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Human Capital and FDI: Development Process of the Developing Country in an Overlapping Generations Model

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Human Capital and FDI: Development Process of the Developing Country in an Overlapping Generations Model *

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Abstract

We construct an overlapping generations model with human capital accumulation to analyze the effect of human capital level on foreign direct investment (FDI) in a small open developing country. In particular, we assume that manufactured goods have the human capital intensive technology and young agents choose whether to work or to educate themselves. When the human capital level in the developing country is sufficiently small, manufactured goods firms do not conduct FDI and the economy in the developing country is trapped in poverty. When the human capital level is sufficiently large, manufacturers conduct FDI in equilibrium and the income of the developing country increases. We can show that if the government of the developing country levies a tariff on the imports of manufactured goods, manufacturers conduct FDI and the economy in the developing country can escape from the poverty trap.

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1 Introduction

Over the past several decades, foreign direct investment (FDI) has spread rapidly throughout developing countries and has emerged as an important approach for developing countries to catch up with developed countries. In fact, FDI inflows jumped from USD 2.4 billion in 1962 to USD 35 billion in 1990 and USD 565 billion in 2007 (United Nations Council on Trade and Development (UNCTAD)) However, there exist regional differences in FDI inflows into developing countries. For example, one third of the FDI inflows into developing countries are into China(including Hong Kong and Macao), and only a fraction flows into the least-developed countries in Africa.

Some empirical studies have suggested that the human capital level is cause of this discrepancy. Noorbakhsh, Paloni and Youssef (2001) and Miyamoto (2003) provide empirical evidence of the positive relationship between human capital (or human resource development) and FDI. Furthermore, they point out that human resource development, (measured in terms of education and training, new skills acquisition, information technology level, and so on) is key factor for host developing countries. Checchi, Simone and Faini (2007) conclude that there exists a complementary relationship between human capital and FDI. Kottaridi and Stengos (2010) suggest a non-linear effect of human capital and FDI infows on national income. [1]

In addition, some empirical works study the relationship between child labor and FDI. Kucera (2002) and Busse and Braun (2004) analyze the relationship between the incidence of child labor and FDI. They find that child labor suppresses the wage rate of unskilled labor, thereby reducing cost of FDI. However, they find a statistically insignificant correlation between the wage rate of unskilled labor and child labor. They also conclude that there is a significant negative correlation between FDI and the incidence of child labor. Braun (2006) provides evidence that child labor can discourage FDI by impeding the accumulation of human capital. He shows that child labor raises the incidence of low skilled labor, but at the same time, suppresses the incidence of high skilled labor by encumbering education. Therefore,

[1] Zhuang (2005) demonstrate this using Chinese data. Blomstrom and Kokko (2003) and Majeed and Ahmad (2008) confirm this in a comparison between East Asia and South America.

the incidence of child labor has a negative relationship with FDI. Edmonds and Pavcnik (2005) find a negative relationship between exposure to trade and the incidence of child labor using cross country data.

In this paper, we propose an overlapping generations model with human capital accumulation to analyze the effect of human capital level on FDI in a small open developing country. The adult agents in the developing country allocate the time of their young agents to work or allocate the young agents' time to educate themselves in order to accumulate their human capital. We assume that manufactured goods have human capital intensive technology. In our model, foreign manufacturers choose their strategies to supply their goods to the developing country: export or conduct FDI to produce their goods in the developing country. When foreign manufacturers choose to export, they have to incur a tariff. When foreign manufactured firms conduct FDI, they have to hire labor in the developing country.

The results of this study depend on the initial level of human capital. When the initial human capital level is sufficiently low, the productivity of manufacturing goods in the developing country is low. Then, foreign manufacturers do not conduct FDI and developing country's incentive to accumulate human capital becomes low. Therefore, the human capital and income level of the developing country become low in the equilibrium and the economy of the developing country is trapped in poverty. When the initial human capital level in the developing country is sufficiently large, the productivity of manufacturing goods in the developing country is high. Then, foreign manufacturers conduct FDI. When foreign manufacturers conduct FDI, labor demand and wage rate in the developing country increase. As wage rate increases, agents in the developing country are willing to educate themselves to accumulate human capital, and the economy can escape from the poverty trap.

We can provide a policy to escape from the poverty trap. As mentioned earlier, many empirical studies have shown that human resource development attracts FDI. In addition, this paper investigates the effect of trade policy on FDI, that is, the effect of the tariff levied by the government of the developing country on manufactured goods. When the developing country's government levies a higher tariff on manufactured goods, manufacturers' incentive to conduct FDI increases as exporting to the developing country becomes more costly. [2] Then, manufacturing

[2]Konishi, Saggi and Weber (1999) theoretically investigate firm's tariff jumping activities in

in the developing become feasible. This increase in FDI leads to an increase in labor demand increases and in the wage rate in the developing country. The developing country can then escape from the poverty trap.

This paper is organized as follows. Section 2 develops the model. Section 3 characterizes the equilibrium given a level of human capital and analyzes the dynamics of human capital. Section 4 provides the conclusion.

2 Model

We construct a two-period overlapping generations model of a small open economy. There exist two types of goods: differentiated manufactured goods and an agricultural good. We let manufactured good j vary continuously in the unit interval $j \in \{0, 1\}$. We denote the population size in the small country as L and deem it constant. An agent is endowed with one unit of time each in youth and adulthood. In adulthood, an agent supplies one unit of time inelastically. Adults (generation $t-1$) allocate youth's time to schooling or to working. We denote the working time of young agents as l_t, and their schooling time as $1 - l_t$. The government levies a tariff on the manufacturing imports.

2.1 Household

Agents have identical preferences:

$$U_t = \log C_t + \beta \log H_{t+1}, \tag{1}$$

where

$$C_t = c_{A,t}^{1-\gamma} c_{M,t}^{\gamma}, \tag{2}$$

$$c_{M,t} = \left[\int_0^1 c_{M,t}(j)^{\sigma} dj \right]^{\frac{1}{\sigma}}. \tag{3}$$

$c_{M,t}$ is the consumption of the composite of manufactured goods at time t. $c^i_{A,t}$ and $c^i_{M,t}(j)$ denote the consumption of the agricultural good and the consumption of manufactured good j at time t, respectively. In addition, utility is derived by the youth's human capital level, H_{t+1} that represents the altruism for the young.

developed countries, and Blonign (2002) supports these activities empirically.

The budget constraint is

$$c_{A,t} + \int_0^1 p_t(j) c_{M,t}(j) dj = w_t H_t + w_{y,t} l_t + D + T \equiv E_t, \tag{4}$$

where $p_t(j)$ denotes price of the manufactured good j at time t, w_t is the adult wage rate, $w_{y,t}$ is the youth wage rate, D is the dividend from the agricultural good sector, and T is the lump-sum transfer from the government.

