DOES THE HOST COUNTRY EXPERIENCE THE BRAIN DRAIN OR THE BRAIN GAIN BY ACCEPTING STUDY MIGRANTS?

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Abstract

This study explores the effects of study migrants on the host country's human capital formation under the possibilities of natives' labour migration. Although it has been a controversial issue whether study migrants exert negative or non-negative effects on natives when receiving education, their effects on natives' human capital formation have been overlooked in the previous studies that dealt with human capital formation under migration. This study fills this research gap. By assuming an overlapping generations' economy, this study attempts to clarify whether the host country experiences the brain drain or the brain gain when study migrants have negative effects on the natives' education. This study finds that natives' human capital formation can be enhanced even if study migrants exert negative effects on natives' education. Moreover, study migrants affect natives' migration decision, causing the brain gain as well as the brain drain in a dynamic context, even in a situation in which study migrants do not remain in the host country after education. Furthermore, the host country may experience the brain drain when the government strengthens education quality regulation. These results suggest that it is not unreasonable for the host countries to accept study migrants even when they exert negative effects on natives' education and that the government should not always strengthen the education quality regulation when accepting study migrants.

Keywords: *human capital, labour migration, study migration, brain drain, brain gain, overlapping generations' economy*

1. INTRODUCTION

This study deals with the problem with human capital formation under the mobility of students and workers. In particular, utilising the overlapping generations' model, this study investigates the effects of study migrants on the host country's human capital formation in a situation where study migrants negatively impact native students and educational institutions.

Students and workers often go abroad to receive a better education and to find suitable jobs. Students can be employed in foreign countries where they received an education. They may also gain employment in other foreign countries because their human capital built by an overseas education is transferable to jobs in those countries. Study migration causes labour migration. Moreover, increased job opportunities for non-natives in foreign countries induce students to study abroad. Accordingly, study and labour migrations are enhancing with each other and the numbers of study migrants and labour migrants are increasing simultaneously. Organisation for Economic Co-operation and Development, OECD (2020) estimated the number of international or foreign students enrolled in tertiary education programmes to have reached 5.6 million in 2018. According to International Labour Organization, ILO (2018), 164 million people work as labour migrants in 2017.

This situation created a problem for several countries which send workers abroad. They suffered human capital outflow. Able or potentially able workers leave their home countries, reducing remaining human capital. This created the problem of the brain drain which was initially focused on by Bhagwati and Hamada (1974) and Hamada and Bhagwati (1975). Of course, as Mountford (1997) and Stark et al. (1997) argued, emigration or its possibilities can increase the sending country's human capital and that they may experience the brain gain. However, which of the brain drain or the brain gain happens cannot be determined a priori (Beine et al., 2011; Zhang and Lucey, 2019).

As a result, many countries attempted to accept skilled foreign workers to cope with decreasing human capital. However, such a policy was difficult to accomplish due to fierce competition for skilled

foreign workers among countries (Docquier and Machado, 2016), and the situation was not easily remedied. This is also related to the issues of selecting immigrant workers by referring to their education level (Bertoli and Stillman, 2019) and the limited transferability of their human capital (Chiswick and Miller, 1992, 2009; Basilio et al., 2017).

Certain countries attempted to generate human capital domestically by accepting able study migrants to complement the skilled labour migrants' acceptance policy. The host country provides foreign students with education. If the host country can induce them to remain in the country after education as workers, then their human capital is added to the country's domestic human capital. Their human capital tends to be suitable to the host country, thus creating an increasing effect on the host country's total human capital (Gribble, 2008; Bhandari et al., 2019).

Native students usually receive an education with study migrants. In the migration literature, their human capital formation is usually assumed to be unaffected by study migrants. However, this issue has been controversial and various results have been derived. Brunello and Rocco (2013), Green and Iversen (2020), Frattini and Meschi (2019) and Bossavie (2018) found the negative effect, whereas Neymotin (2009), Chachashvili-Bolotin et al. (2016) and Hunt (2017) found the non-negative or positive effect. Also, the mixed-effects were found by Seah (2020). Unlike the situation assumed implicitly in the migration literature, study migrants may affect natives' human capital formation negatively, i.e. their effects are not always positive or neutral. Previous studies on labour migration did not take account these possibilities into account. This is a research gap that needs to be filled with.

Since study migrants may hinder the natives' education and human capital formation, the host country's total human capital might be smaller than otherwise, even if the host country accepted study migrants and their human capital were added. That is, they might experience the brain drain. In other words, natives may be encouraged to build larger human capital due to higher wages in a foreign country. However, their education demand may not increase or decrease due to the negative effects of study migrants. As a result, their human capital does not increase significantly even with the migration possibilities and human capital outflow can outweigh their increased human capital. In such a case, the country experiences the brain drain.

This study examines whether the host country experiences the brain drain or the brain gain when accepting study migrants, considering their effects on natives' education and human capital formation. Students are generally affected by their co-students and educational institutions. This study explicitly assumes that study migrants negatively affect natives' human capital formation in the host country not only via native students but also via educational institutions.

This study finds that study migrants affect natives' human capital formation through the educational institution and native students in a different manner. The educational institution accepts fewer study migrants if inconvenience they cause is more serious, for example, if the institution requires larger teaching efforts. However, this increases individual natives' average human capital and utility. In contrast, study migrants have negative effects on natives. Although natives' non-pecuniary costs for receiving education do not change with the number of acceptance, they reduce individual native's education demand, reducing their human capital and utility.

This study also finds that natives do not always attempt to migrate. When average human capital is low, they can increase their utility by not attempting migration. Thus, neither the brain drain nor the brain gain occurs at the low level of the average human capital. After it has exceeded a certain level, either the brain drain or the brain gain occurs. The brain drain or the brain gain in the home country (the host country of study migrants) is associated with the wage disparity between the home country and natives' migration destination. The brain gain occurs when the wage disparity is large, whereas the home country experiences either the brain gain or the brain drain when the wage disparity is small.

Furthermore, although government regulation on education quality effectively increases individual native's human capital and utility, the brain drain becomes likely to happen.

These results suggest that countries have a good reason to accept study migrants even if they exert negative effects on natives' education, whereas it is not necessarily reasonable for the government to raise the education quality constraint when accepting study migrants.

