A Model of Emigration Networks and Brain Gain

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December 2007

Abstract:

This paper explores the role of migration networks in promoting trade and home country development. Migration networks help home firms access foreign markets. The strength of the effect, however, hinges on the mass and talent compositions of the emigrants. Depending on the talent distributions and opportunity costs of migration, two equilibria may emerge–one is that the most talented emigrate, and the other is that the most talented choose to stay home as managers while the intermediate-talented emigrate. It is shown that only in the first case, some talented emigrants will return to their home country to start new businesses, resulting in "reverse migration." In addition to the gains from foreign market access expansion, these talented returnees improve production efficiency and channel knowledge spillover, which further increases the likelihood of "brain gain."

JEL Classification: F22

Keywords: Migration Networks, Talent Distribution, Brain Drain

Acknowledgment: We are grateful for valuable comments and suggestions from Jim Markusen, Peter Neary, Kaz Miyagiwa, and participants of ETSG 2007 in Athens. Financial supports from Academia Sinica and the Research Institute for Economics & Business, Kobe University, which enabled this international collaboration, are gratefully acknowledged.

1 Introduction

Pioneering works on the brain drain issue have established that emigration can reduce the welfare of those left behind, because the ones who migrate overseas take with them the factors they own, or they might be more productive (See for instance Kenen (1971), Bhagwati and Rodriguez (1975) and Rivera-Batiz (1982)). Miyagiwa (1991) presents a model emphasizing scale economies in advanced education, which attracts high-ability migrants. He demonstrates that brain drain raises the education and income levels of a host country, but hurts the source-country professionals possessing intermediate-level abilities.

Subsequent literature has however suggested the possibility of a brain gain, which might increase the welfare of the home country. A brain gain could arise under several scenarios. For instance, Djajic (1986) argues that migrant remittance can increase the welfare of the remaining residents. Wong (1986) and Djajic (1998) show that in the presence of foreign capital, emigration may cause an increase in the welfare of the remaining residents, who would then have more capital to work with after some workers have emigrated. Stark, Helmenstein and Prskawetz (1998) argue that with human capital accumulation, the chance of earning higher income abroad induces workers to invest more in human capital, and the workers who stay at home can take advantage of the accumulated human capital, leading to the possibility a brain gain. Recently, Lien and Wang (2005) provide several conditions that brain drain still dominates brain gain, especially when migration is too high or when residents under invest in education.

This paper contributes to a similar line of research, but provides an alternative argument, namely, we wish to emphasize the effects of migration networks. Studies show that many ethnic groups living outside of their countries of origin create formal or informal ties to which coethnic business people from both the host countries and the mother country have access.[1] Recent work by Greif (1993), Gould (1994), McLaren (1999), Casella and Rauch (2002, 2003), and Greaney (2003) emphasize that coethnic networks also promote bilateral trade by providing market information and by supplying matching and referral services for their consumer goods, or for assemblers to find the right suppliers for their components. Some migrant ethnic groups even enforce community

[1] Lever-Tracy, Ip, and Tracy (1996) report that "Chew Choo Keng of Singapore remembered how 'it was through my friends at the clubs that I was able to expand my business into Thailand, Malaya, Burma and Indonesia"'(p.104). Weidenbaum and Hughes (1996) report "if a business owner violates an agreement, he is blacklisted. This is far worse than being sued, because the entire Chinese network will refrain from doing business with the guilty party." (p.51) See also Fung (1991), Lawrence (1991) and Spencer and Qiu (2001) for examples on Japanese *keiretsu* relationships, Redding (1995) on overseas Chinese, and Rauch (1996) on Japanese sogo shosha.

sanctions that deter opportunistic behavior that might hurt the long-term reputation of the group. Empirical studies such as Gould (1994), Head and Ries (1998), Rauch and Trindade (2002), and Combes et al. (2005) demonstrate the importance of network effects by examining the influence of immigrants on international trade. They find that immigrants have a statistically significant positive effect on bilateral trade between their home and host countries. Rauch (1999) further finds that proximity and common language/colonial ties are more important for trade in differentiated goods than for trade in homogeneous goods. Helliwell (1997) finds that migration mitigates trade-reducing international border effects.

Thus, in the present paper, we explore the role of migration networks in promoting trade and home country development. We model the phenomenon that the home country may transit from a mainly agrarian economy to a manufacturing one, if the migration networks can sufficiently help home firms access foreign markets. We find that in the short run, when migration networks are still in their infancy, a brain drain may arise. As the development in the home country kicks off, talented emigrants may return to their home country to start new businesses, resulting in "reverse migration". It is shown that such "reverse migration" may result in a "brain gain" in the long run when emigration networks become sufficiently strong. In particular, we can identify two equilibria. One is that the most talented emigrate, earning more overseas and the other is that the most talented stay home as managers while the intermediate-talented emigrate.