Adults allocate their young's time endowment to schooling or to working. The young's human capital is as follows:

$$H_{t+1} = \phi(1 - l_t). \tag{5}$$

We assume that $\bar{H} = \phi(1)$, $\underline{\mathrm{H}} = \phi(0)^{\frac{1}{1-\sigma}}$, $\bar{H} > \underline{\mathrm{H}}$, and $\frac{\partial \phi}{\partial l_t} < 0$. The agents' utility maximization problem can be solved in two steps. The first step is to solve their income allocation. Then, we can obtain the following demand functions:

$$c_{A,t} = (1 - \gamma) E_t, \tag{6}$$

$$c_{M,t} = \frac{\gamma E_t p_{M,t}(j)^{\frac{1}{\sigma - 1}}}{\int_0^1 p_{M,t}(j)^{\frac{\sigma}{\sigma-1}} dj}. \tag{7}$$

Substituting (5) (6) and (7) into (2), the following equation can be obtained:

$$C_t = \frac{E_t}{P_t}, \tag{8}$$

where

$$P_t = \left(\frac{\left[p_{M,t}(j)^{\frac{\sigma}{\sigma-1}} dj\right]^{\frac{\sigma-1}{\sigma}}}{\gamma(1-\gamma)^{\frac{1-\gamma}{\gamma}}}\right)^{\gamma}. \tag{9}$$

Substituting (8) and (9) into (1), the indirect utility function is given as

$$U_t = \log \frac{E_t}{P_t} + \beta \log \phi(1 - l_t). \tag{10}$$

In the second step, we obtain the time spend by young agents in work and in educating themselves. We obtain the following equations:

$$\frac{w_{y,t}}{E_t} \begin{cases} < \beta \frac{\phi'(1)}{\phi(1)}, & \text{for } l_t = 0, \\ = \beta \frac{\phi'(1-l_t)}{\phi(1-l_t)}, & \text{for } 0 < l_t < 1, \\ > \beta \frac{\phi'(0)}{\phi(0)}, & \text{for } l_t = 1 \; . \end{cases} \tag{11}$$

The left hand side of (11) represents the cost of education and the right hand side of (11) represents the benefit of education.

2.2 Firm

The agricultural good is produced using both adult and youth labor. We assume that the agricultural good market is perfectly competitive and that the agricultural good is numeraire. We assume that the young agent supplies l_t units of effective labor and the adult agent supplies H_t units of effective labor. H_t represents the level of human capital in the small country. The production function of the agricultural good sector is given by

$$Y_{A,t} = F(\psi_t LH_t, l_t L), \tag{12}$$

where $Y_{A,t}$, F, and ψ_t represent the output of the agricultural good at time t, the fraction of adult agents in the agricultural good sector, respectively. We assume that $F_1 \equiv \frac{\partial F}{\partial \psi_t LH_t} > 0$ and $F_2 \equiv \frac{\partial F}{\partial l_t L} > 0$, $F_{11} = \frac{\partial^2 F}{\partial(\psi_t LH_t)^2} < 0$, $F_{12} \equiv \frac{\partial^2 F}{\partial \psi_t LH_t \partial l_t L} < 0$, and $F_{22} \equiv \frac{\partial^2 F}{\partial (l_t L)^2} < 0$. When ψ goes to zero, $\lim_{\psi \to 0} F_1 = \infty$. When young agents allocate all of their time to education, the production of the agricultural good is possible: $F(\psi LH_t, 0) > 0$. Then, the profit of the agricultural good sector is given by

$$\pi_{A,t} = F(\psi_t LH_t, l_t L) - w_t \psi_t LH_t - w_{y,t} l_t L. \tag{13}$$

Then, the agricultural good firm's profit-maximization problem is as follows:

$$w_t = F_1(\psi_t LH_t, l_t L), \tag{14}$$

$$w_{y,t} = F_2(\psi_t LH_t, l_t L). \tag{15}$$

Manufacturers are foreign-owned and choose whether to export or conduct FDI. The global price of manufactured goods is $p^*(j)$, and we assume that $p^*(j)$ is constant and that $p^*(j) = p^*$. In this small country, the government levies a tariff on the imports of manufactured goods. When manufacturers exports one unit of a manufactured good at price p^*, it has to pay a custom duty of $\tau p^*(j)$ where τ represents the tariff rate. When manufacturers conduct FDI, manufactured goods are produced using adult labor only. In addition, manufactured goods are produced by a technology that is more human capital intensive compared to the agricultural good. We assume that perfect competition prevails in the manufactured goods market. When manufacturers condut FDI, the production function is

$$Y_t(j) = L_{M,t}(j)(H_t)^{\alpha}, \quad \alpha > 1, \quad j \in (0, 1), \tag{16}$$

where $L_{M,t}(j)$ denotes the labor working for manufacturer j and $\alpha > 1$ represents the intensiveness of human capital. Then, manufacturer j's profit is given as

$$\pi_t(j) = p_t(j)L_{M,t}(j)(H_t)^{\alpha} - w_t L_{M,t} H_t. \tag{17}$$

Then, manufacturers' profit-maximization problem becomes:

$$p_t(j) = w_t(H_t)^{1-\alpha}. \tag{18}$$

Therefore, the necessary condition for a manufacturer to conduct FDI is as follows:

$$(1+\tau)p^*(j) \geq p(j) = w_t H_t^{1-\alpha}. \tag{19}$$

From (19) and $\alpha > 1$, we can rewrite the above condition as follows:

$$H_t \geq \hat{H} \equiv \left(\frac{w_t}{(1+\tau)p^*(j)} \right). \tag{20}$$

When the human capital in the small country is sufficiently large, manufacturers conduct FDI.

2.3 Labor market, goods market, and the government's budget constraint

The labor market equilibrium for adult labor requires that labor supply equals labor demand. The supply of adult labor is L. The demand for labor comes from the agricultural good sector and the manufactured goods sector. Therefore, the adult labor market equilibrium condition is given by

$$L = \psi L + \int_0^{n_t} L_{M,t}(j)dj, \tag{21}$$

where n_t is the number of manufacturers that conduct FDI at time t.

Next, we investigate the market equilibrium conditions of the agricultural good and the manufactured goods. The agricultural good market equilibrium condition is

$$Y_{A,t} = (1-\gamma)E_t L, \tag{22}$$

where the left-hand side represents the supply of the agricultural good and the right-hand side represents the demand for the agricultural good. Manufactured goods j's market equilibrium condition becomes $Y_{M,t}(j) = c_{M,t}(j)L$. The left-hand side represents the supply for manufactured good j and the right-hand side represents the demand for manufactured good j.

Last, we show the government's budget constraint. We assume that the government runs a balanced budget in which it finances its outlay with tariff. The government's budget constraint is

$$\int_{n_t}^{1} \tau p^* c_{M,t}(j) L dj = TL, \tag{23}$$

where the left hand side represents the tariff revenue and the right hand side represents the lump-sum transfer to the agents in the small country.

3 Equilibrium

We focus on the manufacturers' decision to conduct FDI or not. From (14) and (19), we can obtain the condition under which manufacturers do not conduct FDI:

$$(1+\tau)p^* \leq F_1(\psi_t L H_t, l_t L) H_t^{1-\alpha}. \tag{24}$$

The right-hand side is decreasing in H_t, l_t, and ψ_t because $F_{11} < 0$, $F_{12} < 0$ and $\alpha > 1$. When ψ approaches to zero, the right-hand side approaches infinity. If the left-hand side is smaller than the right-hand side, the price of manufactured goods produced by FDI firms is larger than the price of imported goods. Then, FDI firms prefer to export from their home country. Therefore, ψ increases and the right-hand side decreases. In contrast, if the left-hand side is larger than the right-hand side, the price of manufactured goods produced by FDI firms is lower than the price of imported goods. Then, some manufacturing firms conduct FDI and the number of FDI increases firms increases, leading to a rise in labor demand. Therefore, ψ decreases and the right-hand side increases. Hence, in the equilibrium, the following equation must be satisfied:

$$(1+\tau)p^* = p_t(j) = F_1(\psi^*(l_t, H_t) L H_t, l_t L) H_t^{1-\alpha}, \tag{25}$$

where $\psi^*(l_t, H_t)$ denotes the ratio of working adult agents in the agricultural good sector in the equilibrium. Totally differentiating (25) with respect to H_t and ψ_t, we can derive the relationship between human capital and the ratio of working adults in the agricultural good sector in the equilibrium as follows:

$$\frac{\partial \psi^*(l_t, H_t)}{\partial H_t} = -\frac{F_{11}\psi^* L H_t + (1-\alpha)F_1}{F_{11} L H_t^2} < 0, \tag{26}$$