The contribution of this study is threefold. Firstly, unlike previous studies on human capital formation under migration, the brain drain or the brain gain occurs in a dynamic context via the effects of study migrants on the natives' migration decision. Since all study migrants are assumed to leave the host country after education in the analysis, their human capital does not become part of the host country's human capital. This occurs by the effects of study migrants on natives' labour migration decision. The brain drain or the brain gain happens only due to changes in the natives' human capital. Secondly, to address the issue of whether study migrants have positive or negative effects on the host country, this study reveals that the mechanism of how study migrants affect the host country has to be specified accurately to determine their effects on natives' human capital. Thirdly, the government should not always tighten the education quality regulations. Such a policy may cause the brain drain.

The remaining of this study is structured as follows: Section 2 refers to the methodology of this study. Section 3 models the dynamic economy with overlapping generations connected with the rest of the world via the acceptance of study migrants and emigration of native workers. Section 4 provides solutions to maximisation problems and determines natives' utility and human capital. Section 5 derives human capital evolution and examines education policy impacts. Lastly, Section 6 provides the concluding remarks.

2. THE METHODOLOGY

This study adopts the analytical method. In particular, this study builds the overlapping generations' model to find the effects of accepting study migrants on the natives' migration decisions and their human capital formation. These effects can be found by solving the utility maximization problems of natives and the educational institution in the dynamic context. Clearly, the empirical analyses on these issues should follow, but this is beyond the scope. Even so, results derived from the mathematical model will offer the basis for them.

3. THE MODEL

This section builds the model that describes the dynamic economy with overlapping generations, connected with the rest of the world via immigration of study migrants and emigration of native workers.

3.1. The Economy

The economy (the home country for natives, hereafter the *home* country) receives study migrants from the rest of the world (the foreign country for natives, hereafter the *foreign* country) and sends natives as workers to the *foreign* country (the study migrants' home country and the natives' destination do not necessarily coincide, but this does not matter in the analysis).

Natives and study migrants live for two periods, namely young and old ages. In the young age, both receive education in the home country, whereas they work in the old age. Natives may attempt to migrate to the foreign country to work or they may remain in the home country to work. All study migrants leave the home country after education. They do not remain in the home country to work and do not contribute to the home country's human capital. This assumption is to make the effects of study migrants on natives' human capital formation and their decision on labour migration clear.

In each period there are a fixed number of natives in the young age who are homogenous. The educational institution determines the number of study migrants subject to the government's education quality regulation. Study migrants are also homogenous. They exert negative effects on the home country via native students and the educational institution.

Two overlapping generations exist. Human capital accumulated by previous generation is partly transmitted to the present generation via the intergenerational externality.

3.2. Natives

An individual native student receives an education in the young age in the home country and builds human capital to be utilised in providing labour in the old age.

By receiving education in period t by e_t, an individual native who was born at the beginning of period t builds human capital that becomes available in his old age and is utilised when working in period $t+1$ by $\tilde{h}_{t+1}$. In principle, human capital is built via

$$\tilde{h}_{t+1} = a^{\frac{1}{2}} e_t h_t^{\frac{1}{2}}$$

where $a > 0$ is a given constant that represents the innate ability of a native. In the following, a is going to assumed to be sufficiently large so that steady state human capital exists. Due to the intergenerational externality, average human capital available to each native in the young age in period t (the home country's total human capital in period t divided by the number of natives in the young age $\bar{N}$) h_t contributes to natives' human capital formation when h_t is not large. However, when it becomes sufficiently large, it ceases to impact further native students' human capital formation. In particular, if $h_t \geq \bar{h}$,

$$\tilde{h}_{t+1} = a^{\frac{1}{2}} e_t \bar{h}^{\frac{1}{2}}$$

Accordingly, individual natives' human capital formation can be summarised as

$$\tilde{h}_{t+1} = \begin{cases} a^{\frac{1}{2}} e_t h_t^{\frac{1}{2}} & \text{if } 0 \leq h_t < \bar{h} \\ a^{\frac{1}{2}} e_t \bar{h}^{\frac{1}{2}} & \text{if } h_t \geq \bar{h} \end{cases}$$

Native students incur pecuniary and non-pecuniary education costs to receive an education. The fee to the educational institution is the pecuniary cost. This study assumes that the fee has to be financed privately. Marginal pecuniary cost increases with the amount of education. For the non-pecuniary cost, this study explicitly assumes that study migrants negatively impact native students when receiving education. For example, native students often face the communication problem with study migrants. Marginal non-pecuniary cost is also increasing. We express such non-pecuniary costs in monetary terms. Summing up these costs, we represent the total cost for native students to receive education by e_t in period t by

$$\frac{1}{2}\left(1 + \frac{\alpha M_t}{\bar{N}}\right) e_t^2$$

where $\alpha > 0$ measures the degree of negative effects that study migrants exert on native students, $M \geq 0$ is the number of study migrants, which is determined by the educational institution and $\bar{N} > 0$ is the number of native students (the number of natives in the young generation), which is given and remains unchanged throughout the analysis.

Natives in the old age have two cases, i.e. non-labour and labour migration. If migration is impossible, or it is not attempted by natives even if it is possible, the individual natives' human capital formation can be summarised as

$$\tilde{h}_{t+1}^{NM} = \left\{ \begin{array}{ll} a^{\frac{1}{2}} e_{NMt} h_t^{NM\frac{1}{2}} & \text{if } 0 \le h_t^{NM} < \bar{h} \\ a^{\frac{1}{2}} e_{NMt} \bar{h}^{\frac{1}{2}} & \text{if } h_t^{NM} \ge \bar{h} \end{array} \right\} \quad (1)$$

$$= h_{t+1}^{NM}$$

where e_{NMt} is education demand by native students at period t when migration does not occur.

In this case, all human capital built by natives in their young age remains in the home country in their old age. Thus, human capital built by an individual native student who was born at the beginning of period t, that becomes available in his old age and is utilised when working in period $t+1$, $\tilde{h}_{t+1}^{NM}$ is equal to the average human capital available to each native in the young age in period $t+1$ (the home country's total human capital in period $t+1$ divided by the number of natives in the young age $\bar{N}$) h_{t+1}^{NM}.

Assuming the home country's wages per efficiency are 1, an individual native born at the beginning of period t derives lifetime utility when migration does not happen by

$$U_{t,t+1}^{NM} = h_{t+1}^{NM} - \frac{1}{2}\left(1 + \frac{\alpha M_t}{\bar{N}}\right) e_{NMt}^2 \quad (2)$$

where the time discount factor is disregarded for simplification.

Accordingly, an individual native determines the amount of education by solving the following maximisation problem when migration does not happen.

$$\max_{e_{NMt}} U_{t,t+1}^{NM}$$

Given the amount of study migrants, the solution to this problem determines the optimal amount of human capital and utility that can be realised when labour migration does not happen.

