Fighting poverty and child malnutrition: on the design of foreign aid policies

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Abstract

In this paper, we develop a two period overlapping generation model on the effects of child nutrition in developing countries.The model gives rise to multiple equilibria including a poverty trap. We show that child nutrition status affects unfavorably the evolution of human capital and leads countries into poverty. We consider different exogenous foreign aid policies implemented by international organizations such as the World Food Program (WFP). We find that school feeding programs solve social problems like child labor.However, they do not necessarily lead countries to achieve economic development. On the contrary they can lead to poverty if the initial human capital is low. We show that if subsidies are high enough they can prevent a country from going into poverty. Also, we argue that if the WFP provides fixed amount of food to households, then a quality-quantity trade off takes place. Parents decrease the nutrition of their offsprings and increase their number of children.Consequently, total nutrition decreases and the developing country is trickles down and gets locked into poverty trap for any given level of human capital.

JEL classification: I10; O11; O40; I11.
Keywords: Child Nutrition; Foreign Aids; poverty traps; human capital;school meals.

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1 Introduction

Malnutrition constitutes a global "silent emergency," killing millions every year and sapping the long-term economic vitality of nations, says the UN Children's Fund (UNICEF). In the state of the World's Children 1998, UNICEF adviced governments and other international organizations to take measures against hunger and the violation of children's rights. The World food Program (WFP) estimates that there are about 925 millions undernourished people in the world today.Hunger and malnutrition are the greatest risk to worldwide health than AIDS, malaria, tuberculosis, combined. Consequently, hunger and malnutrition are top global priority.

About 90 million people per year get food from WFP the largest humanitarian organization worldwide.According to Food Agriculture Organization (FAO),in 2004, WFP delivered almost 50% of global food aid. WFP's mission is to improve the nutrition and quality of life of the most vulnerable people at critical times in their lives and to fight micronutrient deficiencies, reduce child mortality, improve maternal health, and combat disease, including HIV and AIDS.For instance,in 2009,WFP spent 6.7 million dollars supporting regions such as Uganda, Chad, Liberia, Sierra Leone, Ivory Coast and Guinea, offering school feeding programs, subsidizing nutrition prices, providing financial support to local farmers and providing food to households.

This paper explores the causal link nutrition, education and human capital accumulation. It evaluates the efficiency of different WFP food aid programs aimed at improving child nutrition and pushing the developing countries away from deprivation. Several studies like Arcand (2001), Wang *et al* (2003) and recently Curais *et al* (2010) show that nutrition affects the health and economic development of nations. In particular, they argue that low nutrition leads developing countries to impoverishment, but do not show how they can escape from the poverty trap. Also, Galor and Mayers (2003) explain that the link between health and education contributes to explain the long term effects of nutrition and health on economic growth. The authors show that if policies financing education is implemented without addressing deficiencies in nutrition, poverty traps may persist.

In our benchmark model, we consider an overlapping generation model where agents live for two periods. Agents get the utility from the consumption and the human capital of their surviving children. Also, agents choose how many children to have, their amount of schooling and their level of nutrition. It is assumed that parents decide how their children allocate their time between schooling and labor. Child labor, in fact may be crucial to their nutrition, since many children in developing countries are forced to work to provide a supplement to their parents income, see for example (Hazan and Berugo, 2000; Adbus and Rangazas, 2010; Curais *et al.*, 2010 and Moav, 2005).

In our model, if children dedicate less time to education in favor of labor, then the human accumulation of children will have negative impact on future human capital and thus on the income of the country. In this framework, we assume that there is no bargaining between parents and children regarding the allocation of the family's income (see for instance Udry, 2003). Moreover, a key ingredient of our setting is that the children's survival probability depends on their nutrition status (like Strulik *et al*, 2010; Gloom and Palumo,1999). This allows us to investigate the effects of health in human capital through the mortality changes (see Chakraborty and Das,2005) not only in the benchmarck model but also in the extension of model where we also include the aid in the survival probability of children (see Huff and Jimenez, 2003).

Our model underlines the importance of the relationship between health and learning capacity (Curais *et al*, 2010).Here, Nutrition has dynamic and synergistic effects on economic growth, through the channel of education. For instance, Neumann, Murphy *et al* (2007) apply a randomized school feeding study that was conducted in rural Embu District in Kenya to test for a causal link between animal-source food intake and changes in micronutrient nutrition and growth, cognitive, and behavioral outcomes. They show that meat supplementation improves growth, cognitive and behavioral outcomes in children.Simeon (1998) shows that providing school meals can be beneficial for learning because it relieves immediate short-term hunger. Hence, children who are not hungry are more attentive and have higher cognitive abilities.

To capture this complementarity, we consider that our law of motion of human capital includes education, parental human capital (see de la Croix and Doepke ,2003) and nutrition status of the children (see Curais *et al*,2010). Our benchmark model gives arise multiple equilibria(development regimes) and initial conditions matter. Some coutries might caught in a poverty trap. Possible strategies/foreign food aid will be identified and evaluated if they allow the developing countries to escape from poverty.

Recently a number of studies focus on the relationship between foreign aid and economic growth. Empirical studies,such as Hansen and Tarp (2001), Economides *et al* (2008) find that aggregate foreign aid has on average positive growth effects on a country. However, they do not focus on specific policies such as food assistance. Other studies (see, for instance, Easterly *et al*, 2004; Roodman, 2007) argue that the recipient country's characteristics determine the resulting failure or success of foreign aid. Of these, the most substantial are the timing of distributing aid during a negative trade shock (Collier and Dehn, 2001) and the geographic/tropical location of the recipient nation (Daalgard *et al*, 2004).

Our paper is closely related to Azarnert (2008) and Neanidis (2010). Azarnert (2008) explores the influence of humanitarian aid on population growth and human capital accumulation.In his model, the fertility decisions are based on a quantity-quality trade off for children, which dates to Becker (1960).This trade-off arises because the utility of parents depends on both the number of their children and their quality. He shows that for every adult and child aids increase fertility by reducing the quantity cost of having children. As a result, parents invest less to the education of their offspring,which leads to the reduction of human capital.Thus, Azarnert (2008) ignores the potentially beneficial impact of foreign aid in the survival probability of children as documented by a number of studies (see Huff and Jimenez, 2003 ; Neanidis, 2010). His contribution also neglects the effect of aid on children's health status through nutrition (see Kraak *et al* 1999).

Unlike Azarnert (2008), Neanidis (2010) examines the influences of foreign aid on population growth and health capital using a two period OLG model. He assumes that aid is allocated to every child and adult. His model accounts for endogeneity of parents' time allocation to childrearing activities and in this way allows to internalize the impact of their decisions. He finds that the per child aid(flows of medication) increases the child's survival probability thereby reducing fertility, while it contributes to child's health status. On the other hand, per adult aid increases fertility by reducing the quantity cost of children, thereby reducing the time that parents spend to rear their children. In addition, he neglects that the survival probability of children should also depend on health expenditures spent by parents (see Boucekkine and Laffargue, 2010; Chakraborty and Das, 2005) because he considers that it depends only on the foreign aid. He also ignores the complementarity that exists between health, education and human capital accumulation as documented in a number of studies (see Galor and Mayers, 2003 ; Curais *et al*, 2010). This complementarity is crucial because there are foreign aids like school feeding programs which have as goal not only to increase the nutrition status of children, but also to attract them on school and to diminish the child labor.

In contrast to the above studies, the quantity- quality tradeoff in our framework depends on fertility and the parental expenditures for nutrition of their children and also on time that parents allow to children to spend at school. Moreover, we evaluate the foreign food aids for different levels of initial human capitals. Accounting for these considerations in our model allows us to analyze a more complex effect of foreign food aid.

Next, we extend our model by implementing four different foreign aid policies provided mainly by the WFP. Total nutrition is constituted by the foreign aid and the nutrition offered from parents. WFP provides school meals or fixed amount of food in households, subsidizes prices and improves the infrastructure of local food industries of developing countries. We obtain the following important results. School meals and fixed amount of nutrition in households lock the poor developing countries in poverty. In particular, these foreign aid programs increase the fertility by reducing the quantity cost of children. As an outcome parents invest less for the nutrition of their children, leading to a slowndown the human capital accumulation which may even lock the recipient economy into a poverty trap. Nevertheless, if WFP decides to provide high amounts of food in schools or in households, then the total child nutrition depends only on the foreign aid programs. Thus, the developing country can escape from the poverty trap. When the WFP subsidize the prices of child nutrition there is an income effect, even further parents can afford to offer more nutrition resources. The total nutrition rises thereby increasing the survival probability of children and their human capital.As a result, poor countries can escape from the poverty trap.

Additionally, school feeding programs are more efficient for the middle-income developing countries than the other two foreign aid programs. They increase the length of schooling and improve human capital of future generations even if the total nutrition remains unchanged (Jacoby *et al*,1996; Powell *et al*,1983; Murphy *et al*,2003 and Agarwai *et al*,1989). Child labor decreases. Consequently, middle-income countries can achieve their economic development.

Finally, we consider that WFP improves the infrastructure of local food industries or supports financially the local farmers such that to increase the quality of food and to improve the agricultural productivity. This improvement is captured in our framework by the technological level of our law of motion of human capital. Consequently, an increase in the technological level raises the human capital of future generations and hence the poor economies can achieve the economic development.

At the end of this paper, we calibrate our model. Following the technique of Bils and Klenow (2000), we obtain the human capital stock by using surveys which are compiled by the United Nations and reported in the two UNESCO publications Statistics of Educational Attainment and illiteracy 1945-1974 and Statistics of Educational and illiteracy 1970-1980 and Penn Word tables for 66 developing countries (almost half of them are African countries). Also, using data from Barro and Lee data base, World bank data and nutrition data from Food Agriculture Organization (FAO), we estimate the parameters of our human capital accumulation. We find that all the variables that consist the law motion of human capital (nutrition, education and parental human capital) are significant. The rest of parameters are based on the existent literature.

We decide to provide a numerical example of our model for the following reasons. First of all, we know that the majority of developing countries are rural economies. In our model, we consider a linear production function such that we can obtain analytical results. In the calibration part, we investigate the linear production function as in the theoretical part and the decreasing returns to scales production function that characterizes the rural economies.We find that our results remain the same in both cases.

Moreover, we provide this numerical example to investigate what the level of assistance from WFP that can lead the countries out of the poverty for each foreign aid policy. Finally, we provide a sensitivity analysis of our parameters to ensure the validity of our results which is confirmed.

The rest of the paper proceeds as follows. Section 2 presents the benchmark model, section 3 illustrates the dynamics of human capital, section 4 presents the different foreign aid programs incorporated the benchmark model, Section 5 illustrates a computational Experiment and section 6 concludes.

2 The Benchmark Model

Fertility, mortality and net reproduction. Consider an OLG economy in which activity extends over an infinite horizon. In each generation, individuals live for two periods: childhood and adulthood. All the decisions are taken by adults. Let L_t denote the number of adults in period t, and n_t the number of births per adult. The probability of survival from childhood to adulthood is denoted by $\pi_t \in [0,1]$. In particular, it is synonymous to the fraction of children, born in period t and become adult in period $t+1$. We assume that the children live all the period t.At the end of the period t, children either die or become adults in period $t+1$. It follows that the net reproduction rate is $\pi_t n_t$. Thus, the adult population at period $t+1$ is:

$$L_{t+1} = \pi_t n_t L_t. \tag{1}$$

Also, we assume that the survival probability is endogenous and it is a function of the total level of nutrition.In particular, we assume that $\pi_t = \pi(M_t)$, where $\pi^{'}(M_t) > 0$ and $\pi^{''}(M_t) < 0$. This is in line with Fogel(1994) who has shown that better nutrition in childhood affects the health and life span during the adult years of life.Moreover, we are consistent with Gloom and Palumo(1993) who analyze a life cycle model where the survival probability is determined by health capital via nutritional investment. The survival probability of children is expressed by the function:

$$\pi_t = min[M_t^{\sigma}, 1]. \tag{2}$$

with $0 < \sigma < 1$. The specification of survival probability is similar to Chakraborty and Das (2005) and Boucekkine and Laffargue (2010).