because $F_{11} < 0$ and $\alpha > 1$. A decrease in the level of human capital increases the ratio of working adult agents in the agricultural good sector in the equilibrium. Because $\psi^* \leq 1$ must hold, when the level of human capital is sufficiently small, $\psi^* = 1$ holds. Then, suppose that $\hat{H}$ denotes the minimum level of human capital which manufacturers conduct FDI. Therefore, when $H_t < \hat{H}$, $\psi^* = 1$ holds. From (25), regardless of household behavior, the minimum level of human capital at which manufacturers conduct FDI is as follows:

$$(1+\tau)p^* = F_1(L\hat{H}, l_t L)\hat{H}^{1-\alpha}. \tag{27}$$

Therefore, when $H < \hat{H}$, manufacturers do not conduct FDI and we label this economy *RegimeNF*. In contrast, when $H_t > \hat{H}$, manufacturers conduct FDI and we label this economy *RegimeF*. From (27), we can obtain the relationship between $\hat{H}$, τ, and l_t:

$$\frac{\partial \hat{H}}{\partial \tau} = \frac{p^*}{F_{11}L\hat{H}^{1-\alpha} + (1-\alpha)F_1\hat{H}^{-\alpha}} < 0, \tag{28}$$

$$\frac{\partial \hat{H}}{\partial l_t} = \frac{F_{12}L\hat{H}^{1-\alpha}}{F_{11}L\hat{H} + (1-\alpha)F_1\hat{H}^{-\alpha}} < 0. \tag{29}$$

An increase in the tariff rate decreases the minimum level of human capital which manufacturers conduct FDI. When the government levies a tariff on the imports of manufactured goods, manufacturers prefer FDI to exporting. An increase in the young agents' allocation to work decreases the minimum level of human capital which manufacturers conduct FDI and decreases the wage rate of adults. Then, manufacturers prefer FDI and the minimum level of human capital decreases.

When $H_t > \hat{H}$, $0 < \psi^* < 1$ holds. Then, when $H_t > \hat{H}$, from (27), we get the relationship between ψ^*, τ, and l_t as follows:

$$\frac{\partial \psi^*}{\partial \tau} = -\frac{p^*}{F_{11}H_t^{2-\alpha}} < 0, \tag{30}$$

$$\frac{\partial \psi^*}{\partial l_t} = -\frac{F_{12}}{F_{11}H_t} < 0. \tag{31}$$

Then, we can obtain the following proposition:

PROPOSITION 1. *When $H_t > \hat{H}$, $0 < \psi^* < 1$ holds. An increase in the level of human capital, in the young agents' allocation to work, and in tariff decrease the ratio of working adult agents in the agricultural good sector in the equilibrium.*

An increase in the level of human capital raises the productivity of the manufacturing sector, decreasing the labor supply to the agricultural sector. An increase in the labor supply of young agents depresses the marginal productivity of adult labor in the agricultural sector and the labor supply to the agricultural sector decreases. An increase in the tariff rate induces manufacturers to conduct FDI and increases the demand for adult labor. Then, the supply for adult labor to the agricultural sector decreases.

3.1 *RegimeNF*

In this regime, manufacturers do not conduct FDI and $\psi^* = 1$ holds. The price of manufacturers is $p_t(j) = (1+\tau)p^*$ for all j because manufactured goods are imported. Then, the output level of the agricultural good is given by $Y_{A,t} = F(LH_t, l_t L)$. Substituting (7), (13), (23), and $p_t(j) = (1+\tau)p^*$ into (4), the expenditure level in this regime is given as

$$E_t = \frac{1+\tau}{1+\tau-\gamma\tau}\frac{F(LH_t, l_t L)}{L}. \tag{32}$$

Then, substituting (32) into (6) and (7), we can obtain the following equations:

$$c_{A,t} = \frac{(1-\gamma)(1+\tau)}{1+\tau-\gamma\tau}\frac{F(LH_t, l_t L)}{L}, \tag{33}$$

$$c_{M,t} = \frac{\gamma}{p^*(1+\tau-\gamma\tau)}\frac{F(LH_t, l_t L)}{L}. \tag{34}$$

In this regime, we can show that the trade balance condition is satisfied. (See Appendix for proof.)

3.2 *RegimeF*

In this regime, manufacturers conduct FDI and (25) holds. Then, the output level of the agricultural good is given as

$$Y_{A,t} = F(\psi^*(l_t, H_t)LH_t, l_t L). \tag{35}$$

The number of FDI firms is denoted by n_t. Then, the consumption level of manufactured goods is given by

$$c_{M,t} = \frac{\gamma E_t}{(1+\tau)p^*}. \tag{36}$$

In this regime, substituting (7), (13), (23), and $p_t(j) = (1+\tau)p^*$ into (4), the expenditure level can be expressed as follows:

$$E_t = \frac{1+\tau}{(1+\tau) - \tau\gamma(1-n_t)} \left[\frac{F(\psi^*(l_t, H_t)LH_t, l_t L)}{L} + (1-\psi^*(l_t, H_t))w_t H_t \right]. \quad (37)$$

The market clearing condition of the manufactured goods produced in the small country is given by

$$\int_0^{n_t} c_{M,t}(j) L dj = \int_0^{n_t} L_{M,t}(j) H_t^\alpha dj. \quad (38)$$

In this regime, the labor market equilibrium condition is expressed as follows

$$\psi^*(l_t, H_t)L + \int_0^{n_t} L_{M,t}(j) dj = L. \quad (39)$$

Because manufacturers are symmetric, $L_{M,t}(j) = L_{M,t}$ for all j. Then, substituting (38) into (39), we can obtain the number of FDI firms as follows:

$$n_t = \frac{(1+\tau)p^*}{\gamma L E_t}(1-\psi^*(l_t, H_t))H_t^\alpha L.$$

Then, substituting (37) into the above equation, the number of manufacturing firms conducting FDI can be rewritten as follows:

$$n_t^* = \frac{(1+\tau-\gamma\tau)(1-\psi^*(l_t, H_t))p^* H_t^\alpha L}{\gamma(F(\psi^*(l_t, H_t)LH_t, l_t L) + (1-\psi^*(l_t, H_t))p^* H_t^\alpha L)}. \quad (40)$$

Substituting (40) into (37), we can obtain the expenditure level in the equilibrium as follows:

$$E_t^* = \frac{1+\tau}{(1+\tau-\gamma\tau)L} \left[F(\psi^*(l_t, H_t)LH_t, l_t L) + (1-\psi^*(l_t, H_t))p^* H_t^\alpha L) \right]. \quad (41)$$

In this regime, we can show that the trade balance condition is satisfied. (See the Appendix for proof.)