On the other hand, if labour migration is possible and individual natives attempt to migrate to the foreign country, then the individual natives' human capital formation can be summarised as

$$\tilde{h}_{t+1}^{M} = \left\{ \begin{array}{ll} a^{\frac{1}{2}} e_{Mt} h_t^{M\frac{1}{2}} & \text{if } 0 \le h_t^{M} < \bar{h} \\ a^{\frac{1}{2}} e_{Mt} \bar{h}^{\frac{1}{2}} & \text{if } h_t^{M} \ge \bar{h} \end{array} \right\} \quad (3)$$

$$\neq h_{t+1}^{M}.$$

where $\tilde{h}_{t+1}^{M}$ is the human capital built by an individual native student born at the beginning of period t that becomes available in his old age and is utilised in period $t+1$ when migration can happen, e_{Mt} is education demand by native students in period t when migration can happen and h_t^M (h_{t+1}^M) is the average human capital available to each native in the young age in period t ($t+1$) (the home country's total human capital in period t ($t+1$) divided by the number of natives in the young age $\bar{N}$) when migration can happen. It should be noticed that since in this case a certain number of individual natives in the old age migrate to the foreign country, $\tilde{h}_{t+1}^{M}$ does not coincide with h_{t+1}^{M}. Particularly, $h_{t+1}^{M} < \tilde{h}_{t+1}^{M}$.

An individual native in the old age more likely migrates to the foreign country to work if he has a larger human capital. Particularly, the migration probability in period $t+1$, p_{t+1}, for a native with human capital $\tilde{h}_{t+1}$ is

$$p_{t+1} = \bar{\theta}\left(1 - \frac{1}{\tilde{h}_{t+1}}\right) \tag{4}$$

where $1 > \bar{\theta} > 0$ is a given constant that represents the degree of overall ease of labour migration.

When migration is possible and attempted, an individual native born at the beginning of period t derives the lifetime utility by

$$U^{M}_{t,t+1} = p_{t+1}\tilde{h}^{M}_{t+1}w^{*} + (1-p_{t+1})\tilde{h}^{M}_{t+1} - \frac{1}{2}\left(1 + \frac{\alpha M_t}{\bar{N}}\right)e^{2}_{Mt} \tag{5}$$

where $w^{*} > 1$ is the foreign country's wages per efficiency after deducting the migration cost. Due to the wage disparity, it is higher than 1. The time discount factor is disregarded for simplicity.

Accordingly, an individual native's education demand is determined by solving the following maximisation problem when labour migration is possible and attempted.

$$\max_{e_{Mt}} U^{M}_{t,t+1}$$

Given the number of study migrants, the solution to this problem determines the optimal amount of human capital and utility that can be realised when labour migration is possible and attempted.

3.3. Educational Institution

The educational institution's revenue is the fee paid by native and migrant students. Wages paid to teachers are assumed to be the only cost for providing education. Their profit must be non-negative, i.e.

$$f\bar{N} + fM_t - \bar{\tau}h_t \geq 0$$

where f is a constant that represents the fee, $\bar{\tau}$ is the number of teachers, which is given and remains unchanged throughout the analysis, h_t represents the wages paid to individual teachers in period t because h_t is the average human capital in that period and wages per efficiency units of labour are 1. The non-negative profit constraint can be rewritten as

$$M_t \geq \frac{\bar{\tau}(h_t - \hat{h})}{\bar{f}}$$

where $\hat{h}$ is such that $f\bar{N} - \bar{\tau}\hat{h} = 0$. Since $M \geq 0$ and $\bar{\tau}(h_t - \hat{h})/\bar{f}$ can be negative, the constraint on profit is formally expressed as

$$M_t \geq \max\left[0,\ \frac{\bar{\tau}(h_t - \hat{h})}{f}\right]$$

Teachers spend more time managing study migrants than native students to provide the same amount of education. For example, study migrants lack understanding of the local language and customs. Thus, one study migrant is equivalent to $\beta \geq 1$ native students for teachers. It is assumed that β does

not change throughout the analysis. Accordingly, the effective number of students in terms of a native student is $\bar{N} + \beta M$.

This study defines education quality by the teachers' total human capital divided by the effective number of students $\bar{\tau} h_t / (\bar{N} + \beta M_t)$. The government regulates education quality. The educational institution must satisfy the education quality regulation

$$\frac{\bar{\tau} h_t}{\bar{N} + \beta M_t} \geq \varepsilon_t \frac{\bar{\tau} h_t}{\bar{N}}, \; 0 < \bar{\varepsilon}_{\min} \leq \varepsilon_t \leq \bar{\varepsilon}_{\max} < 1$$

where ε_t is the education quality coefficient. The government manipulates ε_t. The maximum and minimum education quality are $\bar{\varepsilon}_{\max}$ and $\bar{\varepsilon}_{\min}$, respectively. This constraint can be rewritten as

$$M_t \leq \frac{1}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\bar{N}$$

This condition suggests that the number of study migrants must be lower than the threshold determined by education quality regulation. This factor is another constraint that the educational institution faces.

The educational institution pursues to be renowned for its quality while earning high profit. Raising education quality and increasing profits are usually in the trade-off relationship. This study assumes that the educational institution does not emphasise education quality more than profits and represents utility of the educational institution by

$$V_t = \lambda \ln(f\bar{N} + fM_t - \bar{\tau} h_t) + (1-\lambda) \ln \frac{\bar{\tau} h_t}{\bar{N} + \beta M_t}, \; 0.5 \leq \lambda < 1 \tag{6}$$

The educational institution maximises its utility by manipulating the number of study migrants.

Accordingly, the problem of the educational institution is stated as

$$\max_{M_t} V_t \text{ subject to } M_t \geq \max\left[0, \; \frac{\bar{\tau}(h_t - \hat{h})}{f}\right], \; M_t \leq \frac{1}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\bar{N}, \; 0.5 \leq \lambda < 1$$

In general, the following inequality is possible if $\bar{N}$ is small

$$\frac{1}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\bar{N} < \max\left[0, \; \frac{\bar{\tau}(h_t - \hat{h})}{f}\right]$$

If this is the case, the educational institution cannot satisfy the profit constraint and education quality regulation simultaneously. However, because $\bar{N}$ is usually large, it is possible to assume that $\bar{N}$ is sufficiently large so that the following condition holds

$$\max\left[0, \; \frac{\bar{\tau}(h_t - \hat{h})}{f}\right] < \frac{1}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\bar{N}$$

Under this assumption, the maximisation problem of the educational institution is encapsulated as

$$\max_{M_t} V_t \text{ subject to}$$

$$\max\left[0, \; \frac{\bar{\tau}(h_t - \hat{h})}{f}\right] \leq M_t \leq \frac{1}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\bar{N} \tag{7}$$

$$0.5 \leq \lambda < 1$$

4. UTILITY AND HUMAN CAPITAL

This section solves natives' and the educational institution's maximisation problems to determine individual natives' utility and the home country's average human capital. We first solve the educational institution's problem and then that of the natives.