Preferences and optimization. Adults maximize utility which they derive from their consumption c_t, the number ,n_t and the human capital of their children h_{t+1} and the children's survival probability,π_t. The utility function is given by :

$$\ln c_t + \beta \ln(\pi_t n_t h_{t+1}). \tag{3}$$

The parameter $\beta > 0$ is the altruism factor. Notice that the parents care about the quantity n_t and the quality h_{t+1} of their surviving children. This type of preferences specification has been used in the literature on fertility and growth(see for instance, Galor and Weil, 2000; Hazan and Berdugo, 2002; Moav,2005).

The adults are endowed with one unit of time.Raising one child takes the fraction $\phi \in (0,1)$of an adult's time. The income of an adult is $w_t h_t$ where w_t is the wage per human capital and h_t is adult's human capital. Consequently, as it is standard in the literature (see for instance Barro and Becker,1989 ; de la Croix and Doepke, 2003; Azarnet, 2008) the existence of the opportunity cost $w_t h_t \phi n_t$ creates a trade off between the quality and the quantity of children.

Furthermore, an adult has to choose a consumption profile c_t, the number children n_t, nutrition of the children m_t and the number of years of schooling per child e_t.Here, we consider that the amount of schooling, e_t is the time that the child spends after primary school which is usually compulsory. Hence, q represents the minimum education received in primary school in developing countries. We shall assume that $q \geqslant \bar{q} > 0$,otherwise human capital would be zero in the low regime. This parameter ensures that human capital is positive. The latter reason is the basis of many papers (see de la Croix and Doepke ,2003 ; Hazan and Berdugo ,2002) of using this parameter. On the contrary, Curais *et al* (2010) consider q as infancy in their human capital accumulation.

Hence, the human capital of children h_{t+1} depends on the education level e_t and total nutrition M_t. In the benchmark model total nutrition coincides with the nutrition offered by parents, m_t. The human capital accumulation is the following :

$$h_{t+1} = BM_t^{\theta_1}(e_t + q)^{\theta_2} h_t^{1-\theta_1-\theta_2}. \tag{4}$$

Also, we assume that the law motion of human capital depends on the human capital of the parents h_t and B which is the productivity of human capital(technological level).This law of motion is different than than the law motion of human capital accumulation used by Curais et al(2010). We suppose that B is constant. More precise it is equal to one and it can be influenced exogenously. Here, in the law motion of human capital, the h_t captures the intergenerational transmission of human capital within a family. In other words young individuals inherits part of the human capital of the parents. This reflects the cultural transmission within the family. Our human capital accumulation differs from that of de la Croix and Doepke(2003) since it contains the nutrition and we also assume that q is primary education.

Children also contribute to family income. Children have an endowment of 1 unit of time. This time is spent either learning e_t or working $(1 - e_t - q)$.The earning of a child who is capable to work is $w_t\gamma(1 - e_t - q)$. The child worker lacks experience and physical strength comparing to adult worker. Thus, we consider that $0 < \gamma < 1$.

Moreover, since we have homogenous agents in one sector model,we assume that all children have the same productivity and their human capital do not influence it. Furthermore, the parents spend the household revenue for their consumption and the nutrition of their children. Thus, the budget constraint has the following form :

$$c_t + m_t n_t = w_t h_t(1 - \phi n_t) + w_t\gamma(1 - e_t - q)n_t. \tag{5}$$

Firms. Firms produce using a constant returns to scale technology:

$$Y_t = H_t, \tag{6}$$

where H_t is the total amount of human capital in the workforce. We make this assumption to obtain analytical results although we know that constant returns to scale are not consistent in rural economies. Nevertheless, the same assumption is done by Adbus and Rangazas (2010) who investigate the effects of food consumption in economic growth in the development of England during the mid-18 century. The main reason that we also use linear production function is to obtain analytical results and simplicity[1]. At the labor market's equilibrium, H_t is:

$$H_t = [1 - \phi n_t]h_t + \gamma[1 - e_t - q]n_t. \tag{7}$$

The workforce participation of a parent consists of his remaining time after childbearing and educating his children and therefore of the time that a child works. As the labor market is competitive, the wage equals to the children's marginal productivity at each date t is constant and normalized to $w_t = 1$ for simplicity.

At this point of our analysis, we impose two assumptions.Assumption 1 ensures the positivity of human capital in the steady state. Hazan and Berdugo (2002) and Curais *et al* (2010) have a similar condition.[2]

Assumption 1. $h_0 > \frac{\gamma}{\phi}$.

Next assumption ensures the positivity of our optimal choices.

Assumption 2. $1 - \theta_1 - \theta_2 - \sigma > 0$.

Optimal Choices. Maximizing equation 3 subject to equations 4-5 the optimal solutions for education, nutrition and fertility are:

$$e_t = \begin{cases} 0 & h_t \leq h_1, \\ \frac{\theta_2[h_t\phi - \gamma]}{\gamma(1-\theta_1-\theta 2-\sigma)} - q & h_1 < h_t < h_2, \\ 1 - q & h_t \geq h_2. \end{cases} \tag{8}$$

[1]In our numerical example we also present a decreasing returns to scale production function $Y = H_t^{\alpha}$ that it is consistent with agriculture economies

[2]They consider that the income generated by children is accrued to parents and the time of rearing a child is intensive. As a result the increasing differential wage(between parental and child labour) leads to a decrease of child labour. Moreover, the initial human capital should be large enough.

The threshold levels of adult human capital[3] $h_1 = \frac{(q(1-\theta_1-\theta_2-\sigma)+\theta_2)\gamma}{\theta_2\phi}$ and $h_2 = \frac{\gamma(1-\theta_1-\sigma)}{\phi\theta_2}$ define three distinct situations. In the low regime, children attend only primary school and they dedicate the rest of their childhood to increase the family income. Time dedicated to education begins to be positive and increasing with parents' income when human capital is . In the high regime, children dedicate the whole unit of time to education. In other words, there is no child labor in the high regime.

The nutrition level offered from parents coincides with the total nutrition that children received:

$$m_t = M_t = \begin{cases} \frac{(\sigma+\theta_1)(h_t\phi-\gamma(1-q)}{1-\sigma-\theta_1} & h_t \leq h_1, \\ \frac{(\sigma+\theta_1)(h_t\phi-\gamma)}{1-\sigma-\theta_1-\theta_2} & h_1 < h_t < h_2, \\ \frac{(\sigma+\theta_1)(h_t\phi)}{1-\sigma-\theta_1} & h_t \geq h_2. \end{cases} \tag{9}$$

The optimal nutrition above is consistent with Arcand (2001) and Wang *et al* (2003). As already mentioned, these studies show that low income levels related to low nutrition levels (see Appendix A and figure 1). Hence, the optimal nutrition choice is an increasing function of human capital. They used pairs of GDP and information and average daily per capita calorie intake in a sample of 114 countries and they show that countries with higher GDP have higher level of nutrition. It is important to mention that when the maximum level of nutrition is achieved the number of children per adult decreases[4].

$$n_t = \begin{cases} \frac{(1-\sigma-\theta_1)h_t\beta}{(1+\beta)(h_t\phi-\gamma(1-q))} & h_t \leq h_1, \\ \frac{\beta h_t(1-\theta_1-\theta_2-\sigma)}{(1+\beta)(h_t\phi-\gamma)} & h_1 < h_t < h_2, \\ \frac{(1-\sigma-\theta_1)\beta}{(1+\beta)\phi} & h_t \geq h_2. \end{cases} \tag{10}$$

[3] We can also be considered as income because we have linear production function.

[4] In the Appendix A, we provide an analysis where we compare the nutrition levels in the different human capital levels.Moreover, we investigate the optimal solutions of fertility as the h_t increases. We show that the nutrition level increases and the fertility decreases as human capital raises. The latter can be observed in figure 1.

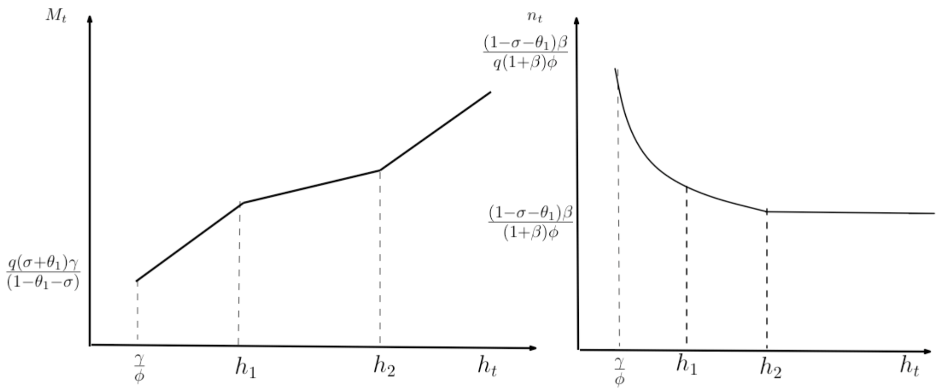

Figure 1: Nutrition and Fertility in Benchmark model

Fertility is positive and decreasing with parental human capital (see Appendix A and figure 1). This mechanism dates to Becker (1960) where fertility decisions are based on a quantity-quality tradeoff for children. This trade off arises because the utility parents depends on both of the number of their survived children and their quality captured by their level of human capital. Given that the human accumulation arises through investments in education and nutrition a trade off emerges since education and nutrition are costly. Thus, as human capital increases through nutrition and education, fertility declines. In other words, parents choose child quality over child quantity. This is consistent with the empirical evidence that shows that the fertility rate is lower in developed countries (for instance see Galor and Weil, 2000; Chakraborty, 2004; Azarnet, 2006; Moav; 2005) and it becomes constant.

3 Evolution of human capital

Using the optimal decisions on education, total nutrition and fertility, we obtain the following picture for human capital accumulation:

$$h_{t+1} = \begin{cases} \frac{(\sigma+\theta_1)^{\theta_1}(h_t\phi-\gamma(1-q))^{\theta_1}h_t^{1-\theta_1-\theta_2}q^{\theta_2}}{(1-\theta_1-\sigma)^{\theta_1}} & h_t \leq h_1, \\ \frac{(\sigma+\theta_1)^{\theta_1}(h_t\phi-\gamma)^{\theta_1+\theta_2}h_t^{1-\theta_1-\theta_2}\theta_2^{\theta_2}}{(1-\theta_1-\sigma-\theta_2)^{\theta_1+\theta_2}\gamma^{\theta_2}} & h_1 \leq h_t \leq h_2, \\ \frac{(\sigma+\theta_1)^{\theta_1}(h_t\phi)^{\theta_1}h_t^{1-\theta_1-\theta_2}}{(1-\theta_1-\sigma)^{\theta_1}} & h_t \geq h_2. \end{cases} \tag{11}$$

We need further assumptions to ensure that children should perceive a minimum human capital equal or above their parents (Assumption 3) and to bound q (Assumption 4).

Assumption 3

$$lim_{h_t \to \frac{\gamma}{\phi}} h_{t+1} \geq \frac{\gamma}{\phi}. \tag{12}$$

Assumption 4.
The q value lies on the following interval, $q \in (\bar{q}, q_{max}]$, where

$$q_{max} = \frac{\theta_2^{\frac{\theta_2}{\theta_1+\theta_2}} (\sigma+\theta_1)^{\frac{\theta_1}{\theta_1+\theta_2}} \phi\theta_2}{\theta_2^{\frac{\theta_2}{\theta_1+\theta_2}} ((\sigma+\theta_1)^{\frac{\theta_1}{\theta_1+\theta_2}} \phi - (1-\theta_1-\theta_2-\sigma)\gamma^{\frac{\theta_2}{\theta_1+\theta_2}})(1-\theta_1-\theta_2-\sigma)}$$

.

This assumption defines a low and upper bound for q. We can see in figure 2 the existence of 3 steady states, one in each regime.Depending on the parameter values, the highest steady state could be below or above h_2[5].