3.3 Threshold levels of human capital

3.3.1 Condition under which young agents' only work

From (11), (15), and (41), the condition under which young agents only work is

$$Z(1, H_t) > \frac{1+\tau}{1+\tau-\gamma\tau} \frac{\beta\phi'(0)}{L\underline{\mathrm{H}}}, \quad (42)$$

where

$$Z(l_t, H_t) \equiv \frac{F_2(\psi^*(l_t, H_t)LH_t, l_tL)}{F(\psi^*(l_t, H_t)LH_t, l_tL) + (1-\psi^*(l_t, H_t))p^*H_t^\alpha L}. \tag{43}$$

We depict (42) in Figure 1. The left-hand side of (42) represents the marginal benefit that young agents get from working and the right-hand side of (42) represents the marginal benefit that young agents from education. Differentiating $Z(1, H_t)$ with respect to H_t, we get

$$\frac{\partial Z(1, H_t)}{\partial H_t} = \frac{A + B\frac{\partial \psi^*(l_t, H_t)}{\partial H_t}}{[F(\psi^*(1, H_t)LH_t, l_tL) + (1-\psi^*(1, H_t))p^*H_t^\alpha L]^2}, \tag{44}$$

where

$$A \equiv F_{21}\psi^*[F + (1-\psi^*)p^*H_t^\alpha L] - F_2p^*H_t^{\alpha-1}[(1+\tau)\psi^* + \alpha(1-\psi^*)] < 0, \tag{45}$$

$$B \equiv F_{21}H_t[F + (1-\psi^*)p^*H_t^\alpha L] - \tau p^*H_t^\alpha F_2 < 0. \tag{46}$$

A is the negative effect on the marginal benefit that young agetns get from working. From (26), $B\partial\psi^*/\partial H_t$ is the positive effect on the marginal benefit that young agents get from working. We give an intuitive explanation for this negative effect. An increase in the human capital level increases the income level of the household and the ratio of earning by young agents to total household income becomes small which decreases the marginal benefit that young agents get from working. In contrast, the positive effect is that an increase in the human capital level decreases the number of adult agents engaged in the agricultural good sector and the wage rate of young agents increases, which increases the marginal benefit that young agents get from working. We can rewrite $A + B\partial\psi^*/\partial H_t$ as follows:

$$\begin{aligned} A + B\frac{\partial \psi^*}{\partial H_t} &= -(\alpha(1-\psi^*) + \psi^*)F_2p^*H_t^{\alpha-1} \\ &\quad - \frac{(1-\alpha)F[F_{21}H_t(F + (1-\psi^*)p^*H_t^\alpha L) - \tau p^*H_t^\alpha F_2]}{F_{11}LH_t^{1+\alpha}}. \end{aligned} \tag{47}$$

Because $F_{21} < 0$ and $F_{11} < 0$, this sign is ambiguous. In this paper, we assume that the positive effect is smaller than the negative effect as follows:

$$-F_{21} < [(\alpha(1-\psi^*) + \psi^*)\frac{F_{11}LH_t}{(1-\alpha)F} - \tau]\frac{p^*H_t^\alpha F_2}{F + (1-\psi^*)p^*H_t^\alpha L}. \tag{Assuption 1}$$

F_{21} is a negative value and F_{21} represents how the wage rate of young agents increases when the ratio of working adult agents in the agricultural good sector decreases. From Assumpation 1, the negative effect is larger than the positive effect and an increase in the human capital level decreases the marginal benefit that the young agents get from working. When $H_t < \hat{H}$, $\psi^* = 1$ holds. Therefore, $B\partial\psi^*/\partial H_t = 0$ holds and the positive effect becomes zero. When $H_t > \hat{H}$, $0 < \psi^* < 1$ holds and $B\partial\psi^*/\partial H_t > 0$. Then, the slope of $\partial LHS|_{(42)}/\partial H_t$ when $H_t < \hat{H}$ is steeper than that when $H_t > \hat{H}$.

In this paper, we assume the following:

$$\min\left(\frac{1+\tau-\gamma\tau}{1+\tau}\frac{F_2(L\hat{H},L)}{F(L\hat{H},L)}, G(1,\tilde{H},\tau)\right) > \frac{\beta\phi'(0)}{L\underline{\mathrm{H}}} \qquad \text{(Assumption 2)}$$

where

$$G(l,h,\tau) = \frac{1+\tau-\gamma\tau}{1+\tau}\frac{F_{21}(\psi(l,h)Lh,lL)}{\tau p^* h^{\alpha-1}} - \frac{\gamma}{1+\tau}\frac{F_{11}(\psi(l,h)Lh,lL)F_2(\psi(l,h)Lh,lL)}{\tau p^{*2}h^{2(\alpha-1)}}.$$

The first term of the left hand side in Assumption 2 gives the marginal benefit that young agents get from working, and the right hand side of Assumption 2 gives the marginal benefit that the young agents get from education. Therefore, the marginal benefit that young agents get from working is larger than the marginal benefit that young agents get from education.

When the level of human capital, $\tilde{H}$, is indipendent of young agents' allocation, (42) holds with equality as follows:

$$Z(1,\tilde{H}) = \frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\psi'(0)}{L\underline{\mathrm{H}}}. \tag{48}$$

From Assumption 2 and Figure 1, we can obtain $\hat{H} < \tilde{H}$. Totally differentiating (48) with respect to τ and $\tilde{H}$, we can obtain the following lemma. (See the Appendix for proof.)

LEMMA 1. *An increase in the tariff rate decreases the threshold level of human capital $\tilde{H}$.*

There are two effects of an increase in the tariff rate: a direct effect and an indirect effect. The direct effect is that an increase in the tariff rate encourages manufacturers to conduct FDI and the adult wage rate increases. Then, adult agents prefer to educate young agents. Therefore, the threshold level of human capital that is independent of young agents' allocation, decreases. The indirect effect is that an increase in the tariff rate decreases the number of adult agents engaged in the agricultural good sector and the wage rate of young agents increases. Then, the marginal benefit that young agetns get from work increases. Therefore, the threshold level of human capital that is independent of young agents' allocation, increases. Assumption 2 deems the direct effect to be larger than the indirect effect.

3.3.2 Condition under which young agents' only educate themselves

From (11), (15), and (41), the condition under which young agents' only educate themselves is given by

$$Z(0, H_t) < \frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\psi'(1)}{L\bar{H}}. \tag{49}$$

From $\partial\psi^*(l_t, H_t)/\partial l_t > 0$, $\psi^*(1, H_t) > \psi^*(0, H_t)$ holds. $Z(0, H_t)$ represents the young agents' marginal benefit from working when they only educate themselves. The right-hand side of (49) represents the marginal benefit from education when they only educate themselves. Because $Z(0, H_t)$ is decreasing in ψ^* and ψ^* is decreasing in l_t, the following inequality holds:

$$Z(0, H_t) < Z(1, H_t). \tag{50}$$

Therefore, the left-hand side of (49) is larger than the left-hand side of (42). Because $\phi'(0) > \phi'(1)$ and $\underline{\mathrm{H}} < \bar{H}$, the right-hand side of (49) is smaller than the right-hand side of (42). We show (49) in Figure 1.

When the level of human capital, $\tilde{H}'$, is independent of young agents' allocation, (49) holds with equality as follows:

$$Z(0, \tilde{H}') = \frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\psi'(1)}{L\bar{H}}. \tag{51}$$

When $H_t > \tilde{H}'$, young agents only educate themselves.In contrast, when $H_t < \tilde{H}'$, young agents both work and educate themselves. From Figure 1, because $Z(1, H_t)$ is larger than $Z(0, H_t)$ and the right-hand side of (49) is smaller than that of (42), $\tilde{H}'$ is larger than $\tilde{H}$. Therefore, $\tilde{H}' > \tilde{H} > \hat{H}$ holds.

For simplicity, we assume the following equation:

$$G(0, \tilde{H}', \tau) > \frac{\beta\phi'(1)}{L\bar{H}} \tag{Assumption 3}$$

Totally differentiating (48) with respect to τ and $\tilde{H}^{'}$, we can obtain the following lemma. (See the Appendix for proof.)

LEMMA 2. *An increase in the tariff rate decreases the threshold level of human capital* $\tilde{H}^{'}$.

There are two effects of an increase in the tariff rate: a direct effect and an indirect effect. The direct effect is that an increase in the tariff rates encourage manufacturers to conduct FDI and the adult wage rate accordingly increases. Then, adult agents prefer to educate young agents. Therefore, the threshold level of human capital the threshold level of human capital that is independent of young agents' allocation, decreases. The indirect effect is that an increase in the tariff rate decreases the number of adult agents engaged in the agricultural good sector and the wage rate of young agents increases. Then, young agents' marginal benefit from working increases. Therefore, the threshold level of human capital that is independent of young agents' allocation, increases. Assumption 3 deems the direct effect to be larger than the indirect effect.