By differentiating Equation (6), we find that the educational institution's profit increases with the number of study migrants, i.e. $dV_t / dM_t > 0$. Accordingly, the optimal number of study migrants for the educational institution is

$$M_t = \frac{1}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\bar{N} \tag{8}$$

Equation (8) suggests that as study migrants cause more inconvenience to teachers, i.e. β is larger, the educational institution accepts few study migrants. Also, as the government tightens the education quality regulation, i.e. ε_t is larger, their number is smaller.

Regarding the natives' maximisation problem, when labour migration is impossible or when natives do not attempt to migrate even if it is possible, an individual native demands education by

$$e_t^{NM} = a^{\frac{1}{2}}\left(1 + \frac{\alpha M_t}{\bar{N}}\right)^{-1} {h_t^{NM}}^{\frac{1}{2}}$$

By substituting Equation (8) into the above equation and then substituting the resulting equation into Equation (1), the evolution of the average human capital available to each native in the young age in period $t+1$ when labour migration does not happen is

$$h_{t+1}^{NM} = \begin{cases} a\left\{1 + \frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\right\}^{-1} h_t^{NM} & \text{if } 0 \leq h_t^{NM} < \bar{h} \\ a\left\{1 + \frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\right\}^{-1} \bar{h} & \text{if } h_t^{NM} \geq \bar{h} \end{cases} \tag{9}$$

where a is assumed to be sufficiently large so that $dh_{t+1}^{NM} / dh_t^{NM} > 1$. The evolution of h^{NM} is equivalent to that of the home country's total human capital when labour migration does not happen because its total human capital is $h^{NM}\bar{N}$. Equation (9) suggests that as the negative effect of study migrants on native students becomes more serious, i.e. α is higher, the average human capital decreases because native students reduce education demand. In contrast, as study migrants cause more inconvenience to teachers, i.e. β is higher, or as the government's education quality regulation becomes stricter, i.e. ε_t is higher, the average human capital increases because the educational institution reduces the acceptance of study migrants and this raises native students' education demand.

By substituting Equation (9) into Equation (2), the maximised utility of an individual native under non-labour migration in period $t+1$ is calculated as

$$\hat{U}_{t,t+1}^{NM} = \begin{cases} \frac{a}{2}\left\{1+\frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t}-1\right)\right\}^{-1} h_t^{NM} & \text{if } 0 \le h_t^{NM} < \bar{h} \\ \frac{a}{2}\left\{1+\frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t}-1\right)\right\}^{-1} \bar{h} & \text{if } h_t^{NM} \ge \bar{h} \end{cases} \quad (10)$$

According to Equation (10), individual natives achieve lower utility in period $t+1$ when study migrants seriously negatively impact native students. The reason is that the average human capital in period $t+1$ and native students' wages are lower. By contrast, individual natives can achieve higher utility in period $t+1$ when study migrants cause inconvenience to teachers or when the government strengthens education quality regulation because the average human capital in period $t+1$ and native students' wages are higher.

Now, we move on to another case. When labour migration is possible and individual natives can migrate to the foreign country, an individual native demands education by

$$e_t^M = \{1+\bar{\theta}(w^*-1)\}a^{\frac{1}{2}}\left(1+\frac{\alpha M_t}{\bar{N}}\right)^{-1} h_t^{M\frac{1}{2}}$$

Substituting Equation (8) into the above equation and then the resulting equation into Equation (3),

$$\tilde{h}_{t+1}^M = \begin{cases} \{1+\bar{\theta}(w^*-1)\}a\left\{1+\frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t}-1\right)\right\}^{-1} h_t^M & \text{if } 0 \le h_t^M < \bar{h} \\ \{1+\bar{\theta}(w^*-1)\}a\left\{1+\frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t}-1\right)\right\}^{-1} \bar{h} & \text{if } h_t^M \ge \bar{h} \end{cases}$$

An individual native migrates to the foreign country with probability p_{t+1} in period $t+1$. Thus, the average human capital available to each native in the young age in period $t+1$ (the home country's total human capital in period $t+1$ divided by the number of natives in the young age $\bar{N}$) h_{t+1}^M is equal to $(1-p_{t+1})\tilde{h}_{t+1}^M$. Accordingly, the evolution of the average human capital available to each native in the young age when labour migration is possible is

$$h_{t+1}^M = \begin{cases} (1-\bar{\theta})\{1+\bar{\theta}(w^*-1)\}a\left\{1+\frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t}-1\right)\right\}^{-1} h_t^M + \bar{\theta} & \text{if } 0 \le h_t^M < \bar{h} \\ (1-\bar{\theta})\{1+\bar{\theta}(w^*-1)\}a\left\{1+\frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t}-1\right)\right\}^{-1} \bar{h} + \bar{\theta} & \text{if } h_t^M \ge \bar{h} \end{cases} \quad (11)$$

In this case, the more serious the negative effect of study migrants on native students, i.e. α is higher, the smaller is the average human capital. Also, the more inconvenience study migrants cause to teachers, i.e. β is higher, or the stricter the government's education quality regulation, i.e. ε_t is higher, the larger is the average human capital.

An individual native's maximised utility in period $t+1$ when migration happens is derived by substituting Equation (11) into Equation (5).

$$\hat{U}_{t,t+1}^{M}=\begin{cases}\{1+\bar{\theta}(w^{*}-1)\}^{2}\dfrac{a}{2}\left\{1+\dfrac{\alpha}{\beta}\left(\dfrac{1}{\varepsilon_{t}}-1\right)\right\}^{-1}h_{t}^{M}-\bar{\theta}(w^{*}-1) & \text{if } 0\le h_{t}^{M}<\bar{h}\\ \{1+\bar{\theta}(w^{*}-1)\}^{2}\dfrac{a}{2}\left\{1+\dfrac{\alpha}{\beta}\left(\dfrac{1}{\varepsilon_{t}}-1\right)\right\}^{-1}\bar{h}-\bar{\theta}(w^{*}-1) & \text{if } h_{t}^{M}\ge\bar{h}\end{cases} \quad (12)$$

Utility is lower in period $t+1$ when study migrants' negative effect on native students is more serious because the average human capital in period $t+1$ and native students' wages are lower. In contrast, utility is higher when study migrants cause more inconvenience to teachers or when the government's education quality regulation is stricter. The reason is that the average human capital in period $t+1$ and native students' wages are higher in these cases.