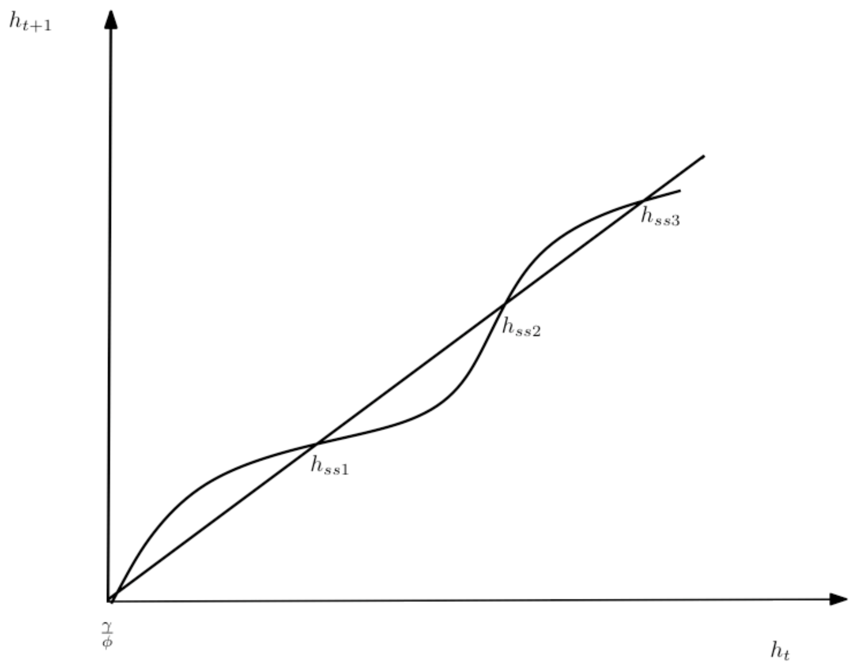

Figure 2: Human capital

We show that when the level of human capital is below h_2, the economy converges to low nutrition , high fertility and low human capital equilibrium h_{ss1} which is locally stable

[5]In the Appendix, we present the three steady states

(see Figure 2). This steady state is a poverty trap because it is an asymptotic destination of any economy whose initial human capital stock is in interval ($\frac{\gamma}{\phi}$,h_{ss2}). We understand a poverty trap as "any self reinforcing mechanism which causes poverty to persist" (Azariadis and Stachurski, 2005).

The following proposition proves that there exists two additional steady states, one unstable equilibrium and one stable. As a result, the economy either falls in poverty or achieves in economic development.

Proposition 1.

1. *Under assumptions 1-4 and $h_{ss3} < h_2$, there exists a unique locally steady state, h_{ss1} and an unstable steady state, h_{ss2}. Hence, if economy's initial human capital stock belongs to interval ($\frac{\gamma}{\phi}$,h_{ss2}) then it falls into a poverty trap, i.e. human capital converges to h_{ss1} .*

2. *If $h_{ss3} > h_2$ and $h_{ss2} \in [h_1, h_2]$, then there are two locally stable steady states and one unstable.*

Proof. See Appendix B. □

Proposition 1 argues that the existence of two or three steady states depends on the initial human capital of the country. Two of them are locally stable and one unstable. If the initial level of human capital is greater than the threshold h_2 the whole economy converges to the low fertility, high nutrition and high human capital equilibrium h_{ss3} which is locally stable. On the other hand if the initial human capital is in $h_{ss3} < h_2$ then the total economy converges to the low nutrition, high fertility and low levels of human capital which is in fact the poverty trap (see Figure 2).

There are several international organizations like World Food Program (WFP), Food Agriculture Organization (FAO), UNESCO that provide food aid to developing countries not only to relief the short term hunger but also to lead them out of poverty. In the next sections, we evaluate the different foreign aid policies that applied from WFP.

4 Food Foreign Aids

In this section, we try to implement different ways to escape from the poverty trap and to lead the countries to economic development. There are different opportunities to escape from poverty trap. In particular, it can be variations in the initial conditions of the system by different foreign aids or a parallel shift-up of the transition function h_{t+1}. More precisely, we examine the different aids provided by the WFP and we investigate if they can be efficient for the countries to escape from the poverty trap. Are all the different aid programs offered by WFP really efficient ? This question will be answered in this section.

WFP provides food to development countries. One of its main activities is procurement by buying food for households, feeding programs in school, enhancing financial local farmers and in general local economies and offering emergency aid to difficult situations. In the following subsection, we introduce feeding programs in school, in subsection 2, we consider that WFP subsidizes the prices for child nutrition and as a result to decrease its price. In subsection 3, WFP offers a fixed amount of nutrition in households and in subsection 4, WFP supports financially the local farmers and the local food industries such that to improve the quality of the nutrition and the infrastructure of the developing country.

4.1 Feeding programmes in school

WFP's school meal programmes work towards achieving several Millennium Development Goals (MDGs)[6]. The programmes directly address the goals of reducing hunger by half, achieving universal primary education and of achieving gender parity in education – all by 2015. In particular, WFP has become the largest organiser of school feeding programmes in the developing world. In 2003, WFP fed more than 15 million children in schools in 69 countries. Working with national governments, local authorities, donors and international and local aid groups, WFP uses food to attract children to school and to keep them on it.

The WFP transfers available resources to children at each period t in order to improve the human capital according to the following rule. A fixed quantity of nutrition commodity T per unit of time dedicated to education and it is transfered per child.

Now the survival probability is the following:

$$\pi_t = (m_t + T(e_t + q)))^{\sigma} \tag{13}$$

where $T(e_t+q)$ stands for the meals offered per child during the time it spends in school.The motion of human capital is given now by

$$h_{t+1} = (m_t + T(e_t + q))^{\theta_1}(e_t + q)^{\theta_2} h_t^{1-\theta_1-\theta_2}. \tag{14}$$

Now, the survival probability and human capital accumulation depends on the nutrition offered from parents and the foreign aid which is the school meals. The total nutrition is$M_t = m_t + T(e_t + q)$.

Maximizing the welfare of equation (3) subject to equations (5) and (14) the following optimal solutions for education, nutrition and fertility are obtained:

$$e_t = \begin{cases} 0 & h_t \leq h_1(T), \\ \frac{\theta_2[h_t\phi-\gamma]}{(\gamma-T)(1-\theta_1-\theta_2-\sigma)} - q & h_1(T) < h_t < h_2(T), \\ 1-q & h_t \geq h_2(T), \end{cases} \tag{15}$$

where $h_1(T) = \frac{q(1-\theta_1-\theta_2-\sigma)(\gamma-T)+\theta_2\gamma}{\theta_2\phi}$ and $h_2(T) = \frac{\gamma(1-\theta_1-\sigma)-T(1-\theta_1-\theta_2-\sigma)}{\phi\theta_2}$ are thresholds and they depend on T.

Proposition 2. *Under Assumption 2 h_1 and h_2 decrease whenever T increases.*

Proof. See Appendix C. □

[6]The Millennium Development Goals are to :1)Eradicate extreme poverty and hunger, 2)achieve universal primary education, 3) promote gender equality and empower women, 4) reduce child mortality, 5)improve maternal health,6)combat HIV/AIDS, malaria and other diseases, 7) ensure environmental sustainability, 8) develop a global partnership for development.

The thresold levels of human capital decrease with T. As an outcome, the policy being considered alters the behavior with respect to fertility, nutrition and human capital investments. After introducing school feeding programs, the total optimal nutrition of children depends on the nutrition offered from parents and the school meals. Now the optimal total nutrition of children is the following:

$$M_t = m_t + T(e_t + q) = \begin{cases} \frac{(\sigma+\theta_1)[h_t\phi-\gamma(1-q)-Tq)}{(1-\sigma-\theta_1)} & h_t \leq h_1(T), \\ \frac{(\theta_1+\sigma)}{(1-\theta_1-\theta_2-\sigma)}[h_t\phi - \gamma] & h_1(T) < h_t < h_2(T), \\ \frac{(\sigma+\theta_1)[h_t\phi-T(1+q)]}{(1-\sigma-\theta_1)} & h_t \geq h_2(T). \end{cases} \tag{16}$$

As it can be observed, the total level of nutrition of children is still an increasing function of human capital (see figure 3).Comparing with the benchmark model, the total nutrition decreases in the low regime because of T and it remains the same in the second regime since it is independent of T.

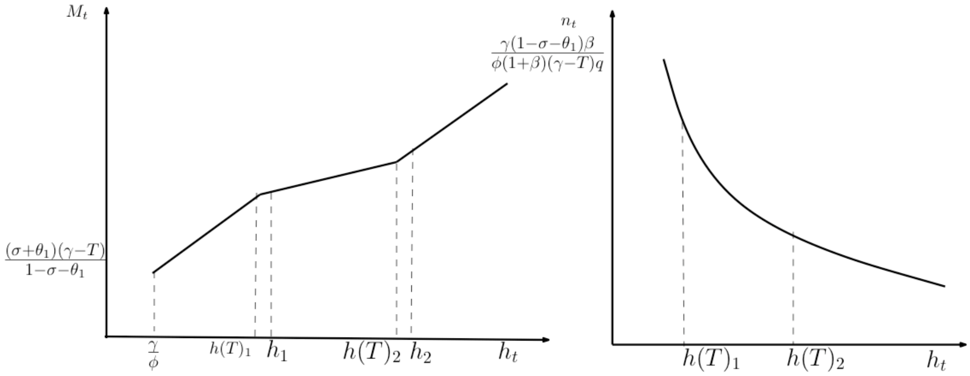

Figure 3: Nutrition and Fertility with school feeding programs

The nutrition offered from parents decreases and it is the following:

$$m_t = \begin{cases} \frac{(\sigma+\theta_1)(h\phi-\gamma)}{1-\theta_1-\sigma} + \frac{[[\sigma+\theta_1]\gamma-T]q}{1-\theta_1-\sigma} & h_t \leq h_1(T) \\ \frac{(\theta_1+\sigma)}{(1-\theta_1-\theta_2-\sigma)}[h_t\phi - \gamma] - \frac{T\theta_2[[h_t\phi-\gamma]}{(\gamma-T)(1-\theta_1-\theta_2-\sigma)} & h_1(T) < h_t < h_2(T) \\ \frac{(\sigma+\theta_1)(h_t\phi)-T(1+q)}{1-\sigma-\theta_1} & h_t \geq h_2(T) \end{cases} \tag{17}$$

Fertility depends on the level of T. We observe that fertility increases and the nutrition decreases comparing with those of benchmark model. The product of quality- quantity trade off[7] is independent of the T and remains the same with that of benchmark model[8]. This means that as parents increase the number of their children they will decrease the amount of nutrition level provided to their children. Comparing to benchmark model, the fertility is a decreasing function with respect to human capital(see figure 3).

$$n_t = \begin{cases} \frac{(1-\sigma-\theta_1)h_t\beta}{(1+\beta)((h_t\phi-\gamma(1-q))-Tq)} & h_t \leq h_1(T), \\ \frac{\beta h_t(1-\theta_1-\theta_2-\sigma)}{(1+\beta)(h_t\phi-\gamma)} & h_1(T) < h_t < h_2(T), \\ \frac{(1-\sigma-\theta_1)\beta h_t}{((1+\beta)(h_t\phi)-(1+q)T)} & h_t \geq h_2(T). \end{cases} \tag{18}$$

Equations (16) and (17) show that school feeding decreases the amount of nutrition offered from parents to their children in all regimes.It can be observed that education has a negative effect on total child nutrition that is offered by parents because it prevents children to work. In particular, in poor developing countries, foreign aid policy decreases not only the total nutrition but also the total human capital. Here, it takes place a tradeoff of the child quantity over the child quality. In the interval $h_t \leq h_1(T)$,school feeding programs increase fertility by reducing the "quantity cost" of children, thereby shifting resources from quality to quantity of children. In other words, parents decrease the level of nutrition of their offsprings and they increase the number of their children.This trade off takes place as long as the fixed commodity, T, is sufficient small (see equation 19 and equation 10). This result is consistent with Azarnet (2008) where humanitarian aid increases fertility by reducing the investment of parents in their children education, and subsequent of accumulation of human capital.