3.4 Phase diagram

In this section, we summarize the above three subsections and phase diagram. When $H_t < \tilde{H}$, young agents work: $l_t = 1$. Therefore, from (5), $H_{t+1} = \underline{\mathrm{H}}$ holds for $H_t < \tilde{H}$. In contrast, when $H_t > \tilde{H}^{'}$, young agents educate themselves: $l_t = 0$. Therefore, from (5), $H_{t+1} = \bar{H}$ holds for $H_t > \tilde{H}^{'}$. When $\tilde{H} < H_t < \tilde{H}^{'}$ holds, young agents both work and educate themselves: $0 < l_t < 1$.

We assume that $\underline{\mathrm{H}} < \tilde{H}^{'} < \bar{H}$ for simplicity. Suppose that $\underline{\mathrm{H}} < \hat{H} < \tilde{H}$. Then, we can depict the phase diagram in Figure 2. In this case, we can obtain three equilibria in Figure 2 which given in Figure 2. Equilibria of A and B are stable and equilibrium of C is unstable. We focus on the two stable equilibria.The level of human capital in equilibrium A is $\underline{\mathrm{H}}$. Because $\underline{\mathrm{H}} < \hat{H} < \tilde{H}$, manufacturers do not conduct FDI and young agent only work. In contrast, the level of human capital in equilibrium B is $\bar{H}$. Because $\hat{H} < \tilde{H} < \bar{H}$, manufacturers conduct FDI and young agents only educate themselves. When the initial level of human capital, H_0, is less than H_T, the economy converges to equilibrium A. H_T is given as

$$H_T = \phi(1 - l_T), \tag{52}$$

where l_T is

$$Z(l_t, H_T) = \frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\phi'(1-l_T)}{L\phi(1-l_T)}. \tag{53}$$

When $H_0 < \hat{H}$, manufacturers do not conduct FDI. When $\hat{H} < H_0 < \tilde{H}$, at time zero, some manufacturers conduct FDI. However, in the next period, the economy converges to equilibrium A and manufacturers do not conduct FDI. When $\tilde{H} < H_0 < H_T$ holds, at the initial time, young agents both work and educate themselves, and some manufacturing firms conduct FDI. As the economy converges to the equilibrium A, young agents' time allocation to education decreases and converges to zero. When the initial level of human capital is larger than H_T, the economy converges to equilibrium B. Then, at time zero, young agents both work and educate themselves, but from then onward, they only educate themselves.

Suppose that the government levies a tariff on the imports of manufactured goods. From Lemma 1 and 2, an increase in the tariff rate decreases $\tilde{H}$ and $\tilde{H}'$. Then, suppose that $\hat{H} < \underline{\mathrm{H}} < \tilde{H}$ holds. We depict this phase diagram in Figure 3. In this case, we can obtain three equilibria: equilibria of D and E are stable while equilibrium F is unstable. We focus on the two stable equilibria. The level of human capital in equilibrium of D is $\underline{\mathrm{H}}$. From $\hat{H} < \underline{\mathrm{H}} < \tilde{H}$, manufacturers conduct FDI and young agents only work. In contrast, the level of human capital in equilibrium of E is $\bar{H}$. From $\hat{H} < \tilde{H} < \bar{H}$, manufacturers conduct FDI and young agent only educate themselves.

Suppose that the government levies higher tariff on the imports of manufactured goods. Then, suppose that $\hat{H} < \tilde{H} < \underline{\mathrm{H}}$ holds. We depict this phase diagram in Figure 4. In this case, we can obtain a unique and stable equilibrium G in Figure 4. The level of human capital in equilibrium G is $\bar{H}$. From $\hat{H} < \underline{\mathrm{H}} < \tilde{H}$, manufacturers conduct FDI and young agent only educate themselves. From these three phase diagrams, we can obtain the following proposition.

PROPOSITION 2. *A policy under which the government levies a tariff on the imports of manufactured goods encourages manufacturers to conduct FDI. Then, the marginal benefit of education increases and the economy converges to a higher education level.*

From Proposition 2, when the government of the developing country levies a tariff on manufacturers, they prefer to conduct FDI to the avoid additional cost of tariff. As a result, the demand for adult labor in the developing country increases and human capital is accumulated. Then, the developing country can escape from the poverty trap.

4 Conclusion

In this paper, we construct an overlapping generations model with human capital accumulation to analyze the effect of human capital level on FDI in a small open developing country. In this model, foreign manufacturers choose to export or to locate to conduct FDI. When manufacturers conduct FDI, they have to hire local labor. Therefore, labor demand increases and the wage rate rises in developing country. As the wage rate rises, adult agents are willing to educate their young and the human capital level increases. We show that when the human capital level is sufficiently small, there is no FDI and the economy is stagnant. When the human capital level is sufficiently large, manufacturers conduct FDI and the human capital level increases.

In this paper, we can show that to attract FDI, the government must not only promote human capital accumulation but also levy a tariff on imports. When the government of a developing country levies a tariff on the imports of manufactured goods, some manufacturers find it cheaper to conduct FDI and the labor demand increases. Then, adult agents are willing to educate their young andthe human capital level increases. In this manner, the developing country can escape from a poverty trap.

We can extend our paper to some directions. In this paper, we assume the efficient public education system in the developing countries. However, in the developing countries, education system is fragile and this increases education costs. In our paper, we ignore the effect of official development aid. It is important to construct model in which there has a transfer from developed contries to developing countries.

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A Deviation of (30) and the trade balance condition in *RegimeNF*

Substituting (7), (13), (24), and $p_t(j) = (1+\tau)p^*$ into (4), the expenditure level in *RegimeNF* is

$$\begin{aligned} E_t &= \frac{F(LH_t, l_tL)}{L} + \tau p^* \int_0^1 \frac{\gamma E_t}{(1+\tau)p^*} dj \\ &= \frac{F(LH_t, l_tL)}{L} + \frac{\gamma\tau}{1+\tau} E_t \end{aligned} \tag{A.1}$$

We can thus obtain (30).

We show that the trade balance condition in *RegimeNF* is satisfied. Here, the developing country exports the agricultural good and imports manufactured goods. Then, we subtract the value of imports from the value of exports as follows:

$$(Y_{A,t} - c_{A,t}L) - \int_0^1 p^* c_{M,t}(j) L dj, \tag{A.2}$$

The first term represents the value of exports and the second term represents the value of imports. Then, substituting (29), (31), and (32) into the above equation, we can show that in this regime, the trade balance condition is satisfied as follows:

$$\begin{aligned} &F(LH_t, l_tL) - \frac{(1-\gamma)(1+\tau)}{1+\tau-\gamma\tau} F(LH_t, l_tL) - p^* \frac{\gamma}{p^*(1+\tau-\gamma\tau)} F(LH_t, l_tL) \\ =& \frac{1+\tau-\gamma\tau-(1-\gamma)(1+\tau)-\gamma}{1+\tau-\gamma\tau} F(LH_t, l_tL) = 0. \end{aligned} \tag{A.3}$$

B Trade balance condition in *RegimeF*

We show that the trade balance condition in *RegimeF* is satisfied. Subtracting the value of imports from the value of exports, we can obtain the following equation:

$$\begin{aligned} &(Y_{A,t} - c_{A,t}L) - \int_{n^*}^1 p^* L c_{M,t}(j) dj \\ =& F(\psi^*(l_t, H_t) LH_t, l_tL) - \frac{(1-\gamma)(1+\tau) + \gamma(1-n^*)}{1+\tau} LE_t \end{aligned} \tag{B.1}$$