A comparison between Equations (9) and (11) and Equations (10) and (12) reveals that whether the average human capital and utility are higher under non-labour or labour migration cannot be determined a priori.

To summarise the results of this section, regardless of whether under non-labour or labour migration, average human capital and natives' utility decrease with study migrants' negative effects on native students, whereas they increase with the degree of the inconvenience they cause and the government's regulation. However, whether the average human capital is higher under non-labour or labour migration cannot be determined a priori. Also, it is not sure whether natives can attain higher utility by attempting labour migration. This suggests that consequences for the brain drain or the brain gain cannot be established in general. (13)

5. THE MIGRATION DECISION, THE EVOLUTION OF HUMAN CAPITAL AND THE EDUCATION POLICY

Firstly, this section examines the natives' migration decision by comparing the utility under non-labour and labour migration. Secondly, the evolution of the average human capital is derived and whether the brain drain or the brain gain happens is explored. Thirdly, given the results on the human capital, this section considers how the government should implement the education policy.

5.1. The Migration Decision

By comparing utility represented by Equations (10) and (12), individual natives determine whether they attempt labour migration or not. Natives do not attempt migration and it does not happen in period $t+1$ if $\hat{U}_{t,t+1}^{NM}>\hat{U}_{t,t+1}^{M}$, whereas they attempt it and some of them actually migrate in period $t+1$ if $\hat{U}_{t,t+1}^{NM}<\hat{U}_{t,t+1}^{M}$. Their decision in period $t+1$, i.e. the ranking of utility, depends on the average human capital available to them in the young age in period *t*. Particularly,

if $h_{t}<\{2+\bar{\theta}(w^{*}-1)\}^{-1}\left(\dfrac{a}{2}\right)^{-1}\left\{1+\dfrac{\alpha}{\beta}\left(\dfrac{1}{\varepsilon_{t}}-1\right)\right\}\left(\equiv h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}\right)$, then natives do not attempt labour migration,

if $h_{t}\ge h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$, then natives attempt labour migration.

Since $\bar{h}$ is assumed to be sufficiently large, $h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$ is smaller than $\bar{h}$. **Fig. 1** illustrates Equations (13).

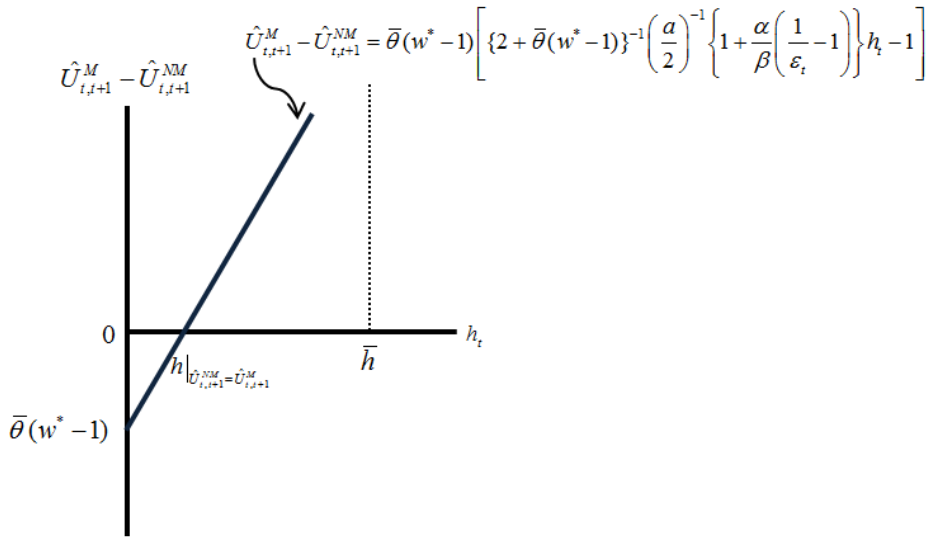


Fig. 1 Comparison of utility under labour migration and non-labour migration

If the average human capital available to each native in the young age is small, then human capital generated by natives is small and the migration probability is low. In such a case, labour migration does not generate high expected wages and thereby natives do not attempt to migrate. Labour migration does not happen. After h_t exceeded $h\big|_{\hat{U}^{NM}_{t,t+1}=\hat{U}^{M}_{t,t+1}}$, the migration probability becomes high enough for labour migration to be profitable. Labour migration happens.

When the foreign country's wages per efficiency are higher, education is more profitable and natives build larger human capital. When the number of study migrants is smaller due to stricter government regulation, non-pecuniary education cost is smaller and large human capital is built. In these cases, natives attempt migration at the lower value of h_t. In other words, $\partial h\big|_{\hat{U}^{NM}_{t,t+1}=\hat{U}^{M}_{t,t+1}} \big/ \partial w^*$, $\partial h\big|_{\hat{U}^{NM}_{t,t+1}=\hat{U}^{M}_{t,t+1}} \big/ \partial \varepsilon_t < 0.$

In sum, labour migration does not always happen. Neither the brain drain nor the brain gain happens when the average human capital is small. When the foreign country's wages are high or the government's education regulation is strict, natives are likely to attempt labour migration at the low level of average human capital.

5.2. The Evolution of Average Human Capital

Utilising Equations (9), (11) and (13), the evolution of the average human capital available to each native can be summarised as

$$\text{if } 0 \le h_t < h\big|_{\hat{U}^{NM}_{t,t+1}=\hat{U}^{M}_{t,t+1}}, \text{ then } h_{t+1} = a\left\{1 + \frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\right\}^{-1} h_t \left(\equiv h^{NM}_{t+1}\Big|_{0 \le h_t < h\big|_{\hat{U}^{NM}_{t,t+1}=\hat{U}^{M}_{t,t+1}}}\right)$$

$$\text{if } \bar{h} > h_t \ge h\big|_{\hat{U}^{NM}_{t,t+1}=\hat{U}^{M}_{t,t+1}}, \text{ then } h_{t+1} = (1-\bar{\theta})\{1 + \bar{\theta}(w^* - 1)\}a\left\{1 + \frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\right\}^{-1} h_t + \bar{\theta}\left(\equiv h^{M}_{t+1}\Big|_{\bar{h} > h_t \ge h\big|_{\hat{U}^{NM}_{t,t+1}=\hat{U}^{M}_{t,t+1}}}\right)$$

$$\text{if } h_t \ge \bar{h}, \text{ then } h_{t+1} = (1-\bar{\theta})\{1 + \bar{\theta}(w^* - 1)\}a\left\{1 + \frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t} - 1\right)\right\}^{-1} \bar{h} + \bar{\theta}\left(\equiv h^{M}_{t+1}\Big|_{h_t \ge \bar{h}}\right)$$

To determine whether the home country experiences the brain drain or the brain gain, it must be clarified whether the average human capital is higher when labour migration is not attempted or when it is attempted.