In the case of "reverse migration", returning migrants might bring skills and capital back and thereby contribute to both human and physical capital accumulation. They may apply foreign knowledge they have learned to identify entrepreneurial opportunities in the domestic market. Thus, in this paper we show remittance that can be used to increase the home country's capital stock, which is a source of "brain gain". Knowledge spillover from returning emigrants may also bring brain gain, because they can increase the efficiency of capital use, or improve the ability of managers. It is reported that in the case of Taiwan, improved economic opportunities from the late 1980s led an increasing number of former migrants to return and establish their own companies, drawing on the knowledge and experience gained in the United States.

Our result on 'reverse migration' is supported by several news reports. **National Public Radio** (NPR) News reports (December 2, 2004) that India is benefiting from "reverse migration." It says that many Indians abroad are returning home, offering the country a "brain gain" that could help solve some of India's social problems. Such large-scale reverse migration only occurred recently, when the Indian economy is developing rapidly. The News report says that until now some of the best Indian universities held class reunions in Sillicon valley in the U.S., now they can come back to India.

Newindpress.com (June 27, 2007) reports a job fair in Chennai, India. It says that "according to recent TIE (*The Indus Entrepreneurs*) reports, about 60,000 IT professionals have returned from the US in recent years. Ten years ago it was brain drain that affected the Indian industry, with professionals migrating to countries like the US in search of better job opportunities. Today, it is reverse migration, with family bonding and the boom in the IT and ITeS sector spearheading this change." [2] Huang Kangxian (2005) reports a similar situation for China. "Many young people in Hong Kong are willing to find a future in China, especially those in the professional occupation... It used to be that people came to Hong Kong from mainland China. But what is happening now is that people are moving from Hong Kong to mainland China. This reversal of direction is not an abnormal turn, but it is a normal course during a time when Hong Kong becomes integrated into the Pearl River delta." (**Ta Kung Pao**, February 24, 2005).

Regarding migration and remittance, Hunte (2004), Zarate-Hoyos (2004) and Lopez-Cordova (2005) present evidence suggesting that international migrants send money back home for different reasons, such as reducing poverty, smoothing consumption, providing working capital for small-scale enterprises. And remittances generally lead to improved developmental outcomes, such as improvement in education, infrastructure, financial deeping, etc.

Finally, we note that while this paper focuses on migration network effects, the analysis applies to other scenarios when the economy of a developing country starts to grow. Better opportunities at home may attract some migrants back home to start new businesses, and fewer top-talented managers choose to migrate. These are evidenced by historical migration data in a number of countries, such as Greece, Hungary, Japan, Poland, South Korea, Spain, Turkey, etc. (see World Bank World Development Index various years). And the role played by migrants and the networks they build in the initial economic takeoff cannot be ignored, such as those played by overseas Chinese in the 1980s and early 1990s, when China had a hard time selling abroad and attracting FDI on large scales.

The rest of the paper is organized as follows. Section 2 sets up the basic model. Section 3 analyzes two long-run equilibria of emigration, with networks effects incorporated. In one equilibrium, the most talented emigrate, while in the other equilibrium, the most talented stay home as managers. Section 4 examines the effects of remittance and knowledge spillover.

[2] See similar reports in the **New York Times**, July 24, 2004, "Indians Go Home, but Don't Leave U.S. Behind".

2 The Basic Model Setup

We consider an open economy which is endowed with K units of capital and a continuum of labor. The mass of labor endowment is L. Moreover, labor is heterogeneous in managerial talent, which is assumed to be uniformly distributed on a support $[0, \bar{\theta}]$ (see Grossman, 2004 and Antras et al., 2006 for similar assumptions but with different focuses). Let $G(\cdot)$ denote the cumulative distribution function; thus $G(\theta) = \theta/\bar{\theta}$. Suppose that there are two sectors, say the manufacturing sector and the traditional agrarian sector, which are denoted by X and Y respectively. Sector X's production technology exhibits increasing returns to scales and that in sector Y is constant returns to scale. Production of good X requires capital input and managerial skills, in a way such that k fixed units of capital are required as set-up costs and the output of X is proportional to the manager's talent, i.e., $f_X(\theta) = A\theta$. Each manager after paying the rent for capital (rk), where r is the capital rental rate, is the residual claimer of his or her talent. Production of good Y requires physical labor only. By assumption each individual regardless of his or her managerial talent can provide one unit labor force (hereafter, we call them workers if employed in sector Y), and $f_Y(L_Y) = L_Y$, where L_Y denotes the mass of workers.

We normalize the price of good Y to be one and use p to denote the relative price of good X. Suppose that good X is entirely exported to the foreign market with an export demand function exogenously given:[3]

$$p = e(n)X^{-\eta},$$

where $\eta < 1$ is the inverse of the price elasticity of demand; $e(n)$ is a function capturing the effects of migration networks measured by n in expanding foreign demand/markets. It is assumed that $e(0) = e_0 > 0$, and $e'(n) > 0$. Equation (1) is the import price from the foreign country's point of view. Even though the home country is a small country, in a two-country world, the export price increases if the export demand rises.

