)). The first occurrence highlight a low exterior unstable solution, the second is the exterior upper unstable solution and the last solution highlight the stable interior solution. Indeed, if $\bar{\theta}$=1 when $\bar{\mu} \succ 0$ means that relative technological change absorption and diffusion are done at highest levels or if $\bar{\theta}$ is inside the open ball (0,1), relative technological change adaptation and diffusion are done at average levels. Finally, if $\bar{\theta}$=-1, relative technological change is low. The last case means that there is no economic policy conducted and the medium case means that both sectors of agriculture and medicine are equally considered instead, the first case means that agriculture and medicine are not in balanced in sustainable development perspective.

Consequently, for a fixed $\bar{\mu} \succ 0$ high unstable sustainable growth g^{max} may exist for $\bar{\theta}$=1, a stable sustainable growth path, g^* is obtained for $\bar{\theta}$ inside the open ball (0,1) and low unstable sustainable growth path

is provided when $\bar{\theta}$ =-1 meaning that relative technological change doesn't diffuse in the economy and human capital doesn't have the required skill to absorb new knowledge. The case for which $\bar{v}>0$ is located in the development zone, whereas $\bar{v}=0$ locate the economy at the take-off locus, $\bar{v}<0$ leads to $\bar{\mu}<0$ which locates the economy in the poverty zone and make the steady state remain kept in a virtuous poverty cycle with negative unsustainable growth at all levels of $\bar{\theta}$. That evidence means that finally non agriculture and medicine policy worsen the situation because of its cost compare to its benefit.

To see how relative technological change diffusion improves sustainability, it is useful to take the logarithm of growth and compute the derivative with respect to relative human capital, then it is conditional to the diffusion parameter such that *k* around 0 or the infinity, lead to growth indeterminacy because the respective average human capital levels in agriculture and in medicine are not linked the one to the other. This interaction absence creates growth unbalanced and instability. Otherwise if *k* is bounded i.e there exist *M>0* such that *k<M=k** then relative human capital interaction exist i.e $\bar{v}>0$ established through the diffusion parameter $\bar{\theta}$ inside the open ball (0,1), therefore their movements lead to several poverty absence sustainable development paths where the optimal path is reached for the interior solution which ensures economic stability. This locus is the solution located inside the system. At least three solutions can be easily identified where only one is an interior solution and the two others are external solutions. The interior solution is the locus where the economy reaches the saddle path and both agriculture and medicine technologies diffusion improves development and sustainability. (see Figure 1)

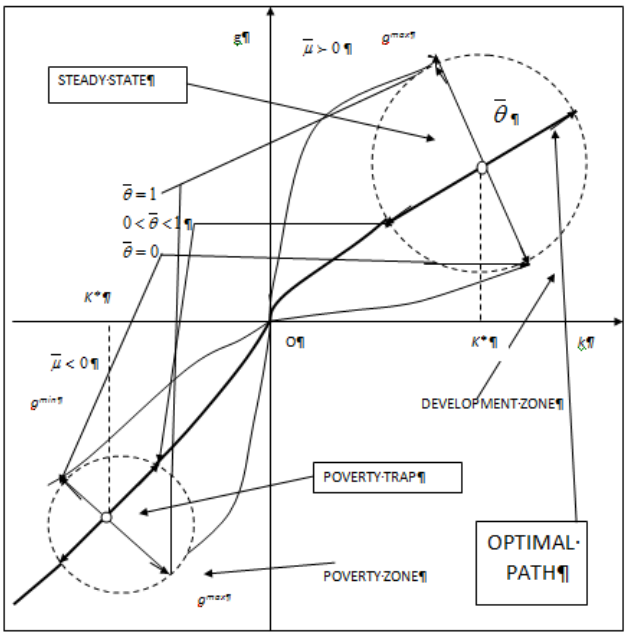
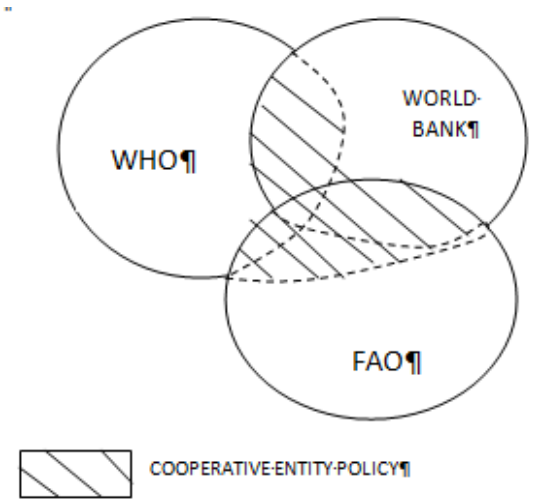


Figure 1. growth prospect in poverty reduction dilemma

4. Conclusions

The question was how to reduce poverty in line with the UN Millennium development goal and the model proposed coordinate investment Roseinstein-Rodan idea to look for reduction paths existence. The results are that, sustainable development target in poor countries through the "big push" leads to the existence of a Cooperative entity in charge of correlated international donors' goal in cooperation with the poor countries governments and highlights multiple poverty reduction paths where only one ensuring long-run stability in poverty reduction terms exits.



Cooperative Investment [4]
WHO: World Helath Organization, FAO: Food and Agriculture Organization.

Figure 2. cooperative unit policy entity is the intercept of the 3 organizations presented in their goals of poverty reduction and sustainability increase

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