For given average human capital in period t, it cannot be determined a priori which of h_{t+1}^{NM} and h_{t+1}^{M} is higher since when $\bar{h} > h_t \geq h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$

$$h_{t+1}^{M} - h_{t+1}^{NM} = \left[(1-\bar{\theta})\{1+\bar{\theta}(w^{*}-1)\}-1\right] a\left(1+\frac{\alpha M}{\bar{N}}\right)^{-1} h_t + \bar{\theta}$$

can be negative, 0 or positive. The sign varies with the magnitude of the wage disparity. Particularly,

if the wage disparity is large and $(1-\bar{\theta})\{1+\bar{\theta}(w^{*}-1)\} \geq 1$, then $h_{t+1}^{M} > h_{t+1}^{NM}$ for any $h_t \geq 0$

In contrast,

if the wage disparity is small and $(1-\bar{\theta})\{1+\bar{\theta}(w^{*}-1)\} < 1$,

then $h_{t+1}^{M} > h_{t+1}^{NM}$ when $0 \leq h_t < \left[1-(1-\bar{\theta})\{1+\bar{\theta}(w^{*}-1)\}\right]^{-1} a^{-1}\left\{1+\frac{\alpha}{\beta}\left(\frac{1}{\varepsilon_t}-1\right)\right\}\bar{\theta}\left(\equiv h\big|_{h_{t+1}^{M}=h_{t+1}^{NM}}\right)$

and $h_{t+1}^{M} < h_{t+1}^{NM}$ when $h_t \geq h\big|_{h_{t+1}^{M}=h_{t+1}^{NM}}$

where $h\big|_{h_{t+1}^{M}=h_{t+1}^{NM}}$ is found to be larger than $h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$.

Accordingly, if the wage disparity is large so that $(1-\bar{\theta})\{1+\bar{\theta}(w^{*}-1)\} \geq 1$, then the average human capital is built by h_{t+1}^{NM} when $h_t < h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$. Since natives do not attempt migration, neither the brain drain nor the brain gain happens in this area. When $h_t \geq h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$, the average human capital is h_{t+1}^{M} because natives attempt migration. This amount is higher than that would be built if natives did not attempt migration. Thereby the brain gain occurs in this area in the short run. Steady-state human capital under labour migration h_{LR}^{M} is also higher than that would be built if migration was not attempted h_{LR}^{NM}. Thereby, the brain gain happens in the long run (see **Fig.2**).

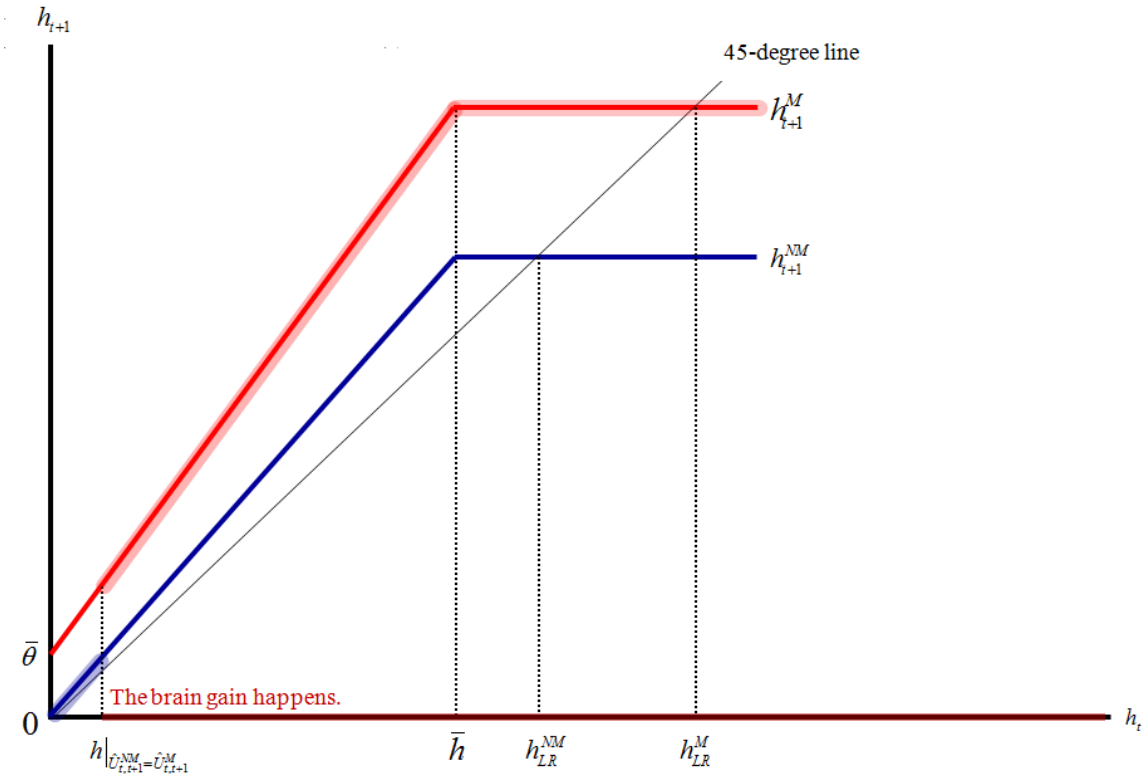


Fig. 2 The evolution of human capital when the wage disparity is large

Why can these results be derived? Higher wages in the foreign country increase natives' human capital formation whereas human capital outflow is also more likely. If the foreign country has sufficiently high wages, the former positive effect always dominates.