Therefore, Neanidis (2010) shows similar results where the per adult aid increases the fertility by reducing the "quantity cost" of children. This shifts resources from quality of children to quantity of children. The main differences with his contribution are the following: first, in our model aid does not reduce the childbearing time but the investment of parents for the nutrition of their children and second we consider that the survival probability depends on the nutrition offered from parents and the foreign aid.

Also, it is important to mention that since the total nutrition level decreases, the survival probability decreases. This shows that there is inverse relation between fertility and survival probability, which is consistent with Agenor (2009)[9] The following proposition summarizes the effect of school feeding programs on the optimal choices of parents with respect to number and quality of their offspring.

Proposition 3. *School Feeding programs generate a substitution effect away from quality of children toward quantity of children in poor developing countries if the T is small.*

Proposition 4 implies the following:

[7]The quantity-quality trade off is more obvious in developing countries than in developed. In a developing country such as India, Burundi, where neither a well-functioning public education system nor generous support the childbearing and childcare, the cost of quality is mostly borne by the parents. There is also some evidence from developing countries in studies of public health. See for instance Karmaus and Botezan (2002).

[8]Since we have logarithmic utility function, the quality-quantity trade off is a constant fraction of household income.

[9]Agenor (2009) refers that if the survival probability decreases there is an increase in the demand of children.

- Parents decrease the investment in nutrition if T is sufficient small (*proof*: see equation (16)).
- Parents increase the number of their children (*proof*: see equation (18)).

This proposition is valid as long as the fixed commodity T is smaller than the nutrition offered by parents. When T is higher than $\frac{(\sigma+\theta_1)((1-\theta_1-\sigma)\gamma)}{(1-\theta_1-\theta_2-\sigma)(\sigma+\theta_1)+\theta_2}$ parents decide to stop offering food at home and the total nutrition of children is equal to school meals[10]. Hence, the human capital accumulation of children depends only on the foreign aid of WFP. If this aid is higher than $\frac{(\sigma+\theta_1)((1-\theta_1-\sigma)\gamma)}{(1-\theta_1-\theta_2-\sigma)(\sigma+\theta_1)+\theta_2}$ the poor country can escape from the poverty trap.

Proposition 4. *For values of T higher than $\frac{(\sigma+\theta_1)((1-\theta_1-\sigma)\gamma)}{(1-\theta_1-\theta_2-\sigma)(\sigma+\theta_1)+\theta_2}$ parents stop offering food at home, the children's nutrition depends on the level of nutrition of foreign aid and poor countries can escape from the poverty trap.*

Proof. See Appendix D. □

Consequently, we conclude that WFP should offer high amounts of school meals if this organization wants to attract children in school, to solve hunger and poverty. This foreign aid has different results for middle income developing countries. More precisely, school feeding programs increase the length of school time In this case, school feeding programs are very effective in solving child labor in developing countries.Furthermore, they lead to an improvement in the human capital and allow better conditions for the next generations (see Chandler *et al*, 1995; Chang *et al*, 1996). Human capital increases only through the channel of education, because the total nutrition remains constant. This result is confirmed by four studies which argue that the benefit of supplements because of the school meals was less than expected in areas like Peru (Jacoby *et al*, 1996); Jamaica (Powell *et al*, 1983); Kenya (Murphy *et al*,2003) and India (Agarwai *et al*,1989). The authors of two of these studies concluded that children who had been offered a substantial supplement at school were provided with less food at home (substitution). The next proposition summarizes the above results.

Proposition 5. *School feeding programs increases the length of schooling and reduce child labor in middle income developing countries.*

Proposition 6. *In middle income developing countries, School feeding programs do not increase the total nutrition of children but increase the length of schooling.*

- These two propositions imply that that the total human capital increases(*Proof* see equations 16, 17 and 18).

We need to mention here, that the feeding programs in school have positive implications that can not be captured by this model. In particular, in developing countries, school meals can provide short term relief of hunger since in the poorest areas families can not have even the basic food for their children. School meals can also affect children with HIV/AIDS, orphans, disabled and former soldiers that these categories are not included in our model.

Looking at the total welfare of parents in the different regimes, we can notice that there are ambiguous effects in the first regime and also there is improvement in the second regime. At the end, it is noteworthy to mention that there is evidence like Bro *et al*(1994 and 1996) which show that a generous breakfast cooked in a practical class before the lesson began

[10] The optimal choices for total nutrition and fertility change change

improved the attention to set tasks and also their data suggested that a school meal that can be a social event stimulates and motivates the students. This aspect is not captured by our model.

4.2 Food provision in Households

In this part of the analysis, we assume that WFP provides two forms of aid. First, we consider that WFP subsidizes the prices of nutrition and second, it provides a fixed amount of nutrition to each child of household. We assume that all the households of the recipient country receives this kind of humanitarian aid.

4.2.1 Subsidize the price of nutrition of children or procurement by WFP

Food prices in developing countries have declined since 2008 but remain much higher than pre-food prices some years earlier. This high food price situation continues to raise concern for the food security of populations in urban and rural areas, as these groups spend a large share of the incomes in food(see for instance report of FAO july 2009). Consequently, WFP tries not only to stabilize the food prices but also to reduce by subsidizing them.

In this subsection we consider that the WFP purchases food at the most advantageous price taking into account the cost of transport and shipping, with preferences towards procuring locally ore regionally in developing countries wherever possible (see for instance report WFP about Egypt (2005)).

We assume that WFP buys and offers a percentage of nutrition of each child as voucher or as cash to families to buy only nutrition for children, η_t in each household.We suppose that the price of nutrition is equal to 1.Thus their offer is $\eta_t m_t n_t$ in each household. We suppose that this is a project of WFP offering aid continuously for years in a developing country or it is a bilateral food aid that supplied by government to government. Later the government provides this food to households without cost. Of course there are certain types of food aid that can actually be destructive. Dumping food on to poor nations (i.e. free, subsidized, or cheap food, below market prices) undercuts local farmers, who cannot compete and are driven out of jobs and into poverty. In this analysis, we assume that WFP subsidizes the price of the nutrition of children and we do not include these kind of aid in our framework.Also, we mention that the nutrition that offered from parents to children is equal to the total nutrition.

Next we maximize the young adults' welfare that is described in equation (3) under the budget constraint

$$c_t + (1-\eta_t)m_t n_t = h_t(1-\phi n_t) + \gamma(1-e_t-q)n_t, \tag{19}$$

and the motion of human capital given by the equation (4).

The optimal choices for education, nutrition and fertility are

$$e_t = \begin{cases} 0 & h_t \leq h_1, \\ \frac{\theta_2[h_t\phi-\gamma]}{\gamma(1-\theta_1-\theta_2-\sigma)} - q & h_1 < h_t < h_2, \\ 1-q & h_t \geq h_2. \end{cases} \tag{20}$$

The thresholds h_1 and h_2 defined in the benchmark model. Also, we notice that the level of education remains the same with the level of education before aid(see equation 8).

$$M_t = m_t = \begin{cases} \frac{(\sigma+\theta_1)(h_t\phi-\gamma(1-q))}{(1-\sigma-\theta_1)(1-\eta_t)} & h_t \leq h_1, \\ \frac{(\sigma+\theta_1)(h_t\phi-\gamma))}{(1-\sigma-\theta_1-\theta_2)(1-\eta_t)} & h_1 < h_t < h_2 \\ \frac{(\sigma+\theta_1)(h_t\phi)}{(1-\sigma-\theta_1)(1-\eta_t)} & h_t \geq h_2. \end{cases} \tag{21}$$

Equation (21) argues that the nutrition of children increases in all regimes (see figure 4). Low prices for nutrition allow parents to spend more for it than before. Thus, the total level of nutrition increases.

$$n_t = \begin{cases} \frac{(1-\sigma-\theta_1)h_t\beta}{(1+\beta)(h_t\phi-\gamma(1-q))} & h_t \leq h_1, \\ \frac{\beta h_t(1-\theta_1-\theta_2-\sigma)}{(1+\beta)(h_t\phi-\gamma)} & h_1 < h_t < h_2, \\ \frac{(1-\sigma-\theta_1)\beta}{(1+\beta)\phi} & h_t \geq h_2. \end{cases} \tag{22}$$

Equation (22) shows that the level of fertility is not affected by the introduction of this foreign aid.

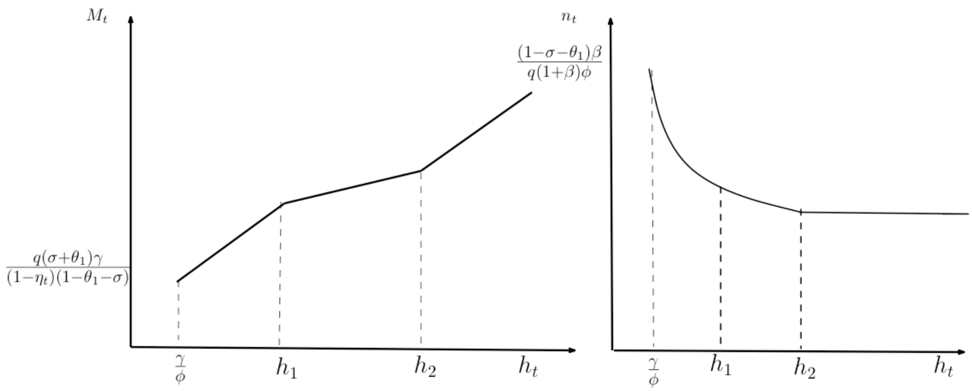

Figure 4: Nutrition and Fertility with subsidizing food

Proposition 7. *There is a level of η_t which leads out of the poverty trap. This level is :*

$$\eta_t > 1 - \frac{h_1^{(-\theta_1-\theta_2)^{1/\theta_1}} q^{\frac{\theta_2}{\theta_1}} (\sigma+\theta_1)(h_1\phi - \gamma(1-q))}{(1-\sigma-\theta_1)}$$

.

Proof. See in Appendix E. □

As pointed out earlier, we note that the allocation of time in education remains the same as the pre aid scenario. On other hand, we notice that there is an improvement in the nutrition level and leading in an improvement in human capital. Like Neanidis (2010) this kind of aid raises the probability of a child's survival thereby reducing indirect the fertility while at the same time it contributes to children's health status though improving nutrition. This has a positive effect on growth and it allows the poor developing countries to escape from poverty trap after a certain value of aid (see proposition 8) In the meantime, we show that children will continue to work and there is not reduction in the child labor if the aid is not sufficient. The reduction of child labor is an indirect consequence of the increase of human capital through nutrition. In other words, food aid program may have positive intergenerational effects, which leads the developing countries out of poverty.

Looking the total welfare of parents we note that there is an improvement because of this kind of aid in all the regimes. As it is mentioned before, this aid can have a negative impact on the economy if WFP does not subsidize the prices of nutrition but buy this percentage of food outside of the country. The main reason is that the majority of workers are farmers and such aid can lead them to obtain lower incomes. In this framework, we assumed that either the government or WFP buys the nutrition for the local industries. This assumption has also an indirect income of the total economy that it does not captured by the model.

4.2.2 Food provision to households

In this subsection, we investigate the case that WFP offers a fixed amount of nutrition for each child of households. Nice example of this aid is that in 2010, WFP provided 36.500 metric tons of food aid to assist families in Pakistan. This aid can be taken place as a small amount of supplemental feeding in each child of a household.A supplemental feeding exists for a certain sectors of populations which are poor and they are unaffordable to cover the expenses for their children. But, in our model, we suppose that each household of the receipt country receives this kind of aid.