Then, we substitute n^* into the numerator of the second term of (B.1), and get

$$(1-\gamma)(1+\tau)+\gamma(1-n^*) = \frac{(1+\tau-\gamma\tau)F(\psi^*(l_t,H_t)LH_t,l_tL)}{F(\psi^*(l_t,H_t)LH_t,l_tL)+(1-\psi^*(l_t,H_t))p^*H_t^\alpha L} \tag{B.2}$$

Substituting E_t^* into (B.1), we can show that the trade balance condition in *RegimeF* is satisfied:

$$\begin{aligned}
&F(\psi^*(l_t,H_t)LH_t,l_tL) - \frac{(1-\gamma)(1+\tau)+\gamma(1-n^*)}{1+\tau}LE_t \\
=&F(\psi^*(l_t,H_t)LH_t,l_tL) - \frac{(1+\tau-\gamma\tau)F(\psi^*(l_t,H_t)LH_t,l_tL)}{F(\psi^*(l_t,H_t)LH_t,l_tL)+(1-\psi^*(l_t,H_t))p^*H_t^\alpha L}\frac{L}{1+\tau} \\
&\times \frac{(1+\tau)\left[F(\psi^*(l_t,H_t)LH_t,l_tL)+(1-\psi^*(l_t,H_t))p^*H_t^\alpha L)\right]}{(1+\tau-\gamma\tau)L} \\
&=0
\end{aligned} \tag{B.3}$$

C Proof of Lemma 1

Totally differentiating (47) with respect to τ and $\tilde{H}$, we can obtain the following equation:

$$\frac{d\tilde{H}}{d\tau} = \frac{\frac{\beta\phi'(0)}{L\underline{\mathrm{H}}}\frac{\gamma}{(1+\tau-\gamma\tau)^2} - \frac{\partial Z(1,H_t)}{\partial\psi^*}\frac{\partial\psi^*}{\partial\tau}}{\frac{\partial Z(1,H_t)}{\partial\tilde{H}}}. \tag{C.1}$$

From (46), $\partial Z(1,H_t)/\partial\tilde{H}$ is negative. Then, we focus on the sign of the numerator in the above equation. $\partial Z(1,H_t)/\partial\psi^*$ is given as

$$\frac{\partial Z(1,H_t)}{\partial\psi^*} = \frac{L\tilde{H}}{(F+(1-\psi^*)p^*\tilde{H}^\alpha L)^2}\left[F_{21}(F+(1-\psi^*)p^*\tilde{H}^\alpha L) - \tau p^*\tilde{H}^{\alpha-1}F_2\right] < 0, \tag{C.2}$$

because F_{21} is negative. Then, the second term of the numerator can be rewritten as follows:

$$\begin{aligned}
&\frac{\partial Z(1,H_t)}{\partial\psi^*}\frac{\partial\psi^*}{\partial\tau} \\
&= \frac{p^*\tilde{H}^{\alpha-1}F_{21}}{F_{11}}\frac{1}{F+(1-\psi^*)p^*\tilde{H}^\alpha L} - \frac{\tau p^{*2}\tilde{H}^{2(\alpha-1)}F_2}{F_{11}}\frac{1}{(F+(1-\psi^*)p^*\tilde{H}^\alpha L)^2} \\
&= \frac{p^*\tilde{H}^{\alpha-1}F_{21}}{F_{11}F_2}\frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\psi'(0)}{L\underline{\mathrm{H}}} - \frac{p^{*2}\tilde{H}^{2(\alpha-1)}}{F_{11}F_2}\left(\frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\psi'(0)}{L\underline{\mathrm{H}}}\right)^2.
\end{aligned} \tag{C.3}$$

Therefore, the numerator is given by

$$\frac{\beta\phi'(0)}{L\underline{\mathrm{H}}}\frac{\gamma}{(1+\tau-\gamma\tau)^2}-\frac{\partial Z(1,H_t)}{\partial\psi^*}\frac{\partial\psi^*}{\partial\tau}$$
$$=\frac{1+\tau}{(1+\tau-\gamma\tau)^2}\frac{\beta\phi'(0)}{L\underline{\mathrm{H}}}\left[\frac{\gamma}{1+\tau}-\frac{(1+\tau-\gamma\tau)p^*\tilde{H}^{\alpha-1}F_{21}}{F_{11}F_2}+\frac{(1+\tau)\tau p^{*2}\tilde{H}^{2(\alpha-1)}}{F_{11}F_2}\frac{\beta\phi'(0)}{L\underline{\mathrm{H}}}\right]. \tag{C.4}$$

From Assumption 2, the square bracket is positive. Therefore, the numerator is positive. Then, because the denominator is negative and the numerator is positive, $d\tilde{H}/d\tau$ is negative.

D Proof of Lemma 2

Total differentiating (50) with respect to τ and $\tilde{H}'$, we can obtain the following equation:

$$\frac{d\tilde{H}'}{d\tau}=\frac{\frac{\beta\phi'(1)}{L\bar{H}}\frac{\gamma}{(1+\tau-\gamma\tau)^2}-\frac{\partial Z(0,H_t)}{\partial\psi^*}\frac{\partial\psi^*}{\partial\tau}}{\frac{\partial Z(0,H_t)}{\partial\tilde{H}'}}. \tag{D.1}$$

From (46), $\partial Z(0,H_t)/\partial\tilde{H}'$ is negative. Then, we focus on the sign of the numerator in the above equation. $\partial Z(0,H_t)/\partial\psi^*$ is given as

$$\frac{\partial Z(0,H_t)}{\partial\psi^*}=\frac{L\tilde{H}'}{(F+(1-\psi^*)p^*\tilde{H}'^{\alpha}L)^2}\left[F_{21}(F+(1-\psi^*)p^*\tilde{H}'^{\alpha}L)-\tau p^*\tilde{H}'^{\alpha-1}F_2\right]<0, \tag{D.2}$$

because F_{21} is negative. Then, the second term of the numerator can be rewritten as follows:

$$\frac{\partial Z(0,H_t)}{\partial\psi^*}\frac{\partial\psi^*}{\partial\tau}$$
$$=\frac{p^*\tilde{H}'^{\alpha-1}F_{21}}{F_{11}}\frac{1}{F+(1-\psi^*)p^*\tilde{H}'^{\alpha}L}-\frac{\tau p^{*2}\tilde{H}'^{2(\alpha-1)}F_2}{F_{11}}\frac{1}{(F+(1-\psi^*)p^*\tilde{H}'^{\alpha}L)^2}$$
$$=\frac{p^*\tilde{H}'^{\alpha-1}F_{21}}{F_{11}F_2}\frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\psi'(1)}{L\bar{H}}-\frac{p^{*2}\tilde{H}'^{2(\alpha-1)}}{F_{11}F_2}\left(\frac{1+\tau}{1+\tau-\gamma\tau}\frac{\beta\psi'(1)}{L\bar{H}}\right)^2. \tag{D.3}$$

Therefore, the numerator is given as

$$\frac{\beta\phi'(1)}{L\bar{H}}\frac{\gamma}{(1+\tau-\gamma\tau)^2}-\frac{\partial Z(0,H_t)}{\partial\psi^*}\frac{\partial\psi^*}{\partial\tau}$$
$$=\frac{1+\tau}{(1+\tau-\gamma\tau)^2}\frac{\beta\phi'(1)}{L\bar{H}}\left[\frac{\gamma}{1+\tau}-\frac{(1+\tau-\gamma\tau)p^*\tilde{H}'^{\alpha-1}F_{21}}{F_{11}F_2}+\frac{(1+\tau)\tau p^{*2}\tilde{H}'^{2(\alpha-1)}}{F_{11}F_2}\frac{\beta\phi'(1)}{L\bar{H}}\right]. \tag{D.4}$$

From Assumption 3, the square bracket is positive. Therefore, the numerator is positive. Then, because the denominator is negative and the numerator is positive, $d\tilde{H}^{'}/d\tau$ is negative.