2.1 Benchmark Case: No Migration

We start with the benchmark case of no international migration. Each individual, knowing his or her talent θ, chooses to work in sector X as a manager or in sector Y as a worker by comparing the

[3] Home market demand is abstracted for simplicity. It could be added and our qualitative results would not be affected under segmented markets. In addition, an alternative way of modeling network effects is to assume that they reduce trade costs, so that home firms can sell more in foreign markets. This in essence is similar to our approach in the current paper.

relative magnitude of rent for his or her talent, $pf_X(\theta) - rk$, or the wage which is equal to value of marginal product of labor in sector Y (i.e., one). We can find the pivotal type $\tilde{\theta}$, such that any individual with talent above $\tilde{\theta}$ strictly prefers to be a manager than a worker, and talent below that strictly prefers Y to X as illustrated in Figure 1.

The benchmark equilibrium can be characterized as follows. First, since each entrepreneur/manager uses k units of capital, full employment of K gives:

$$K = \int_{\tilde{\theta}}^{\bar{\theta}} LkdG(\theta) = \frac{(\bar{\theta} - \tilde{\theta})Lk}{\bar{\theta}},$$

which leads to

$$\tilde{\theta} = \left(1 - \frac{K}{kL}\right)\bar{\theta}. \tag{1}$$

At the critical talent level $\tilde{\theta}$, the payoffs from working in sector Y and managing in sector X must be equal,

$$1 = pA\tilde{\theta} - rk,$$

which gives

$$r = \frac{pA\tilde{\theta} - 1}{k}. \tag{2}$$

Substituting the above into the export demand function to obtain,

$$\begin{aligned} p &= e_0 \left(\int_{\tilde{\theta}}^{\bar{\theta}} LA\theta dG(\theta) \right)^{-\eta} \\ &= e_0 \left[\frac{LA\left(\bar{\theta}^2 - \tilde{\theta}^2\right)}{2\bar{\theta}} \right]^{-\eta}. \end{aligned} \tag{3}$$

Finally, we are interested in the welfare of the home country. Following the tradition in the literature (see for instance Rivera-Batiz (1982), Wong (1986), Djajic (1986, 1998)), we calculate the welfare of the remaining residents. To be consistent, we calculate and compare their GDP levels in various cases. This is qualitatively the same as comparing utility based welfare if we assume homothetic preferences and representative consumers. Note that the GDP also includes migrant remittances because remittance increases the total capital stock K. In the benchmark case the GDP can be defined as,

$$\begin{aligned} GDP &= Y + pX \\ &= \int_0^{\tilde{\theta}} LdG(\theta) + e_0 X^{1-\eta} \\ &= \frac{L\tilde{\theta}}{\bar{\theta}} + e_0 \left[\frac{LA\left(\bar{\theta}^2 - \tilde{\theta}^2\right)}{2\bar{\theta}} \right]^{1-\eta}. \end{aligned} \tag{4}$$

Solving the above system of four simultaneous equations, we have the analytical solutions for $\{\tilde{\theta}, p, r, GDP\}$ as:

$$\tilde{\theta} = c\bar{\theta}, \tag{5}$$

$$p = e_0 \left[\frac{(1-c^2)LA\bar{\theta}}{2} \right]^{-\eta}, \tag{6}$$

$$r = \frac{e_0 c \left[\frac{(1-c^2)L}{2} \right]^{-\eta} \left(A\bar{\theta}\right)^{1-\eta} - 1}{k}, \tag{7}$$

$$GDP = cL + e_0 \left[\frac{(1-c^2)LA\bar{\theta}}{2} \right]^{1-\eta}, \tag{8}$$

where $c \equiv 1 - \frac{K}{kL} > 0$. As long as there is positive production in both sectors, $c \in (0,1)$. It is obvious that $p > 0$. And the condition for $r > 0$ is $p > \frac{1}{cA\bar{\theta}}$.

3 Short Run : Migration without Network Effects

We define the short run as a period of time with positive emigration, but too short to generate network effects. There are type pf two short run equilibria, depending on the home and destinating countries' characteristics.

3.1 Short Run (s): the Most Talented Migrate

The first type of equilibria is that the most talented individuals migrate as deonted by (s). Equilibrium (s) emerges if and only if $\frac{w*}{p_s A} < \frac{1+F}{1+r_s k}$. We use the following vector of notation $\{\tilde{\theta}_s, \hat{\theta}_s, n_s, p_s, r_s, GDP_s\}$ for the endoneous variables for short run (s), where $\tilde{\theta}_s$ denotes the critical level of talent that equalizes earnings between working in sectors X and Y, $\hat{\theta}_s$ denotes that equalizing the earnings between working/managing in sector X and emigrating (see Figure 2), and n_s, p_s, r_s, GDP_s are as defined earlier but for the case of the short run. In Figure 2, those with talent below $\tilde{\theta}_s$ work in agriculture, those above $\hat{\theta}_s$ emigrate, and those in between stay home as managers in the manufacturing sector.