If the wage disparity is small so that $(1-\bar{\theta})\{1+\bar{\theta}(w^{*}-1)\} \leq 1$, then the average human capital is h_{t+1}^{NM} when $h_t < h|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$. Neither the brain drain nor the brain gain happens because natives do not attempt migration in this area. When $h|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}} \leq h_t < h|_{h_{t+1}^{M}=h_{t+1}^{NM}}$, the average human capital is h_{t+1}^{M}. This amount of human capital is higher than that under non-migration. Accordingly, the home country experiences the brain gain in this area in the short run. However, when $h_t \geq h|_{h_{t+1}^{M}=h_{t+1}^{NM}}$, the average human capital is still h_{t+1}^{M} because higher utility is attained by attempting migration. This amount of human capital is lower than that under non-migration. Accordingly, the home country experiences the brain drain in this area in the short run. These results suggest that natives experience either the brain gain or the brain drain, depending on the level of the average human capital after the average human capital has exceeded a certain level. Steady-state human capital under labour migration h_{LR}^{M} is lower than that would be built if migration was not attempted h_{LR}^{NM}. The brain drain happens in the long run (see **Fig. 3**).

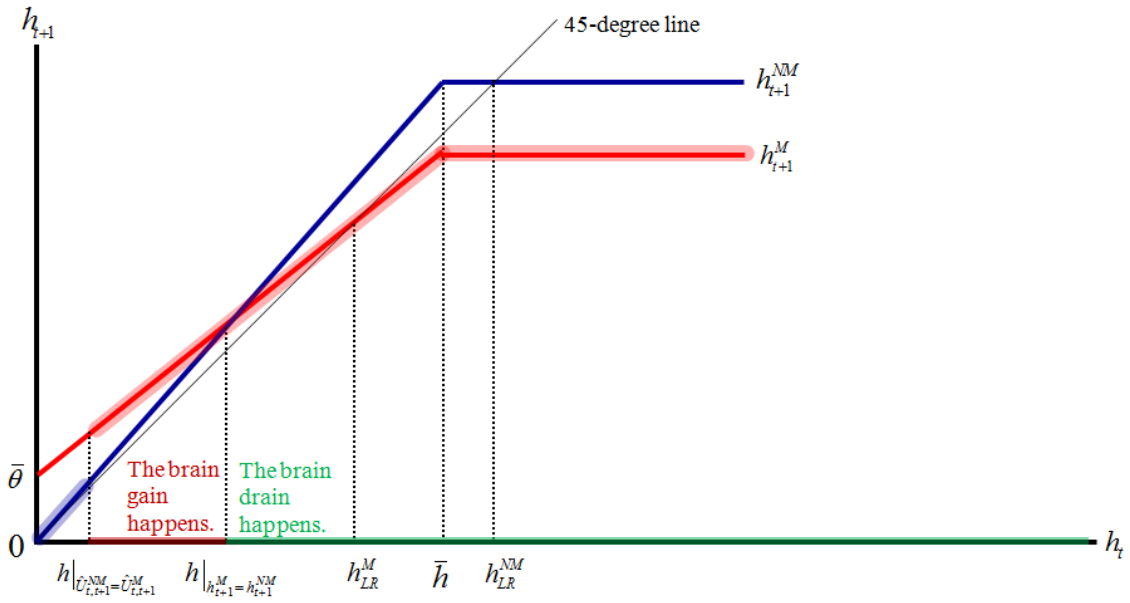


Fig. 3 The evolution of human capital when the wage disparity is small

Why can these results be derived? When the wage disparity is small, human capital formation is not strongly motivated even if migration is attempted. However, human capital is initially small. Hence, migration probability is low, restraining human capital outflow. As a result, human capital is higher when labour migration is attempted and the brain gain happens. However, with increases in the average human capital, the negative effects arising from increases in the migration probability and human capital outflow become more dominant than the positive effects from the foreign country's higher wages and the brain drain happens.

In sum, whether the home country experiences the brain drain or the brain gain depends on the wage disparity and the average human capital. When the wage disparity is large, the home country always experiences the brain gain both in the short run and in the long run. When the wage disparity is small, they experience either the brain gain or the brain drain in the short run whereas the brain drain occurs in the long run.

5.3. The Education Policy

This subsection considers how the education policy should be conducted to prevent the brain drain and to induce the brain gain.

When the wage disparity is large, by raising ε_t it becomes more likely that the brain gain happens since $h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$ decreases with ε_t. Also, human capital under labour migration increases, i.e. $\partial h_{t+1}^{M}/\partial\varepsilon_t > 0$. The curve for h_{t+1}^{M} shifts upward. Therefore, when the wage disparity is large, the government should conduct the education policy that seeks the higher education's quality. Such a policy is also beneficial in the long run since steady state human capital also increases (see **Fig. 4**).

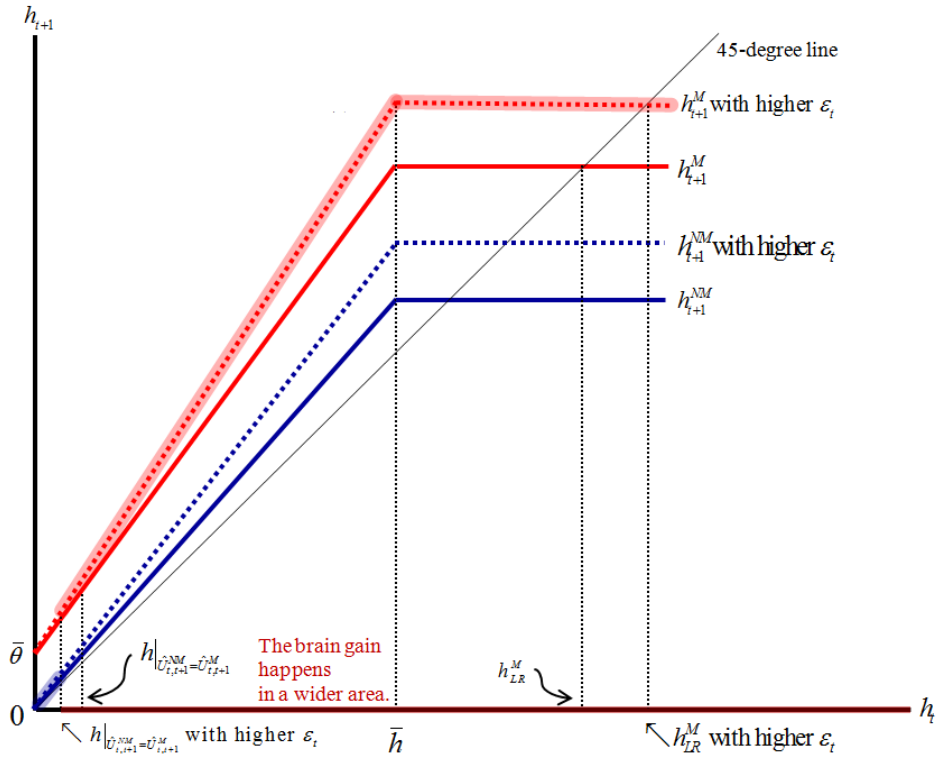


Fig. 4 The effects of tightening the education policy when the wage disparity is large

Why can these results be derived? Given h_t^M, by raising ε_t, education demand and human capital built by an individual native student $\tilde{h}_{t+1}^M$ increase. On the other hand, the migration probability and human capital outflow increase. However, when wage disparity is large, the former positive effect always dominates.