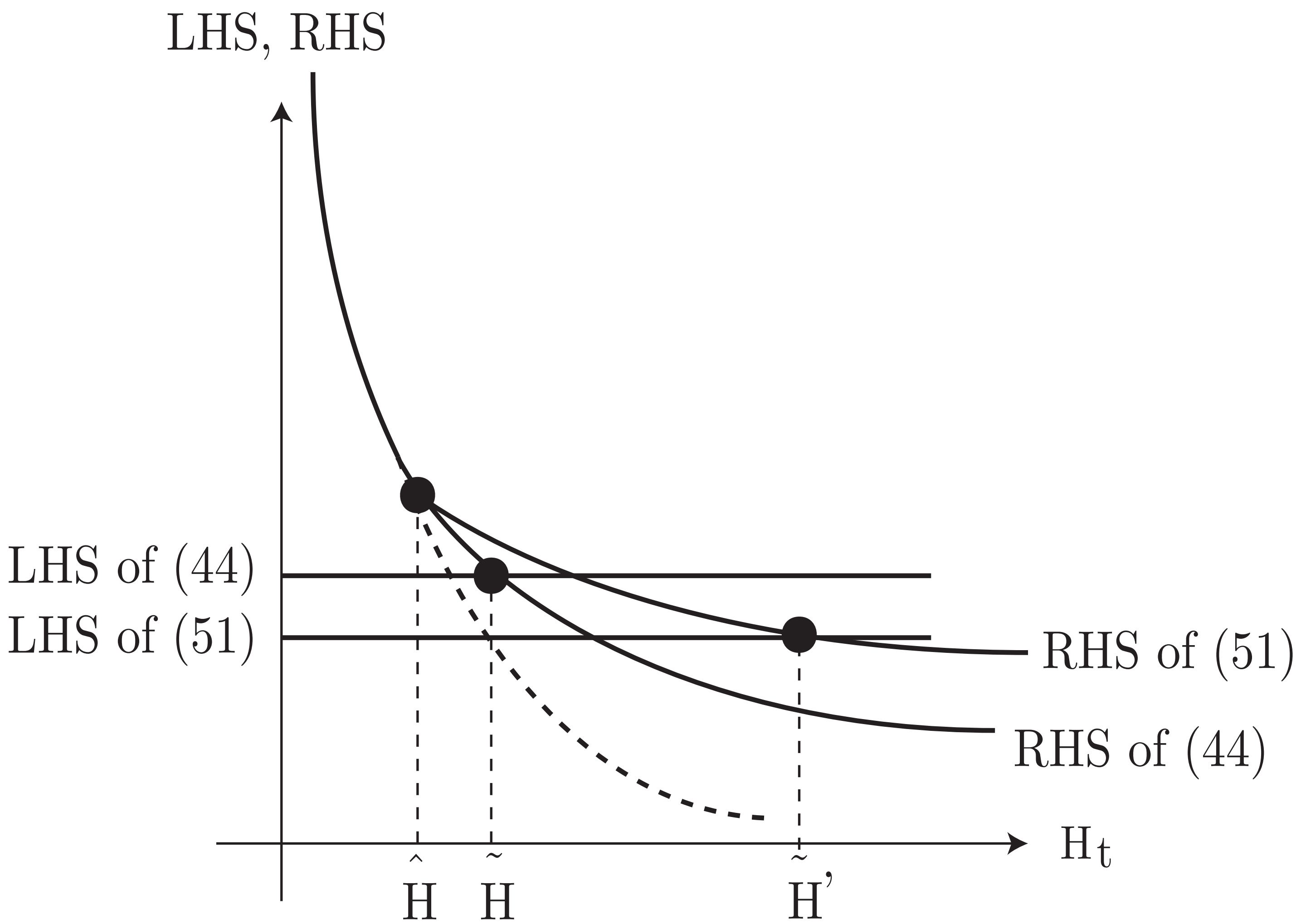

Figure 1: Relationship between (44) and (51)