The equilibrium conditions in the short run can then be described as follows.

$$K = \int_{\tilde{\theta}_s}^{\hat{\theta}_s} LkdG(\theta) = \frac{kL(\hat{\theta}_s - \tilde{\theta}_s)}{\bar{\theta}},$$

which leads to

$$\tilde{\theta}_s = \hat{\theta}_s - \frac{\bar{\theta}K}{kL}. \tag{9}$$

Earnings equalization between managing in sector X and emigrating at critical talent $\hat{\theta}_s$ gives

$$\pi_s^X \equiv p_s A\hat{\theta}_s - r_s k = w^* \hat{\theta}_s - F \equiv \pi_s^M,$$

where w^* is the exogenous wage rate in the host country, and F is a fixed cost an emigrant must incur. It yields

$$\hat{\theta}_s = \frac{F - r_s k}{w^* - p_s A}. \tag{10}$$

Moreover, from earnings equalization at $\tilde{\theta}_s$ between managing in sector X and working in sector Y, we have

$$r_s = \frac{p_s A\tilde{\theta}_s - 1}{k}. \tag{11}$$

Using the above we further derive

$$\begin{aligned} p_s &= e_0 \left(\int_{\tilde{\theta}_s}^{\hat{\theta}_s} LA\theta dG(\theta) \right)^{-\eta} \\ &= e_0 \left[\frac{LA\left(\hat{\theta}_s^2 - \tilde{\theta}_s^2\right)}{2\bar{\theta}} \right]^{-\eta}, \end{aligned} \tag{12}$$

$$\begin{aligned} GDP_s &= Y_s + p_s X_s \\ &= \int_0^{\tilde{\theta}_s} LdG(\theta) + e_0 X_s^{1-\eta} \\ &= \frac{L\tilde{\theta}_s}{\bar{\theta}} + e_0 \left[\frac{LA\left(\hat{\theta}_s^2 - \tilde{\theta}_s^2\right)}{2\bar{\theta}} \right]^{1-\eta}. \end{aligned} \tag{13}$$

Lemma 1 *In the short run, emigration causes brain drain in the home country, i.e., $GDP_s < GDP$.*

Proof. *Notice that $\tilde{\theta} = \bar{\theta} - \frac{K\bar{\theta}}{kL}$ and $\tilde{\theta}_s = \hat{\theta}_s - \frac{K\bar{\theta}}{kL}$. Since $\hat{\theta}_s < \bar{\theta}$, we have $\tilde{\theta}_s < \tilde{\theta}$, which further implies that $Y_s < Y$. Moreover, since $1 - \eta > 0$ and*

$$(\bar{\theta}^2 - \tilde{\theta}^2) = (\bar{\theta} + \tilde{\theta})(\bar{\theta} - \tilde{\theta}) = (\bar{\theta} + \tilde{\theta})\frac{K\bar{\theta}}{kL},$$

$$(\hat{\theta}_s^2 - \tilde{\theta}_s^2) = (\hat{\theta}_s + \tilde{\theta}_s)(\hat{\theta}_s - \tilde{\theta}_s) = (\hat{\theta}_s + \tilde{\theta}_s)\frac{K\bar{\theta}}{kL},$$

we know $(\hat{\theta}_s^2 - \tilde{\theta}_s^2)^{1-\eta} < (\bar{\theta}^2 - \tilde{\theta}^2)^{1-\eta}$, which yields $p_s X_s < pX$. Therefore, $GDP_s < GDP$. ***Q.E.D.***

■

Lemma 1 arises because more talented workers left the country but strong migration networks have yet to be formed in the short run.

3.2 Short Run (s'): the Most Talented Stay Home as Managers without Migration Network

In the second type of short run equilibria denoted by ($s\prime$), the individuals with intermediate talent emigrate. Equilibrium (s') emerges if and only if $\frac{w*}{p_{s'}A} > \frac{1+F}{1+r_{s'}k}$ as shown in Figure 3. We use the following vector of notation $\{\tilde{\theta}_{s'}, \hat{\theta}_{s'}, n_{s'}, p_{s'}, r_{s'}, GDP_{s'}\}$ for the endoneous variables for short run (s'). In this case, the most talented workers stay at the home country, managing manufacturing firms in sector X. In Figure 3, the curve representing the value of emigration, π_M, cuts from above the curve representing the value of managing in the home country, π_X. Their intersection is at the critical talent $\tilde{\theta}_{s'}$. The other critical talent level is $\hat{\theta}_{s'}$, which equates the values between working in sector Y and emigrating (*not managing in sector* X). That is, the mass of workers between the two critical talent levels emigrate. In this equilibrium, the network effects are so strong that the curve representing the manager earnings π_X rotates counter-clockwise and it becomes steeper than π_M. As a result, after the initial emigration, not only reverse migration occurs, but the most talented also choose not to emigrate, because their earnings is higher staying home being managers.