When the wage disparity is small, h_{t+1}^M increases by raising ε_t. However, the difference $h\big|_{h_{t+1}^M=h_{t+1}^{NM}} - h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$ decreases with ε_t. In other words, although $h\big|_{h_{t+1}^M=h_{t+1}^{NM},\text{ higher }\varepsilon_t} < h\big|_{h_{t+1}^M=h_{t+1}^{NM}}$ and $h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M},\text{higher }\varepsilon_t} < h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$, $h\big|_{h_{t+1}^M=h_{t+1}^{NM},\text{higher }\varepsilon_t} - h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M},\text{higher }\varepsilon_t} < h\big|_{h_{t+1}^M=h_{t+1}^{NM}} - h\big|_{\hat{U}_{t,t+1}^{NM}=\hat{U}_{t,t+1}^{M}}$. This suggests that by strengthening the education regulation, the brain gain becomes less likely to happen and the brain drain becomes more likely to happen. As for the level of human capital in the short run and in the long run, it increases with ε_t (see **Fig. 5**).

Why can these results be derived? By raising ε_t, both h_{t+1}^M and h_{t+1}^{NM} increase. However, due to the small wage disparity, the increase in h_{t+1}^M is smaller (the smaller upward shift of the curve of h_{t+1}^M) than the increase in h_{t+1}^{NM} (the larger upward shift of the curve of h_{t+1}^{NM}). As a result, $h\big|_{h_{t+1}^M=h_{t+1}^{NM}}$ decreases.

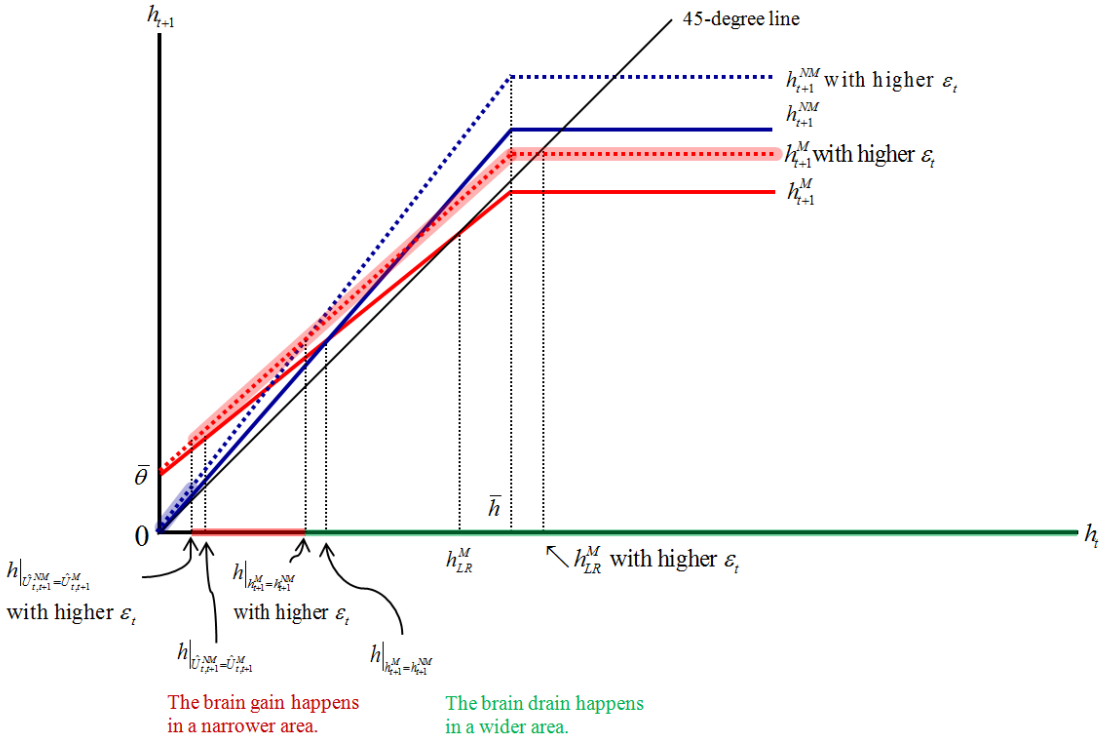


Fig. 5 The effects of tightening the education policy when the wage disparity is small

In sum, raising education regulation does not necessarily produce positive effects in terms of the brain gain and the brain drain. Its consequences depend on the wage disparity. These results suggest that it is not always better for the government to raise the education quality constraint when accepting study migrants.

6. CONCLUDING REMARKS

Accepting study migrants is considered effective in increasing domestic human capital since they likely remain in the host country after education to constitute part of the host country's human capital. This policy appears to complement the skilled labour migrants' acceptance policy.

The effects of study migrants on native students' education have been an issue in many studies. However, the effects of study migrants on natives' human capital formation have not been introduced explicitly into the migration literature. Even if study migrants remained after education, total human capital would decrease if they significantly negatively impacted natives' human formation. Such a possibility has been overlooked by previous studies.

This study filled this research gap by investigating the study migrants' negative effects on the host country's human capital formation in an overlapping generations' economy. The findings show that study migrants decrease the average human capital and native's utility by raising the native's education cost, whereas they increase the average human capital and native's utility by causing inconvenience to the educational institution and reducing the number of their acceptance. Furthermore, the brain drain or the brain gain does not necessarily happen and which of them happens is associated with the wage disparity and the average human capital. The host country may experience the brain drain when the government raises education regulation.

To focus on the study migrants' negative effect on natives' human capital formation, this study did not assume study migrants' human capital formation explicitly and did not assume the possibility for them to remain as workers after education. However, if we are to derive more general results on the brain drain and the brain gain, it is necessary to change these assumptions. Also, it was assumed that natives

and migrants pay all the pecuniary education cost privately. This assumption reflects the recent trend of tertiary education financing. However, taxes are also used to finance tertiary education partially in many countries. This study can be extended by including the case of tax and fee financing.

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