Maximizing the utility function of young adults of equation (3) subject to the budget constraint of equation (5) and the law motion of human capital which is now :

$$h_{t+1} = (m_t + \bar{m})^{\theta_1} (e_t + q)^{\theta_2} h_t^{1-\theta_1-\theta_2}. \tag{23}$$

Now the total nutrition depends on the the nutrition offered from parents and the fixed amount of nutrition,$\bar{m_t}$ provided from the WFP, $M_t = m_t + \bar{m}$.As a result, the survival probability is $\pi_t = (m_t + \bar{m})^{\sigma}$. The optimal choices are the following:

$$e_t = \begin{cases} 0 & h_t \leq h_1(\bar{m}), \\ \frac{\theta_2[h_t\phi-\gamma)-(\theta_2)\bar{m}}{(\gamma(1-\theta_1-\theta_2-\sigma)} - q & h_1(\bar{m}) < h_t < h_2(\bar{m}), \\ 1-q & h_t \geq h_2(\bar{m}). \end{cases} \tag{24}$$

where $h_1(\bar{m}) = \frac{(q(1-\theta_1-\theta_2-\sigma)+\theta_2)\gamma+\theta_2\bar{m}}{\theta_2\phi}$ and $h_2(\bar{m}) = \frac{((1-\theta_1-\sigma)\gamma+\theta_2\bar{m}}{\theta_2\phi}$ depend on $\bar{m}$. The equation (24) shows that the length of schooling decreases when this kind of aid offered in middle income countries. The following optimal choices of nutrition and fertility show that the total level of nutrition, nutrition offered from parents and fertility decrease with the offer of fixed food in households.

$$m_t = \begin{cases} \frac{(\sigma+\theta_1)(w_t h_t\phi - w_t\gamma(1-q)-\bar{m}}{1-\sigma-\theta_1} & h_t \leq h_1(\bar{m}) \\ \frac{(\sigma+\theta_1)(w_t h_t\phi - w_t\gamma)-(1-\theta_2)\bar{m}}{1-\sigma-\theta_1-\theta_2} & h_1(\bar{m}) < h_t < h_2(\bar{m}) \\ \frac{(\sigma+\theta_1)(w_t h_t\phi)-\bar{m}}{1-\sigma-\theta_1} & h_t \geq h_2(\bar{m}) \end{cases} \tag{25}$$

As highlighted before the total nutrition is the sum of the nutrition offered from parental income and the fixed amount of nutrition offered from WFP. Thus, the following equation constitutes the total nutrition level. It remains an increasing function with respect to human capital(See Figure 5).

$$M_t = \begin{cases} \frac{(\sigma+\theta_1)(h_t\phi-\gamma(1-q)-[\sigma+\theta_1]\bar{m}}{1-\sigma-\theta_1} & h_t \leq h_1(\bar{m}), \\ \frac{(\sigma+\theta_1)(h_t\phi-\gamma)-(\sigma+\theta_1)\bar{m}}{1-\sigma-\theta_1-\theta_2} & h_1(\bar{m}) < h_t < h_2(\bar{m}), \\ \frac{(\sigma+\theta_1)(h_t\phi)-(\sigma+\theta_1)\bar{m}}{1-\sigma-\theta_1} & h_t \geq h_2(\bar{m}). \end{cases} \tag{26}$$

The parents decrease the nutrition level offered to their children and they increase the number of their children such that the product of quantity and quality trade-off remains the same with that of benchmark model. The product of quality and quantity trade-off is independent from the fixed amount of food.

$$n_t = \begin{cases} \frac{(1-\sigma-\theta_1)h_t\beta}{(1+\beta)(h_t\phi-\gamma(1-q))-\bar{m})} & h_t \leq h_1(\bar{m},) \\ \frac{\beta h_t(1-\theta_1-\theta_2-\sigma)}{(1+\beta)(h_t\phi-\gamma-\bar{m})} & h_1(\bar{m}) < h_t < h_2(\bar{m}), \\ \frac{(1-\sigma-\theta_1)\beta h_t}{(1+\beta)(h_t\phi-\bar{m})} & h_t \geq h_2(\bar{m}). \end{cases} \tag{27}$$

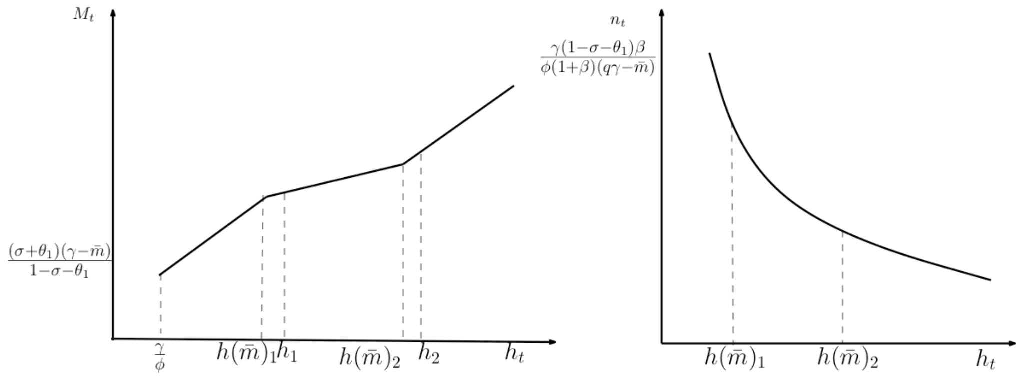

Figure 5: Nutrition and Fertility with fixed food

We have proven that providing fixed amount of food do not solve the poverty of the country. In particular, if WFP continues to offer a fixed level amount in households in middle income developing countries, it leads them to deprivation. This kind of aid does not only decrease the total level of nutrition of children but also it decreases the length of schooling. Parents decide not only to reduce the investment of health of their children through nutrition but also the time that their children spend at school. On the contrary they increase the number of their children such that the quality-quantity trade off remains constant and the same of benchmark model.

Thus, the following proposition summarizes the effect of school feeding programs on the optimal choices of parents with respect to number and quality of their offspring.

Proposition 8. *Fixed amount of nutrition offered from WFP in households generates a substitution effect away from quality of children toward quantity of children in poor and middle income developing countries if the* $\bar{m}$ *is small.*

Proposition implies the following:

- Parents decrease the investment for nutrition for their children if $\bar{m}$ is sufficient small (*proof* : see equations (25),(26)).
- Parents increase the total fertility(*proof*: see Equation (27)).
- Parents decrease the investment for nutrition for their children and also their length of schooling in middle income developing countries (*proof* see equations:(24),(26) and (27)).

This proposition implies that for smaller values of $\bar{m}$ than the level of nutrition can be affordable offered from parents, the countries are locked to poverty trap. When $\bar{m}$ is higher than $\frac{(\sigma+\theta_1)\gamma}{\theta_2}$, then parents decide stopping pay for food and the total nutrition offered to children is equal to fixed amount offered by the WFP[11]. Hence, the human capital accumulation of children depends only on the foreign aid of WFP. If this aid is higher than $\frac{(\sigma+\theta_1)\gamma}{\theta_2}$ the poor country can escape from the poverty trap.

[11] When the subsistence of food of children is based only in the fixed amount of foreign aid then the optimal choices for total nutrition and fertility change. Then the developing countries can escape from the poverty trap temporary. if the WFP decides to reduce the amount of fixed food and parents start to offer food at their children then the countries fall into poverty again (see second regime).We need to mention that this aid is provided specially in cases where parents can not offer food to their children (emergencies situations, war).

Proposition 9. *For values of $\bar{m}$ higher than $\frac{(\sigma+\theta_1)\gamma}{\theta_2}$ parents stop buying food at home. Therefore, the children's nutrition depends solely on the level of nutrition of foreign aid offered. In this case, poor countries can escape from the poverty trap.*

Proof. See Appendix F. □

Poor countries can escape from the poverty only if WFP offers a large amount of food to the households. Then, like in school feeding programs, parents stop offering nutrition level to their children and the total nutrition is consisted by the fixed amount of aid. We can conclude that this kind of aid hurts the receipt countries and WFP should give importance in which countries should offer this.Looking the welfare of parents, we can observe that there are ambiguous effects in the first regime but it decreases in the second regime. It is important to mention that this kind of aid is important even if this result was not expected. The importance of this aid is that it can be a short term hunger relief of poor countries countries when terrible events happen to them.

4.3 Other strategies to escape the developing countries from the poverty trap

In this subsection, we include different foreign aid policies which we did not mention above.The majority of foreign aid policies concern improvement in infrastructure. They then lead to parallel shift up of the transitory function h_{t+1}. We explain why these aids are efficient and can lead the developing countries out from the poverty trap.In particular, any improvement in infrastructure and quality of food increase the technological level, B, of human capital accumulation.

There are some programs such that Food for Work and/or Training (FWT) in which they provide food in exchange of labor in public works projects (such as development of rural infrastructure, roads, or irrigation) which can stimulate the local economy and lay the foundations for the development of local security capacity. FWT not only provides food for the workers in the short run but also improves the infrastructure which has a positive impact in communities and the country in the long run.

Also,there are national organizations which offer food in clinics and in other health structures to combat malnutrition for the poor and unhealthy people. Kraak *et al*(1999) show this kind of food aid directly benefits poor people while it improves the quality of diet of people with HIV/AIDS. Moreover, governments, interested in improvement of nutrition status, try to find donors that are willing to finance health programs and to contribute the health infrastructure of their country (For instance see report of Economic and Social Council of United Nations for Nambia,2010). The improvements in health sector have as a target the mother and child. Thus, these exogenous interventions has as a goal not only the reduction of infant mortality, underweight rates, and micronutrients deficiencies but also the improvement and development of human capital and the economic growth of the country.

The WFP invests in local food industries in developing countries to enable it to find local sources for blended and fortified foods. Thanks these investments there is an increase in the food quality. For instance, in 2004, WFP decided that the local food processors should conform the international standard to control quality for the entire manufacturing process in Southern Africa. With a grant from the Government of Canada, an extensive study was launched to provide support to WFP for this effort. Thus, WFP supported the local processors in food sector to succeed to meet the quality standards in Southern Africa.

All the above aids can be captured in our model by B which is the technological level or efficiency parameter of human capital. We suppose that improvements in quality of food (Fogel, 1994,Kraak *et al*, 1999) and health(Shultz,1961; Kuznets,1966; Barro and Sala-i-Martin,1995) can raise the efficiency and the labor productivity of adults and children. Hence unexpectable exogenous improvements in health infrastructure, in the local food industries can increase the efficiency of human capital B and as a consequence the law motion of human capital. All of these exogenous shocks have positive results in economic growth and solve the poverty. Equation 31 illustrates the raise in B which should be such that the poor country can escape the poverty trap.

$$B > \frac{h_1}{[h_1\phi - \gamma(1-q)]^{\theta_1} q^{\theta_2} h_1^{1-\theta_1-\theta_2} [\sigma + \theta_1]^{\theta_1}} \tag{28}$$

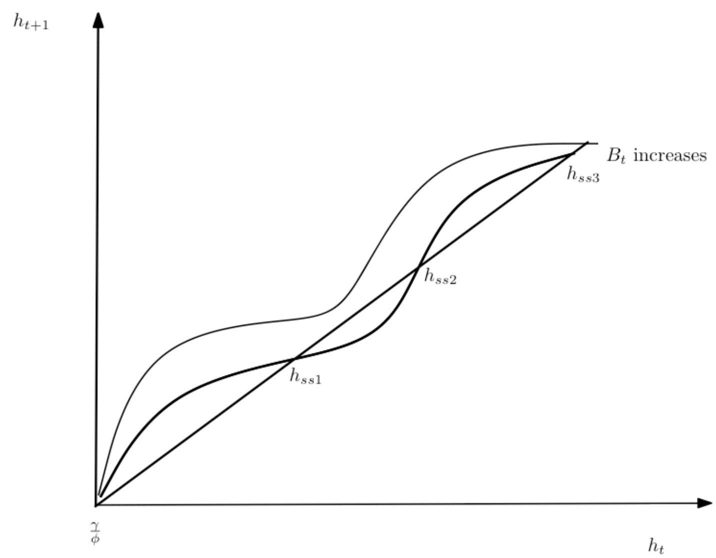

Figure 6: Increasing B_t

Figure 6 illustrates the increase of B that leads the law motion of human capital to move upwards. The above aids can be the big push and solve the poverty of developing countries.