With the above said, the equilibrium conditions can be constructed as follows, keeping the order as in previous sections:

Full use of all capital endowment gives,

$$K = \int_{\hat{\theta}_{s'}}^{\bar{\theta}} LkdG(\theta) = \frac{kL(\bar{\theta} - \hat{\theta}_{s'})}{\bar{\theta}},$$

$$\Rightarrow \hat{\theta}_{s'} = \bar{\theta} - \frac{\bar{\theta}K}{kL} = \tilde{\theta} = c\bar{\theta}; \tag{14}$$

Earnings equalization between emigrating and managing in sector X yields,

$$p_{s'}A\hat{\theta}_{s'} - r_{s'}k = w^*\hat{\theta}_{s'} - F,$$

$$\Rightarrow \hat{\theta}_{s'} = \frac{F - r_{s'}k}{w^* - p_{s'}A}; \tag{15}$$

Earnings equalization between emigrating and working in sector Y leads to,

$$1 = w^*\tilde{\theta}_{s'} - F,$$

$$\Rightarrow \tilde{\theta}_{s'} = \frac{1+F}{w^*}; \tag{16}$$

The export demand becomes,

$$\begin{aligned} p_{s'} &= e_0 \left(\int_{\hat{\theta}_{s'}}^{\bar{\theta}} LA\theta dG(\theta) \right)^{-\eta} \\ &= e_0 \left[\frac{LA\left(\bar{\theta}^2 - \hat{\theta}_{s'}^2\right)}{2\bar{\theta}} \right]^{-\eta}; \end{aligned}$$

$$\begin{aligned} GDP_{s'} &= Y_{s'} + p_{s'}X_{s'} \\ &= \int_0^{\tilde{\theta}_{s'}} LdG(\theta) + e_0 X_{s'}^{1-\eta} \\ &= \frac{L\tilde{\theta}_{s'}}{\bar{\theta}} + e_0 \left[\frac{LA\left(\bar{\theta}^2 - \hat{\theta}_{s'}^2\right)}{2\bar{\theta}} \right]^{1-\eta}. \end{aligned}$$

Lemma 2 *In the short run, emigration causes brain drain in the home country, i.e.,* $GDP_{s'} < GDP$.

Proof. *Notice that* $\tilde{\theta} = \hat{\theta}_{s'} > \tilde{\theta}_{s'}$. *It is trivial that* $Y > Y_{s'}$, *and* $X = X_{s'}$. *Since in the short run, the network effect has not taken place yet,* $p = p_{s'}$. *Therefore,* $GDP_{s'} < GDP$. ***Q.E.D.*** ■

Simillar to Lemma 1, Lemma 2 arises because some workers left the country but strong migration networks have yet to be formed in the short run.

4 Long Run Equilibrium: Migration and Network Effects

Suppose that in the long run, the network effects generated by emigration take place and follow the form specified here:

$$e(n) = e_0(1 + hn), \tag{17}$$

where $h > 0$ denotes the marginal network effects, which might be affected by culture, geographical distance, language, colony, and institution, etc. We restrict our attention to the equilibrium only, abstracting from analysis on the transitional path.

We consider one statistic that expresses the emigration network effects taking into account both the mass of emigration and the talents of emigrants as written as:

$$n = \int_0^{\bar{\theta}} I(\text{type } \theta \text{ emigrate})\theta dG(\theta).$$

As we can see right away that the quanity and quality of the migrants in the short run affects the effectiveness of the network, which in trun has non-trivial long run impacts to the home country's development. Later, we will use (a) and (a') to denote two long-run equilibria corresponding to the two short-run equilibria (s) and (s'), respectively.

We first identify the measures of network induced by two short run equilibria below:

$$n_a = \int_{\hat{\theta}_s}^{\bar{\theta}} \theta dG(\theta) = \frac{(\bar{\theta}^2 - \hat{\theta}_s^2)}{2\bar{\theta}}$$

$$n_{a'} = \int_{\tilde{\theta}_{s'}}^{\hat{\theta}_{s'}} \theta dG(\theta) = \frac{(\hat{\theta}_{s'}^2 - \tilde{\theta}_{s'}^2)L}{2\bar{\theta}}$$

We then examine the long run effect of migration network sequentially.

4.1 Equilibrium (a): the Most Talented Emigrate

In the first case as denoted as Equilibrium (a), the most talented workers emigrate. Equilibrium (a) emerges if and only if $\frac{w*}{p_a A} > \frac{1+F}{1+r_a k}$. In Figure 4, the curve representing the value of emigration, π_M, cuts from below the curve representing the value of managing in the home country, $\pi_{X.}$ Their intersection is at the critical talent $\hat{\theta}_a$. The other critical talent level is $\tilde{\theta}_a$, which equates the values between working in sector Y and managing in sector X. The mass of workers between $\tilde{\theta}_a$ and $\hat{\theta}_a$ conduct managing tasks at home. Therefore, the equilibrium conditions can be constructed as follows, keeping the order as in the previous section:

$$K = \int_{\tilde{\theta}_a}^{\hat{\theta}_a} LkdG(\theta) = \frac{kL(\hat{\theta}_a - \tilde{\theta}_a)}{\bar{\theta}},$$