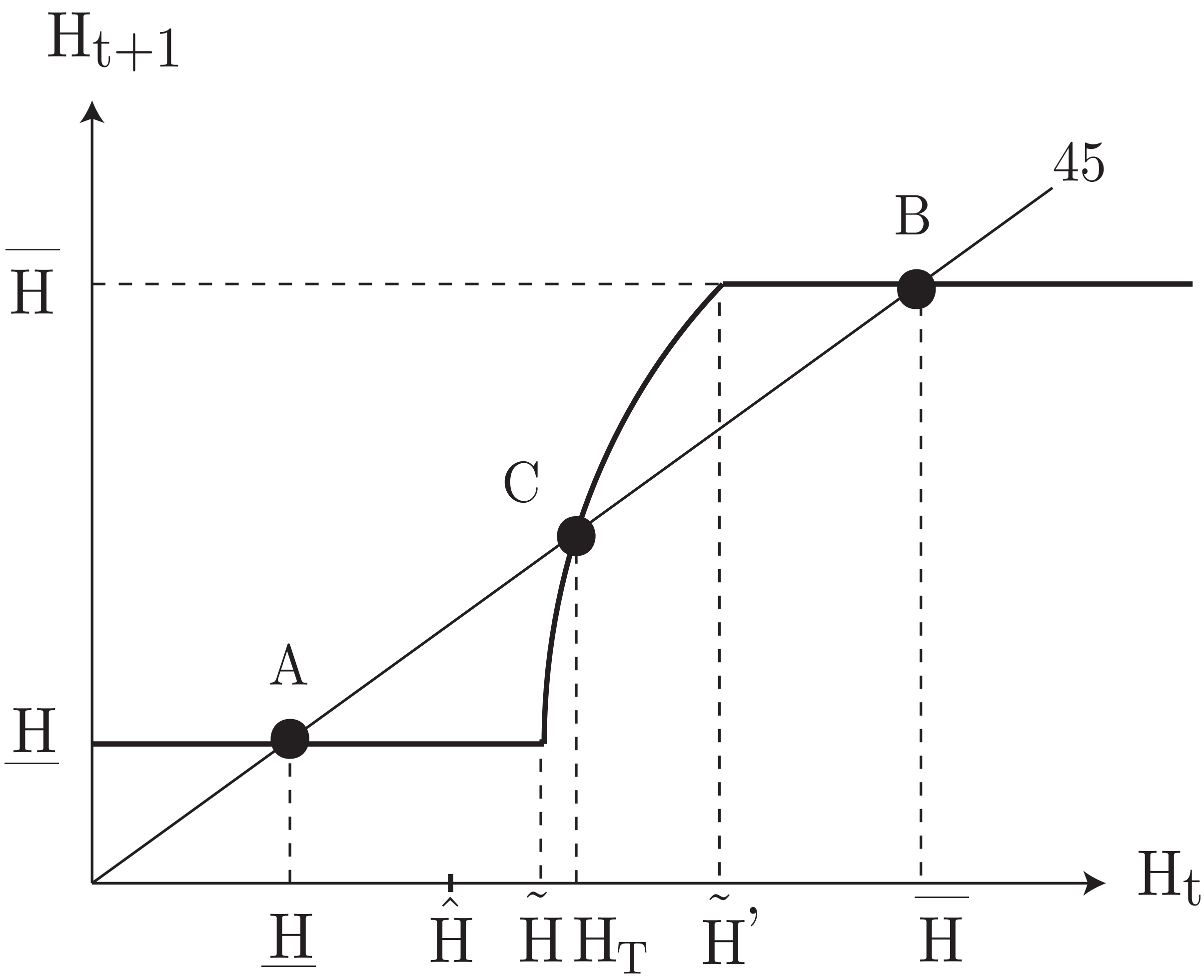

Figure 2: Phase diagram when $\underline{H} < \hat{H} < \tilde{H}$

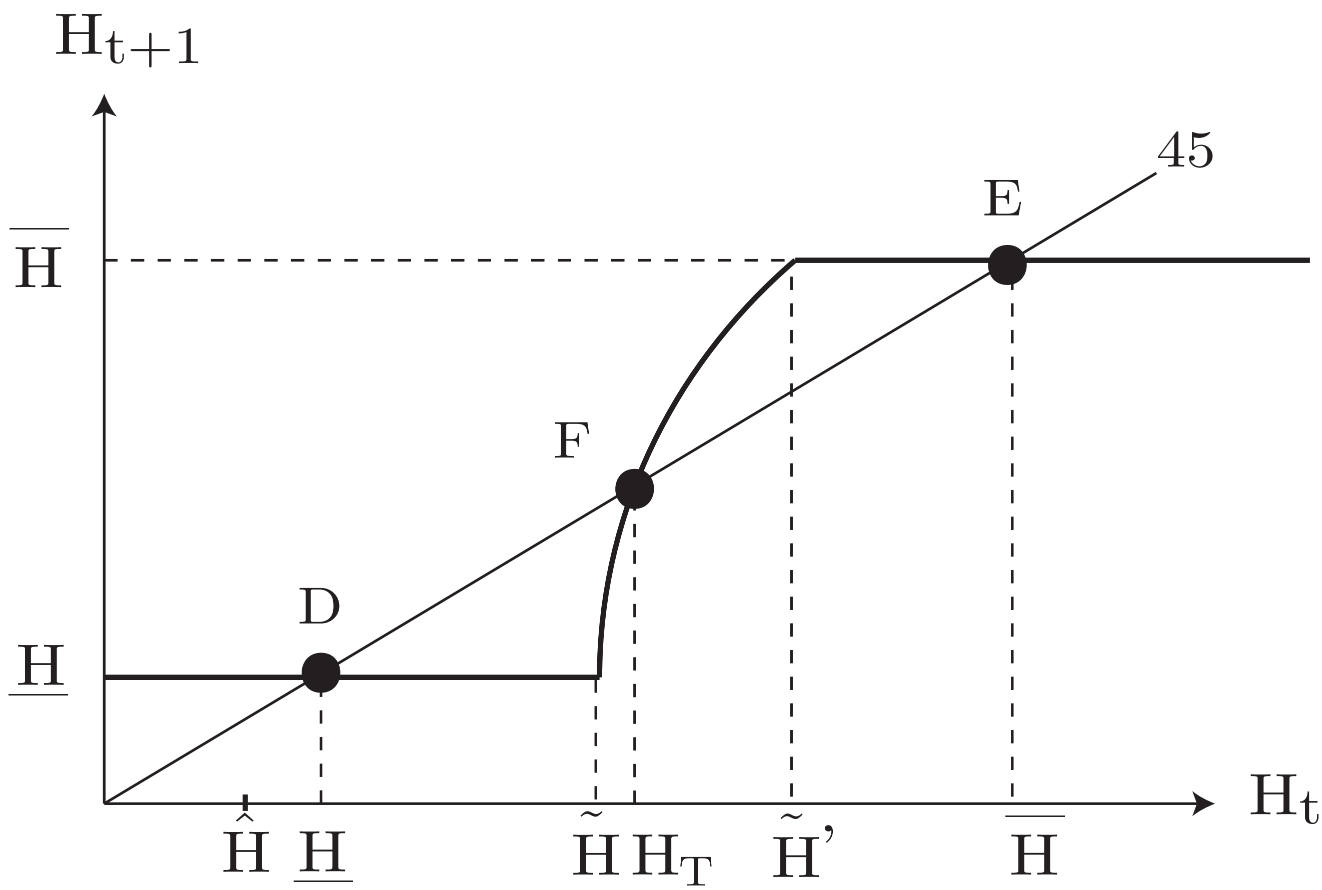

Figure 3: Phase diagram when $\hat{H} < \underline{H} < \tilde{H}$

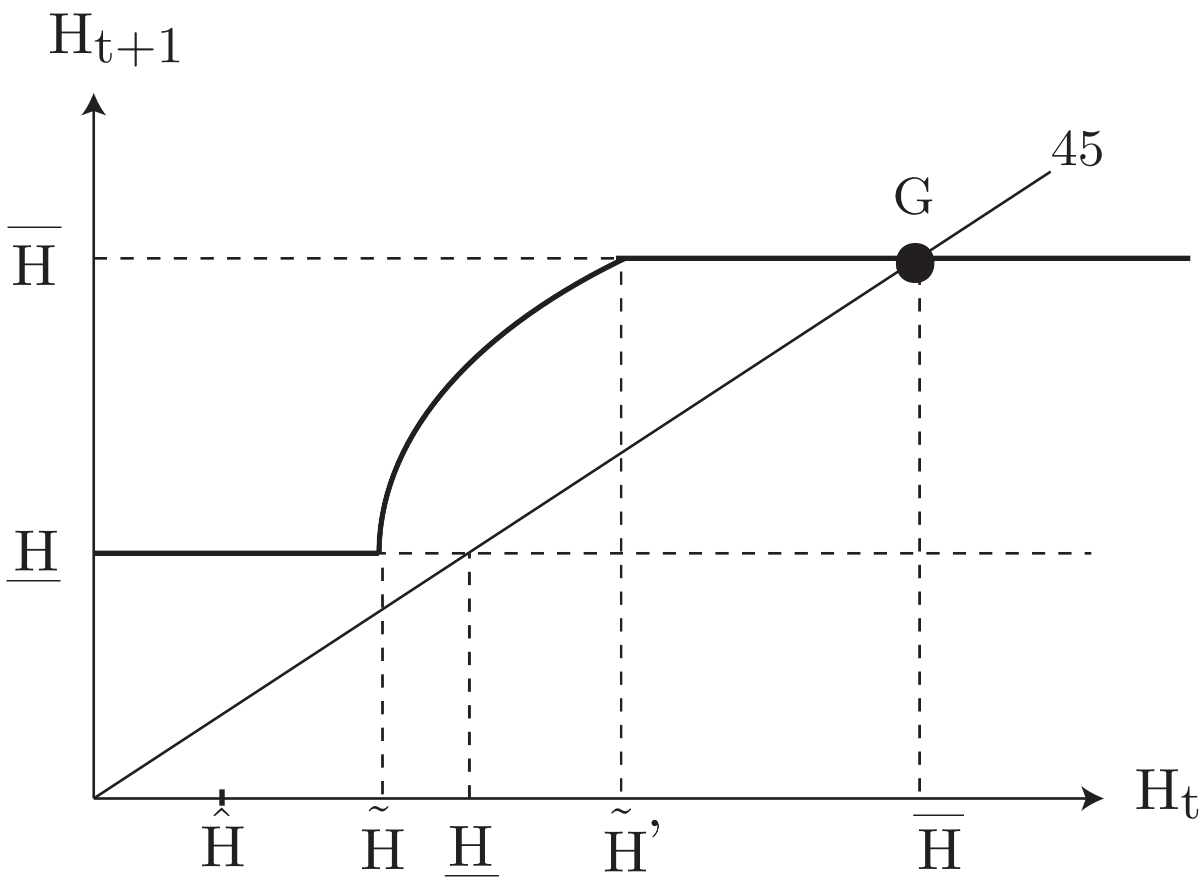

Figure 4: Phase diagram when $\hat{H} < \tilde{H} < \underline{H}$