5 Computational Experiment

In this section, we examine the quantitative implications of the benchmark and the extensions of our model. We calibrate it with values of the existing literature.

The weight β of children in the utility function governs the growth rate of population in the balanced growth path. This parameter is set to $\beta = 0.216$ like Fernadez -Villaverde and Kruger (2004). A similar value is imposed in Attanasio, Kitao and Violante (2010). We impose that the technological level of human capital B is set to 1 for simplicity.

The time cost parameter ϕ for having children defines the overall opportunity cost of having children.Like de la Croix and Doepke(2003), we set $\phi = 0.075$ even if they do not have child labor in their model. The authors use evidence from Robert Haveman and Wolfe (1995) and Knowles (1999) which suggests that the opportunity cost of a child is equal to 15 percent of the parents'time endownment. This cost only accumulates as long as the child is living with the parents. To impose this value they refer that if they assume that children live with parents for 15 years and that the adult period lasts for 30 years, the overall time cost should be 50 percent of time cost per year with the child present. Moreover, this parameter ϕ also sets an upper limit on the number of children a person can have. With their choice, a person spending all the time raising a children would have a little above 13 children.

The productivity of children is set to $\gamma= 0.0006$ [12]. This is an arbitrary value and in the section of sensitivity analysis we investigate its behavior. We trigger this variable too low in the fact that child labor laws restricts the use of child labor (Doepke, 2004) and also, we need $\phi > \gamma$ to ensure positivity of our optimal choices.The intuition theoretically is that the parents's cost is higher than the lack of experience of children otherwise the children should live without the parental presence. Furthermore, we assume that having one sector model with homogenous agents the productivity of children remains the same and it can not be influenced by their human capital.

Furthermore, the elasticity of survival probability, σ, is set to 0.1. It is an arbitrary value that leads us to the implementation of sensitivity analysis of this parameter in our numerical example. In particular, we find that an increase in σ leads to an increase in the level of nutrition that parents offer to their children. Also, there is an increase in the length of schooling and consequently to human capital.

Concerning the value of time in primary school, q, is set equal to 0.1 which respects assumption 4.

Now, we need to discuss all the process of the estimation of elasticities of human capital accumulation. Before we start this analysis, we estimate the elasticities of human capital for countries under the stage of development in order to calibrate the theoretical framework[13] and investigate mainly its dynamics.As econometric technique, we use the constraint OLS regression since we need the sum of elasticities to be equal to one. in our regression, we use a sample of developing countries. First of all, taking the logarithms in the Equation 5 that we can rewrite the law motion of human capital as:

$$\ln(h_{t+1}) = \theta_1 \ln(m_t) + \theta_2 \ln(e_t + q) + (1 - \theta_1 - \theta_2) \ln(h_t) + \epsilon_t. \tag{29}$$

All the empirical literature (see for instance Becker,1974; Lee,1995) uses that as proxy of human capital we need to use enrollment rates at school. In our case this is not possible

[12]In numerical example for regime 2, we consider that γ=0.006. We supposed this value for this regime for two reasons. First, it is arbitrary value and second because the above value is too small and inversely related to education by imposing it we arrive to the high steady state without aids since the second equilibrium is unstable.Consequently, in our case we want to show the influence of the different foreign aids we suppose that γ=0.0006. If we use this value in the regime 1 then across the generations parents stop to feed their children and the nutrition status is based on only on foreign aid, specially for school feeding program

[13]According to the literature (Azariadis *et al* 2004 ; Quan ,1993,1996) persistent poverty can be explain from the poverty traps. But persistent poverty and emergent bimodality can be used as proof that poverty traps explain the data.In our paper, we do not try to investigate empirically the existence of poverty trap. Having lackness of data, we try to estimate the coefficients of law motion of human capital for homogenous sample(developing countries) which remain constant according to the assumptions of our model.The reason which we realize this regression is to calibrate the model and for the robustness of our results we provide a sensitivity analysis with numbers given by the existence literature.

because the law motion of human capital depends on education, nutrition and parental human capital. Consequently, we use the approach of Bils and Klenow (2000) to avoid problems of endogeneity and correlation between the variables. Their methodology allows to me to obtain a proxy for the human capital. They construct human capital stock which is the dependent variable and the enrollment rates of schooling is independent variable in their regression avoiding endogeneity bias[14]. This human capital stock consists of the percentage gains in human capital from each year of education and experience respectively. More precise, they construct human capital stocks from 1960 to 1990 by country as follows. They first construct an estimate of human capital for workers at each age from 25 to 59 for both 1960 and 1990 incorporating schooling,experience and teacher's human capital specific to each age. Then,using population weights by age, they weight the age-specific human capitals into aggregates for 25 to 59 years old. Their measure of human capital for an individual is based on the Mincerian model of human capital accumation generalized for an impact from human capital of the previous generation. It also allows for the experience to have a quadratic form in their model. Returns to experience and experience-squared are chosen such that they experience-earnings profiles mimic the average profile of the sample of Mincer estimates.

They calculate the educational attainment because an individual's human capital is a function of the human capital in past cohorts.[15] Their analysis is based on surveys compiled by the United Nations and reported in the two UNESCO publications Statistics of Educational Attainment and illiteracy 1945-1974 and Statistics of Educational and illeteracy 1970-1980 and Penn Word tables.

As we mention above, their technique allows them to regress human capital stocks with schooling without problems of endogeneity and correlation. We follow their methodology and use the Penn World tables, the above UNESCO publications and the mincer earnings estimations as given in the appendix of their paper to obtain the human capital stocks for 1960 and 1990 that consist two different generations for our model since each generation is approximated around 30 years. Thus we consider that $\ln h60 = \ln h_t$and $\ln h90 = h_{t+1}$ in our model.In our data set there are 66 developing countries. Lack of data leads us to use only developing countries in our sample. We realize this regression only to use the estimates of the coefficients to calibrate our model. Later , we provide a sensitivity analysis to them. For the level of length of schooling, we used data from the Barro-Lee data set and World bank database.

For nutrition, we use the approach of Arcand (2001) and Six World Food Survey of the Food Agricuture organization who use as proxy the Prevalence of food inadequacy[16] (PFI)[17]. We use data from F.A.O (Food and Agriculture organisation of the United nations). Assuming that the error term is log normal multiplitative, the results of our constraint OLS regression are :

[14]Since the human capital depends only on the percentage gains in human capital from each year of education and experience respectively is independent on the enrollment rates. Thus, we can regress this human capital stock with the enrollment rates.

[15]For more details, see Bils and Klenow(2000)

[16]PFI is a measure which involves comparison of household food consumption with a minimum dietary energy requirement and classification of individuals in households with per capital calorie consumption levels below the minimum requirement as being in the undernourished category.

[17]Arcand used several variables as a proxy for the nutrition like Prevelance of food inadequacy and Dietary Energy Supply(DES). He refers that there is a measurement error for Dietary Energy supply (DES) that are constructed by FAO. Hence, we prefer to use Prevalence of food inadequacy.

Table 1

VARIABLES	(1) in90
ih60	0.53***
	(0.000)
education	0.25***
	(0.03)
nutrition	0.20***
	(0.04)
Observations	66

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 1 presents the results of our constraint regression[18]. We used constraint regression as method of estimation since we need to keep the sum of elasticities of human capital equal to one. First of all, we need to mention that our sample is small because we do not have availability for more data using the technique of Bils and Klenow(2000). We controlled for heteroskedasticity and serial correlation.[19]Also, we observe that all the variables are significant at 5%. This is in line with Bils and Klenow (2000), Arcand (2001) and Wang *et al* (2003). Specially, the latter studies show that nutrition status is significant in the long run and hence it has an impact on the growth rate of real GDP per capita. Furthermore, as it concerns the returns of human capital of education, Abdus and Rangazas (2010) impose as a value 0.304. Kalemli-Ozcan, Ryder and Weil (2000) use the same approach as Bils and Klenow(2000) and impose the value of 0.32. Consequently, our coefficient for education is closed to the literature. Table 2 summarizes the values of the parameters:

Table 2: Parameters Values

θ_1	0.2	θ_2	0.25
σ	0.1	γ	0.0006
ϕ	0.075	β	0.216

Now, it is assumed that the parameters are set at their baseline. We compute the effects on child nutrition, length of schooling, level of human capital and fertility.The first of our analysis concerns the values of foreign aids that allow a developing country to escape from the poverty trap. The second part focus on a simulation in which the intergenerational effects of the foreign food aids, in particular the feeding programs and the subsidy in prices of nutrition, are compared to the evolution of the system in absence of these aids. The simulation exercise is done under to different production functions. Firstly, we use $Y_t = H_t$ as in the theoretical section and secondly, $Y_t = H_t^{\alpha}$, where α we impose the value α=0.33[20].

[18]Our regression takes into account the assumptions of the theoretical model to ensure the positivity of the coefficients i.e Assumption 1.

[19]We used the command robust in STATA to control for heteroskedasticity.

[20]Now the wages are not constant anymore, consequently the intervals of regimes are not constant since the succeed regimes are moving over time and we can not analytically characterize them.

5.1 Values that allows escaping from poverty trap

The results of the values of aid in which the country escapes from the poverty trap are summarized in table 3.

Insert Table 3

The η_t is equal to 0.96. That it means that the organizations like WFP should provide the 96% of the nutrition that parents buy for their children. At this percent the country can escape of the poverty trap. This value can be characterize to much high consequently it is obvious that it is difficult the poverty to be solved in developing countries by this foreign aid.Also, since the productivity of human capital,B, is equal to 1, it would need an increase of 100% in this value. Thereby, investing the local food industries such that the quality of food increase or investing in the agricultural sector by subsidizing local farmers it would lead this economy out of poverty only if it is sufficient high. This is in line with studies like Harris (2003) and Smedley and Kinniburg (2001) which refer that the investments for infrastructure and the support for the local industries should be high enough for developing countries if we want to achieve their economic development.

At the end,in the above table, we present the value of fixed commodity that it is provided as a meal in school or offered at home at which parents decide stopping to feed their children at home and also to send the country out of the deprivation. It is equal to T=0.0032 and $\bar{m}$=0.00069[21].

5.2 Computational experiment

In tables 4, 5, 6 and 7 we present the first and second regime under two different production functions, the linear one and the diminishing returns to scale.In particular, we compare the level of nutrition and human capital, fertility and also the length of schooling before and after the implication of school feeding programs or subsidizing the nutrition's prices. The values for the total nutrition represents amount of commodity. The education is the time spent from secondary school to university and the fertility is the number of children.

Insert Table 4
Insert Table 5
Insert Table 6
Insert Table 7

Model predictions have been computed for a period of three generations (120 years, each generation is 30 years). We provide this computational experiment to investigate the effects of the implication of the two different aids in the two regimes. We also investigate if our theoretical results are robust under different production functions, the linear and the diminishing returns[22]. The results are similar for both of production functions. This is consistent with studies like Hansen and Tarp (2001), Economides *et al* (2008) and Daalgard *et al*(2004) which show that the aggregate aid impacts on growth either positively or negatively remains unchanged with or without diminish returns.

In tables 4 and 6, we observe that the school feeding programs increase the length of schooling and as a result there is an improvement of human capital. It is important to mention that we concluded that in the theoretical part that the total nutrition remains the

[21] The maximum T and $\bar{m}$ are units of commodities.

[22] Now the wage is not constant and it depends on the population. There are not analytical solutions incorporating this production function.Thus the calibration is necessary in this case.

same ((Jacoby *et al*, 1996; Powell *et al*, 1983; Murphy *et al*,2003 and Agarwai *et al*, 1989) but through the intergenerational transmission of human capital we observe that there is an increase of it after two generations (see tables 4 and 6 generation 3). This is a line with the empirical evidence(Simon,1998).

On the contrary, tables 5 and 7 show that low levels of commodity T trickle down not only the total nutrition but also the human capital. As a consequence, the total economy of the developing country is locked in the poverty trap. In particular, we can observe that there is the quantity and quality trade off. Parents decreases the nutrition levels that offer to their children, the total nutrition decreases and at the meantime they increase the number of their children. Since there is decrease in the human capital, the negative consequences become even worse across the generations for the poor developing countries.