$$\Rightarrow \tilde{\theta}_a = \hat{\theta}_a - \frac{\bar{\theta}K}{kL}; \tag{18}$$

$$p_a A\hat{\theta}_a - r_a k = w^*\hat{\theta}_a - F,$$

$$\Rightarrow \hat{\theta}_a = \frac{F - r_a k}{w^* - p_a A}; \tag{19}$$

$$1 = p_a A\tilde{\theta}_a - r_a k,$$

$$\Rightarrow r_a = \frac{p_a A\tilde{\theta}_a - 1}{k}; \tag{20}$$

$$\begin{aligned} p_a &= e(n_a)\left(\int_{\tilde{\theta}_a}^{\hat{\theta}_a} LA\theta dG(\theta)\right)^{-\eta} \\ &= e(n_a)\left[\frac{LA\left(\hat{\theta}_a^2 - \tilde{\theta}_a^2\right)}{2\bar{\theta}}\right]^{-\eta}; \end{aligned} \tag{21}$$

$$\begin{aligned} GDP_a &= Y_a + p_a X_a \\ &= \int_0^{\tilde{\theta}_a} LdG(\theta) + e(n_a)X_a^{1-\eta} \\ &= \frac{L\tilde{\theta}_a}{\bar{\theta}} + e(n_a)\left[\frac{LA\left(\hat{\theta}_a^2 - \tilde{\theta}_a^2\right)}{2\bar{\theta}}\right]^{1-\eta}, \end{aligned} \tag{22}$$

where the network effects can be expressed respectively as

$$n_a = \int_{\hat{\theta}_s}^{\bar{\theta}} \theta dG(\theta) = \frac{(\bar{\theta}^2 - \hat{\theta}_s^2)}{2\bar{\theta}}.$$

In Figure 4, the mass of workers with talent between $\hat{\theta}_s$ and $\hat{\theta}_a$ are the 'reverse migrants'. Intuitively, the network effects raise the export demand, increasing export price and manager earnings at home. This is represented by an upward shift of the curve in Figure 4 from π_s^X to π_a^X. It then induces some emigrants to return home to start new businesses. As a result, the mass of managers at home increases from the interval $\left[\tilde{\theta}_s, \hat{\theta}_s\right]$to the interval $\left[\tilde{\theta}_a, \hat{\theta}_a\right]$. There are numerous examples in many developing countries, such as the ones cited in the introduction section about China and India. In fact, such cases were also historically common in some developed and newly industrialized economies when growth was taking off in these economies, such as Japan and South Korea, etc.

With network effects incorporated, the model cannot be solved explicitly, without specifying specific values for the parameters. However, the set of simultaneous equations can be simplified, which then allows us to analyze the model graphically.

We first rewrite $\tilde{\theta}_a$, r_a, and p_a in terms of $\hat{\theta}_a$ and the exogenous variables using (18), (19), and (20):

$$\tilde{\theta}_a(\hat{\theta}_a) = \hat{\theta}_a - \frac{K\bar{\theta}}{kL},$$

$$r_a(\hat{\theta}_a) = \frac{p_a A[\hat{\theta}_a - \frac{K\bar{\theta}}{kL}] - 1}{k},$$

$$p_a(\hat{\theta}_a) = e(n_a)\left(\frac{AK}{2k}\right)^{-\eta}\left[2\hat{\theta}_a - \frac{K\bar{\theta}}{kL}\right]^{-\eta}, \tag{23}$$

Since

$$\hat{\theta}_a = \frac{1+F}{w^*} + \left(\frac{P_a A}{w^*}\right)\frac{K\bar{\theta}}{kL}, \tag{24}$$

by inserting (23) into(24), we have:

$$\hat{\theta}_a = \frac{1+F}{w^*} + e(n_a)\frac{2\bar{\theta}}{w^* L}\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta}_a - \frac{K\bar{\theta}}{kL}\right]^{-\eta} \tag{25}$$

Let us define a function $H(\hat{\theta})$, sucyh that:

$$H(\hat{\theta}) \equiv \frac{1+F}{w^*} + e(n_a)\frac{2\bar{\theta}}{w^* L}\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta} - \frac{K\bar{\theta}}{kL}\right]^{-\eta}$$

where

$$\lim_{\hat{\theta}\to\frac{K\bar{\theta}}{2kL}} H(\hat{\theta}) = \infty,$$

$$\lim_{\hat{\theta}\to\infty} H(\hat{\theta}) = 0,$$

$$\frac{\partial H(\hat{\theta})}{\partial\hat{\theta}} = -2\eta e(n_a)\left(\frac{2\bar{\theta}}{w^*L}\right)\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta}-\frac{K\bar{\theta}}{kL}\right]^{-\eta-1} < 0$$

$$\frac{\partial^2 H(\hat{\theta})}{\partial\hat{\theta}^2} = 2\eta(1+\eta)e(n_a)\frac{2\bar{\theta}}{w^*L}\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta}-\frac{K\bar{\theta}}{kL}\right]^{-\eta-2} > 0$$

$$\frac{\partial H(\hat{\theta})}{\partial h} = n_a\left(\frac{2\bar{\theta}}{w^*L}\right)\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta}-\frac{K\bar{\theta}}{kL}\right]^{-\eta} > 0$$

As shown in Figure 5, the long-run cut-off point, $\hat{\theta}_a$, where individual is indiffient beween migrating and being manager at home is identified as the intersection of the 45^oline and $H(\hat{\theta})$. Notice that $H(\hat{\theta})$ increases as h increases, the schedule $H(\hat{\theta})$ is at the lowest position when $h=0$, and shits up as the effect of network increases. In particular, when $h=0$, migration network plays no role in poromoting trade, there is no distinction between short run and long run, and thus $\hat{\theta}_s = \hat{\theta}_a$. As a result, we will not observe revers migration in the long run. However, in the case that $h>0$, we have $\hat{\theta}_s < \hat{\theta}_a$, which implies that individuals with talent ranged between $\hat{\theta}_s$ and $\hat{\theta}_a$, who emigrate in the short run, will return to their home country as the rewards to their managerial skills increaes due to the network effects which facilitate home country exapnding the foreign market access. If the marginal effect of network is strong enough, it is posibble that all the migrats will return to their home country. As shown in Figure 5, for any $h>\bar{h}$, where $\bar{h}$ satisfies that:

$$\bar{\theta} = H(\bar{\theta}) = \frac{1+F}{w^*} + \frac{e_0(1+\bar{h}n_a)}{w^*}\left(\frac{AK\bar{\theta}}{kL}\right)^{1-\eta}\left[L-\frac{K}{2k}\right]^{-\eta},$$

we know that $\hat{\theta}_s < \hat{\theta}_a = \bar{\theta}$, which results in full-range of reverse migration.

We then move to examine the GDP level in the long run in which retrun emigrants change the talent composition of the managers in the home country. Recall the definition of GDP:

$$\begin{aligned} GDP_a(\hat{\theta}_a) &= Y_a + p_a X_a \\ &= \frac{L\tilde{\theta}_a}{\bar{\theta}} + e_0(1+\bar{h}n_a)X_a^{1-\eta} \\ &= \frac{L\left(\hat{\theta}_a - \frac{K\bar{\theta}}{kL}\right)}{\bar{\theta}} + e_0(1+\bar{h}n_a)\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta}_a - \frac{K\bar{\theta}}{kL}\right]^{1-\eta}, \end{aligned}$$

where

$$\frac{\partial GDP(\hat{\theta})}{\partial \hat{\theta}} = \frac{L}{\hat{\theta}} + 2(1-\eta)e_0(1+\overline{h}n_a)\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta}_a - \frac{K\bar{\theta}}{kL}\right]^{-\eta} > 0,$$

$$\frac{\partial^2 GDP(\hat{\theta})}{\partial \hat{\theta}^2} = -4\eta(1-\eta)e_0(1+\overline{h}n_a)\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta}_a - \frac{K\bar{\theta}}{kL}\right]^{-\eta-1} < 0,$$

$$\frac{\partial GDP(\hat{\theta})}{\partial h} = e_0 n_a\left(\frac{AK}{2k}\right)^{1-\eta}\left[2\hat{\theta} - \frac{K\bar{\theta}}{kL}\right]^{1-\eta}.$$

It is shown that $GDP(\hat{\theta})$ is strictly increasing in $\hat{\theta}$ and is concave. Moreover, $GDP(\hat{\theta})$ shifts upward as h increases.

In the case that $h = 0$, $GDP_s(\hat{\theta}_s) = GDP_a(\hat{\theta}_a) < GDP$, the home country suffers from barin drain for sure; in the case that $h = \overline{h}$, the home country unambiguously experiences brain gain in the long run as shown below:

$$\begin{aligned}
\overline{GDP_a} &\equiv GDP_a(\bar{\theta}; \overline{h}) = \left(1 - \frac{K}{kL}\right)L + e_0(1+\overline{h}n_a)\left(\frac{AK\bar{\theta}}{k}\right)^{1-\eta}\left[1 - \frac{K}{2kL}\right]^{1-\eta} \\
&= cL + e_0(1+\overline{h}n_a)\left[\frac{(1-c^2)LA\bar{\theta}}{2}\right]^{1-\eta} \\
&= GDP + e_0(\overline{h}n_a)\left[\frac{(1-c^2)LA\bar{\theta}}{2}\right]^{1-\eta} > GDP
\end{aligned}$$

By continuity, we know that there exist a threshold $h^g \in \left[0, \overline{h}\right]$, such that $GDP_a(\hat{\theta}_a(h^g)) = GDP$. For any $h \in [0, h^g]$, home country experiences brain drain, and for any $h \in [h^g, \infty]$, the country experiences brain gain as shown in Figure 6.