Furthermore, if WFP subsidizes the nutrition's prices, we observe that the total level of nutrition increases. Here the intuition is simple.Having the same income parents can offer higher levels of nutrition to their children and hence their human capital increases in both regimes.

It is noteworthy to refer that both foreign aids underline the reduction of child labor. Child labor is a social undesirable phenomenon in all the developing countries[23]. Thus, we can conclude that these two foreign food aids not only solve the short term hunger and improve the human capital but also they increase the length of schooling either direct (school feeding programs) or indirect (subsidizing nutrition's prices) specially in the middle income developing countries.

5.3 Sensitivity analysis

In this last subsection, we provide a sensitivity analysis for our parameters. All the above tables illustrates the baseline parameters used for our numerical example. Now, we present the different effects of parameters variations on our main variables, namely nutrition resources, levels of length of schooling and human capital.

Insert Table 8
Insert Table 9

Firstly, we consider the parameter θ_1 which represents the return to nutrition and includes the direct effects of nourishing on human capital. Thereby decreasing the returns, we note that the amount of resources dedicated to child nutrition is decreasing. On the contrary, the human capital and the length of schooling increase. Opposite results are obtained by the variation of the return to schooling, θ_2.

One other important parameter is γ since it is the earning that the children obtain in the work (when the production function is $Y_t = H_t$). This parameter has inverse relationship with the length of schooling and as we observe the higher it is then much more prevents the children to attend school. On the other hand, it increases the nutrition resources since there is more income in the families and also the human capital.

Another, parameter is the elasticity of survival probability, σ. We observe that by increasing σ there is an increase in the level of nutrition resources, human capital and education. This means that as the elasticity of survival probability decreases the parents spend more for the nutrition of their children to keep the alive. (Boucekkine and Laffargue(2010) have

[23]According to UNICEF, there are an estimated 158 million children aged 5 to 14 in child labour worldwide, excluding child domestic labour

the same approach in their model[24]). We do not provide sensitivity analysis for the parameters β and ϕ since these two parameters are straightforward having effects in fertility. In particular the effects of an increased time-cost of bringing up a child, ϕ leads in a reduction of fertility but it increases education and nutrition resources and thus the human capital.

6 Conclusions

Our aim in this paper has been to evaluate the efficiency of the different foreign food aid policies as provided from WFP in the developing countries.

We develop a two-period OLG model in which agents choose their present consumption, the number of their children, the length of schooling and the amount of resources dedicated to nutrition for each for their children. It is assumed that children share the unit of their available time between work and education in accordance with the decision parents make. Following the literature, our human capital accumulation is consisted by the nutrition, education and parental human capital. Thus, our framework captures the complementarity of child nutrition and child learning capacity (see Curais *et al*, 2010). It can be shown that our benchmark model emerges multiple equilibria and may explain the existence of poverty traps.In particular, It shows that countries with low human capital find themselves to be trapped in conditions of low nutrition, high levels of child labor and high fertility rates.

We extend our model by implement four different foreign aids policies provided mainly from WFP. First of all, we suppose that WFP provides school meals in developing countries . School meals provide an enhancement in the nutrition status and as consequence in our model they improve the human capital accumulation and the survival rate of children.

First, we find that school meals lock the poor developing countries in the poverty.In particular, this aid increases the fertility because the cost of having children decreases. Thus parents invest less in nutrition of their children, leading to a slowndown the human capital accumulation. Then the recipient economy is locked into a poverty trap. Nevertheless, if WFP decides to provide a high amount of food in schools, parents decide to stop feed their children at home. The total nutrition depends only on the school meals.The developing country can escape from the poverty trap. Moreover, school feeding programs are really efficient for the middle-income developing countries. More precisely, they increase the length of schooling and improve the human capital for future generations even if the total nutrition remains unchanged (Jacoby *et al*,1996; Powell *et al*,1983; Murphy *et al*,2003 and Agarwai *et al*,1989). Consequently, middle-income countries can achieve their economic development.

We introduce as foreign aid program the fact that WFP subsidize the prices of food for households. This program can be characterized really efficient for high level of subsidy as it will be shown in the calibration of the model. It allows the poor countries to escape from the poverty because there is an income effect. Now, parents are affordable to offer more nutrition resources than before. The total nutrition rises and therefore the survival probability of children and their human capital.

Moreover, when we consider that WFP offers a constant level of nutrition on households. We find that this foreign aid policy is not effective.Poor countries and also middle income countries tickle down to poverty trap. This foreign aid increases the fertility because the quantity cost of children falls. As a result, parents decreases not only the nutrition level but also the length of schooling of their children.

[24]In contrast to our framework they consider that when there is a mortality shock and survival probability of adults decrease there will be an increase in their health investment.

Finally, we consider that WFP improves the infrastructure of local food industries or supports financially the local farmers such that to increase the quality of food and to improve the agricultural productivity. This improvement is captured in our framework by the technological level of our law of motion of human capital. Consequently, an increase in the technological level raises the human capital of future generations and hence the poor economies can achieve the economic development.

Finally, we provide a computational experiment where we show that our theoretical results are robust under different production functions. Also, we find that introducing school feeding programs generates an indirect increase of total nutrition across the generations in the middle income developing countries.

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Appendices

A Proof of Optimal Choices

To prove that the optimal choice of nutrition is an increasing function across the different regimes, we compare the maximum of each regime with the minimum of the next regime. In particular, we compare the nutrition of the first regime and the nutrition of the second plugging h_1 in both values.

$\frac{(\sigma+\theta_1)\left(\frac{q\gamma(1-\theta_1-\theta_2-\sigma)}{\theta_2}+\gamma q\right)}{1-\sigma-\theta_1} < \frac{(\sigma+\theta_1)\left(\frac{q\gamma(1-\theta_1-\theta_2-\sigma)}{\theta_2}\right)}{1-\sigma-\theta_1-\theta_2}$

Thus, we have that $\frac{(-\theta_1-\theta_2-\sigma)q\gamma}{(1-\sigma-\theta_1)} < \frac{q\gamma(1-\theta_2-\theta_1-\sigma)}{(1-\sigma-\theta_1-\theta_2}$

$(1-\theta_1-\theta_2-\sigma)(-\theta_1-\theta_2-\sigma)q\gamma < q\gamma(1-\theta_1-\theta_2-\sigma)(1-\theta_1-\sigma)$

$(-\theta_2)(1-\theta_1-\theta_2-\sigma)q\gamma < q\gamma(1-\theta_1-\theta_2-\sigma)$

$0 < 1+\theta_2$ which is valid.

We continue that the comparison of the value of nutrition of the second regime with that of third. $\frac{(\sigma+\theta_1)\left(\frac{\gamma(1-\theta_1-\sigma)}{\theta_2}-\gamma\right)}{1-\sigma-\theta_1-\theta_2} < \frac{(\sigma+\theta_1)\left(\frac{\gamma(1-\theta_1-\sigma)}{\theta_2}\right)}{1-\sigma-\theta_1}$

$\frac{\gamma(-\theta_1-\sigma)}{\theta_2(1-\sigma-\theta_1-\theta_2)} < \frac{\gamma(1-\theta_1-\sigma)}{\theta_2(1-\sigma-\theta_1)}$

$0 < 1-\theta_2$ which is valid since θ_2 is between zero and one. Now, we compare the levels of fertility across the different regimes. We can see that the fertility is decreasing with $h_t$if we take the derivative with respect to h_t.

$\frac{\partial n_t}{\partial h_t} = \frac{-\gamma(1-q)}{(1+\beta)^2(h_t\phi-\gamma(1-q)} < 0$

Since all the parameters are positive, the fertlity decreases as long as h_t increases.

B Steady States

We denote by $h_{ss1}$the steady state equilibrium in the interval $(\frac{\gamma}{\phi}, h_1]$.

$$h_{ss1} = \frac{(h_{ss1}\phi-\gamma)^{\theta_1}(\sigma+\theta_1)^{\theta_1}h_{ss1}^{1-\theta_1-\theta_2}}{(1-\theta_1-\sigma)^{\theta_1}}. \tag{A.1}$$

On the interval $(h_1, h_2]$, the steady state equilibrium is the following:

$$h_{ss2} = \frac{\theta_2^{\frac{\theta_2}{\theta_1+\theta_2}}(\sigma+\theta_1)^{\frac{\theta_1}{\theta_1+\theta_2}}\gamma}{\theta_2^{\frac{\theta_2}{\theta_1+\theta_2}}(\sigma+\theta_1)^{\frac{\theta_1}{\theta_1+\theta_2}}\phi-(1-\theta_1-\theta_2-\sigma)\gamma^{\frac{\theta_2}{\theta_1+\theta_2}}}. \tag{A.2}$$

Finally for the interval $[h_2, \infty)$ the expression of equlilibrium is

$$h_{ss3} = \frac{(\sigma+\theta_1)^{\frac{\theta_1}{\theta_2}}\phi^{\frac{\theta_1}{\theta_2}}}{(1-\theta_1-\sigma)^{\frac{\theta_1}{\theta_2}}} \tag{A.3}$$

C Proof of Proposition 1

1. To prove the existence of a unique steady state which locally stable, we define two functions. The first function is the 45^o line, $f(h_t) = h_t$(see Figure 1) and the second is which the first regime of the equation 11, $g(h_t) = \frac{(\sigma+\theta_1)^{\theta_1}(h_t\phi-\gamma(1-q))^{\theta_1}h_t^{1-\theta_1-\theta_2}q^{\theta_2}}{(1-\theta_1-\sigma)^{\theta_1}}$. To prove the existence we need to prove that functions f and g cross once. Thus, we need to show that $f(h) < g(h)$ for $h = \frac{\gamma}{\phi}$ which exists because of the Assumption 2, and also that $f(h_1) > g(h_1)$ which exists because of the Assumption 4. If g function is concave, then the steady state previously is locally stable and hence a poverty trap. Now we need to prove that the $g(h_t) = \frac{(\sigma+\theta_1)^{\theta_1}(h_t\phi-\gamma(1-q))^{\theta_1}h_t^{1-\theta_1-\theta_2}q^{\theta_2}}{(1-\theta_1-\sigma)^{\theta_1}}$ is concave function. First i define as $k = \frac{\sigma+\theta_1^{\theta_1}q^{\theta_2}}{(1-\sigma-\theta_1)_1^{\theta}}$.The first derivative is $\frac{\partial g}{\partial h_t} = k\theta_1[h_t\phi - \gamma(1-q)]^{\theta_1-1}h_t^{1-\theta_1-\theta_2}\phi + k(1-\theta_1-\theta_2)[h_t\phi-\gamma(1-q)]^{\theta_1}h_t^{-\theta_1-\theta_2}$. It is positive. The second derivative is
$\frac{\partial^2 g}{\partial^2 h_t} = k\theta_1(\theta_1-1)[h_t\phi-\gamma(1-q)]^{\theta_1-2}\phi^2 h_t^{1-\theta_1-\theta_2} + 2k\theta_1(1-\theta_1-\theta_2)[h_t\phi-\gamma(1-q)]^{\theta-1}h_t^{-\theta_1-\theta_2}\phi + k(1-\theta_1-\theta_2)(-\theta_1-\theta_2)[h_t\phi-\gamma(1-q)]^{\theta_1}]h_t^{-\theta_1-\theta_2-1} =$

   $k[h_t\phi-\gamma(1-q)]^{\theta_1-2}h_t^{-\theta_1-\theta_2-1}[h_t^2\phi^2\theta_1(\theta_1-1) + 2\theta_1(1-\theta_1-\theta_2)\phi[h_t\phi-\gamma(1-q)]h_t + (1-\theta_1-\theta_2)(-\theta_1-\theta_2)[h_t\phi-\gamma(1-q)]^2$

   The first part is positive, the second part is negative because the discriminant of quadratic polynomial is negative.Consequently, the second derivative is less than zero. As a result, there exists a unique steady state and it is locally stable. Next, we investigate the equilibrium in the interval $(h_1, h_2]$. The equilibrium in this interval is $h_{ss2} = \frac{\theta_2^{\frac{\theta_2}{\theta_1+\theta_2}}(\sigma+\theta_1)^{\frac{\theta_1}{\theta_1+\theta_2}}\gamma}{\theta_2^{\frac{\theta_2}{\theta_1+\theta_2}}(\sigma+\theta_1)^{\frac{\theta_1}{\theta_1+\theta_2}}\phi-(1-\theta_1-\theta_2-\sigma)\gamma^{\frac{\theta_2}{\theta_1+\theta_2}}}$ and also the humal accumulation is equal $h_{t+1} = \frac{(\sigma+\theta_1)^{\theta_1}[h_t\phi-\gamma]^{\theta_1+\theta_2}\theta_2^{\theta_2}h_t^{1-\theta_1-\theta_2}}{(1-\theta_1-\theta_2-\sigma)^{\theta_1+\theta_2}\gamma^{\theta_2}}$. Let us denote as $A = \frac{(\sigma+\theta_1)^{\theta_1}\theta_2^{\theta_2}}{(1-\theta_1-\theta_2-\sigma)^{\theta_1+\theta_2}\gamma^{\theta_2}}$ and we take the first derivative of the law motion of human capital accumulation for this interval. The
$\frac{\partial h_{t+1}}{\partial h_t} = A(\theta_1+\theta_2)[h_t\phi-\gamma]^{\theta_1+\theta_2-1}\phi h_t^{1-\theta_1-\theta_2} + (1-\theta_1-\theta_2)h_t^{-(\theta_1+\theta_2)}A[h_t\phi-\gamma]^{\theta_1+\theta_2}$
when we plug the steady state in the above derivative we have $\frac{\partial h_{t+1}}{\partial h_t}|_{h_{ss2}} > 1$ then h_{ss2} is unstable.This case is represented by the figure 2.

2. To prove stability of the steady state in the interval $[h_2, \infty)$. Thus, we take the first derivative of the function h_{t+1} in the interval $[h_2, \infty)$ is $\frac{\partial h_{t+1}}{\partial h_t} = (1-\theta_2)h_t^{-\theta_2}\frac{(\sigma+\theta_1)^{\theta_1}\phi^{\theta_1}}{(1-\theta_1-\sigma)^{\theta_1}}$.

The steady state is $h_{ss3} = \left(\frac{(\sigma+\theta_1)\phi}{(1-\theta_1-\sigma)}\right)^{\frac{\theta_1}{\theta_2}}$. Substituting for the steady state in the derivative above we find that $\frac{\partial h_{t+1}}{\partial h_t} = (1-\theta_2) > 0$ since $0 < \theta_2 < 1$ and also $\frac{\partial h_{t+1}}{\partial h_t}|_{h_{ss3}} < 1$. This proves that the steady state h_{ss3} is locally stable.

D Proof of Proposition 2

We derive human capital thresholds with respect to T.

$\frac{\partial h_1}{\partial T} = \frac{-2q(1-\theta_1-\theta_2-\sigma)}{\theta_2\phi} < 0$

$\frac{\partial h_2}{\partial T} = \frac{-2(1-\theta_1-\theta_2-\sigma)}{\theta_2\phi} < 0$

Since both are negative, our proposition is proven.

E Proof of Proposition 4

The nutrition for the low regime is equal to $m_t = \frac{(\sigma+\theta_1)[h_t\phi-\gamma(1-q)-Tq)}{(1-\sigma-\theta_1)}$ We want $T = m_t$, that it means that parents stop to offer food at home. We know that the threshold depends on T and it is equal to $h_1(T) = \frac{q(1-\theta_1-\theta_2-\sigma)(\gamma-T)+\theta_2\gamma}{\theta_2\phi}$.We plug the h_1 and we solve for T and we have that $T = \frac{(\sigma+\theta_1)(1-\theta_1-\sigma)\gamma)}{(1-\theta_1-\theta_2-\sigma)(\sigma+\theta_1)+\theta_2}$.Also, for values of T higher than the above level m_t can not be negative, thus the nutrition of the children is higher than before and human capital accumulation depends on the foreign aid, $h_{t+1} = (T(q))^{\theta_1+\theta_2}h_t^{1-\theta_1-\theta_2}$.

F Proof of Proposition 7

We need the h_{t+1} function to be higher than the regime h_1 to escape from poverty trap. Thus, we have the following: $\frac{(\sigma+\theta_1)^{\theta_1}[h_1\phi-\gamma(1-q)]^{\theta_1}}{(1-\sigma-\theta_1)^{\theta_1}(1-\eta_t)^{\theta_1}}q^{\theta_2}h_1^{1-\theta_1-\theta_2} > h_1$

$$\frac{(\sigma+\theta_1)^{\theta_1}[h_1\phi-\gamma(1-q)]^{\theta_1}}{(1-\sigma-\theta_1)^{\theta_1}h_1}q^{\theta_2}h_1^{1-\theta_1-\theta_2} > (1-\eta_t)^{\theta_1}$$

$$\frac{(\sigma+\theta_1)^{\theta_1}[h_1\phi-\gamma(1-q)]^{\theta_1}}{(1-\sigma-\theta_1)^{\theta_1}}q^{\theta_2}h_1^{-\theta_1-\theta_2} > (1-\eta_t)^{\theta_1}$$

$$\frac{(\sigma+\theta_1)[h_1\phi-\gamma(1-q)]}{(1-\sigma-\theta_1)}q^{\frac{\theta_2}{\theta_1}}h_1^{\frac{-(\theta_1+\theta_2)}{\theta_1}} > (1-\eta_t)$$

$$1-\frac{(\sigma+\theta_1)[h_1\phi-\gamma(1-q)]}{(1-\sigma-\theta_1)}q^{\frac{\theta_2}{\theta_1}}h_1^{\frac{-(\theta_1+\theta_2)}{\theta_1}} < \eta_t$$

The latter defines our proposition.

G Proof of Proposition 9

The nutrition for the low regime is equal to $\frac{(\sigma+\theta_1)(h_t\phi-w_t\gamma(1-q)-[\sigma+\theta_1]\bar{m}}{1-\sigma-\theta_1}$. For $\bar{m}=m_t$ that it means that the nutrition offered from parents is equal to zero. We know that the threshold depends on T and it is equal to $h_1(\bar{m}) = \frac{(q(1-\theta_1-\theta_2-\sigma)+\theta_2)\gamma+\theta_2\bar{m}}{\theta_2\phi}$. We plug the h_1 and we solve for $\bar{m}$ and we have that $\bar{m}=\frac{(\sigma+\theta_1)\gamma}{\theta_2}$. Also, for values of $\bar{m}$ higher than the above level

m_t can not be negative, thus the nutrition of the children is higher than before and human capital accumulation depends on the foreign aid, $h_{t+1} = (\bar{m})^{\theta_1+\theta_2} h_t^{1-\theta_1-\theta_2}$.

H Tables

Table 3

Values Escaping Poverty Trap

η_t	0.96
T	0.0032
B	2
$\bar{m}$	0.00069

Table 4: Linear Production function (Regime 2)

Generations	Nutrition	Human Capital	Education	fertility
Without Aid				
Generation 1	0.17	0.18	0.1	2
Generation 2	0.0053	0.1829	0.66	1.8230
Generation 3	0.0026	0.1303	0.27	3.79
Feeding Programmes with T=0.00009				
Generation 1	0.17	0.18	0.1	2
Generation 2	0.0053	0.1820	0.67	1.8229
Generation 3	0.0027	0.131	0.20	3.75
Offer food in households with η=0.8				
Generation 1	0.17	0.18	0.1	2
Generation 2	0.0263	0.183	0.66	1.82
Generation 3	0.0255	0.1797	0.63	1.91

Table 5 : Linear Production Function (Regime 1)

Generations	Nutrition	Human Capital	Education	Fertility
Without Aid				
Generation 1	0.12	0.1	Basic	2
Generation 2	0.0030	0.1	Basic	1.7865
Generation 3	0.0014	0.05	Basic	1.9398
Feeding Programmes				
Generation 1	0.12	0.1	Basic	2
Generation 2	0.0029	0.09	Basic	1.788
Generation 3	0.0013	0.04	Basic	1.94
Offer food in households				
Generation 1	0.12	0.1	Basic	2
Generation 2	0.0149	0.11	Basic	1.7864
Generation 3	0.0098	0.07	Basic	1.8531

Table 6:Decreasing returns to scale (Regime 2)

Generations	Nutrition	Human Capital	Education	fertility
Without Aid				
Generation 1	0.18	0.18	0.002	1
Generation 2	0.0044	0.1696	0.6386	2.3982
Generation 3	0.0076	0.2257	0.5621	1.9632
Feeding Programmes				
Generation 1	0.18	0.18	0.002	1
Generation 2	0.0044	0.17	0.65	2.39
Generation 3	0.0077	0.2266	0.57	1.95
Offer food in households				
Generation 1	0.18	0.18	0.002	1
Generation 2	0.0219	0.17	0.63	2.3982
Generation 3	0.0398	0.2328	0.56	1.93

Table 7:Decreasing returns to scale(Regime 1)

Generations	Nutrition	Human Capital	Education	Fertility
Without Aid				
Generation 1	0.13	0.13	Basic	2
Generation 2	0.0002	0.1214	Basic	1.76
Generation 3	0.0001	0.0284	Basic	2.21
Feeding Programmes				
Generation 1	0.13	0.13	Basic	1
Generation 2	0.00019	0.1213	Basic	1.77
Generation 3	0.00001	0.0282	Basic	2.29
Offer food in households				
Generation 1	0.13	0.13	Basic	2
Generation 2	0.0088	0.1214	Basic	1.76
Generation 3	0.0030	0.07	Basic	1.85

Table 8 : Sensitivity Analysis

	Generations		
Generations	Nutrition	Human capital	Education
	Without Aid		
Generation 1	0.17	0.18	0.1
Generation 2	0.0053	0.1829	0.66
Generation 3	0.0026	0.1303	0.27
	γ=0.003		
Generation 1	0.17	0.18	0.1
Generation 2	0.0365	0.1829	1
Generation 3	0.0538	0.2503	1
	σ=0.1		
	Without Aid		
Generation 1	0.17	0.18	0.1
Generation 2	0.0053	0.1829	0.66
Generation 3	0.0026	0.1303	0.27
	σ=0.2		
Generation 1	0.17	0.18	0.1
Generation 2	0.091	0.1829	0.8836
Generation 3	0.0066	0.1554	0.62

Table 9 : Sensitivity analysis of returns of human Capital

	Generations		
Generations	Nutrition	Human capital	Education
	Returns of Nutrition:0.2		
	Without Aid		
Generation 1	0.17	0.18	0.1
Generation 2	0.0053	0.1829	0.66
Generation 3	0.0026	0.1303	0.27
	Returns of Nutrition:0.07		
Generation 1	0.17	0.18	0.1
Generation 2	0.0023	0.1843	0.69
Generation 3	0.0023	0.13	0.49

Countries of the sample.

	Countries	
Algeria	Togo	Peru
Benin	Tunisia	Uruguay
Botswana	Uganda	Venezuela
Cameroon	Zaire	China
Central Africa	Zambia	Hong Kong
Egypt	Zimbabwe	India
Gambia	Costa Rica	Indonesia
Ghana	Dominican R	Iran
Kenya	Guatemala	Iraq
Lesotho	Haiti	Korea
Malawi	Honduras	Kuwait
Mali	Jamaica	Malaysia
Mauritania	Mexico	Pakistan
Morocco	Nicaragua	Saudi Arabia
Mozambique	Panama	Singapore
Niger	Trinidad and Tobago	Sri Lanka
Nigeria	Argentina	Taiwan
Rwanda	Bolivia	Thailand
Senegal	Brazil	Turkey
Sierra Leone	Chile	Papua New Guinea
Sudan	Colombia	Tanzania
Swaziland	Ecuador	Paraguay