Proposition 3 *As the network effect takes place in the long-run, i.e.* $h > 0$, *(i) the home country becomes better off than in the short run, i.e.,* $GDP_s(\hat{\theta}_s) < GDP_a(\hat{\theta}_a)$*; (ii) reverse migration will be carried out by individuals with talent* $\left[\hat{\theta}_s, \hat{\theta}_a\right]$*; and (iii) the home country, however, is still worse off than the benchmark case if the network effect is only marginal, i.e.,* $GDP_a(\hat{\theta}_a(h)) < GDP$ *holds if* $0 < h < h^g$*; (iv) a 'brain gain' emerges if the network effect is strong, i.e.,* $GDP_a(\hat{\theta}_a(h)) > GDP$ *holds if* $h^g < h$.

4.2 Equilibrium (a'): the Most Talented Stay Home as Managers

In the second case, the most talented workers stay at the home country, managing manufacturing firms in sector X as denoted as equilibrium $(a\prime)$. It emerges if and only if $\frac{w*}{p_{a'}A} > \frac{1+F}{1+r_{a'}k}$. In Figure 7, the curve representing the value of emigration, π_M, cuts from above the curve representing the value of managing in the home country, π_X. Their intersection is at the critical talent $\tilde{\theta}_{a'}$. The other critical talent level is $\hat{\theta}_{a'}$, which equates the values between working in sector Y and emigrating (*not managing in sector* X). That is, the mass of workers between the two critical talent levels emigrate. In this equilibrium, the network effects are so strong that the curve representing the manager earnings π_X rotates counter-clockwise and it becomes steeper than π_M. As a result, after the initial emigration, not only reverse migration occurs, but the most talented also choose not to emigrate, because their earnings is higher staying home being managers.

With the above said, the equilibrium conditions can be constructed as follows, keeping the order as in previous sections:

Full use of all capital endowment gives,

$$K = \int_{\hat{\theta}_{a'}}^{\bar{\theta}} LkdG(\theta) = \frac{kL(\bar{\theta} - \hat{\theta}_{a'})}{\bar{\theta}},$$

$$\Rightarrow \hat{\theta}_{a'} = \bar{\theta} - \frac{\bar{\theta}K}{kL} = \tilde{\theta} = c\bar{\theta} = \hat{\theta}_{s'}; \tag{26}$$

Earnings equalization between emigrating and managing in sector X yields,

$$p_{a'}A\hat{\theta}_{a'} - r_{a'}k = w^*\hat{\theta}_{a'} - F,$$

$$\Rightarrow \hat{\theta}_{a'} = \frac{F - r_{a'}k}{w^* - p_{a'}A}; \tag{27}$$

Earnings equalization between emigrating and working in sector Y leads to,

$$1 = w^*\tilde{\theta}_{a'} - F,$$

$$\Rightarrow \tilde{\theta}_{a'} = \frac{1+F}{w^*} = \tilde{\theta}_{s'}; \tag{28}$$

The export demand becomes,

$$
\begin{aligned}
p_{a'} &= e(n_{a'})\left(\int_{\hat{\theta}_{a'}}^{\bar{\theta}} LA\theta dG(\theta)\right)^{-\eta} \\
&= e(n_{a'})\left[\frac{LA\left(\bar{\theta}^2-\hat{\theta}_{a'}^2\right)}{2\bar{\theta}}\right]^{-\eta};
\end{aligned}
$$

where the network effect is:

$$
\begin{aligned}
n_{a'} &= \int_{\tilde{\theta}_{s'}}^{\hat{\theta}_{s'}} \theta dG(\theta) = \frac{(\hat{\theta}_{s'}^2-\tilde{\theta}_{s'}^2)L}{2\bar{\theta}} \\
&= \frac{(\hat{\theta}_{a'}^2-\tilde{\theta}_{a'}^2)L}{2\bar{\theta}};
\end{aligned}
$$

Using all the above expressions to derive the GDP as,

$$
\begin{aligned}
GDP_{a'} &= Y_{a'} + p_{a'}X_{a'} \\
&= \int_0^{\tilde{\theta}_{a'}} LdG(\theta) + e(n_{a'})X_{a'}^{1-\eta} \\
&= \frac{L\tilde{\theta}_{a'}}{\bar{\theta}} + e(n_{a'})\left[\frac{LA\left(\bar{\theta}^2-\hat{\theta}_{a'}^2\right)}{2\bar{\theta}}\right]^{1-\eta}.
\end{aligned}
$$

Proposition 4 *(i) No reverse-migration will occur in the long run. (ii) If* $0 < h < h^{g'}$*,* $GDP_{s'} < GDP_{a'} < GDP$*, that is the home country experiences brain drain even in the long run. (iii) If* $h^{g'} < h$*,* $GDP_{s'} < GDP < GDP_{a'}$*, the home country experiences brain gain, where* $h^{g'} = \frac{2w^*}{e_0(c\bar{\theta}w^*+1+F)}\left[\frac{2}{(1-c^2)LA\bar{\theta}}\right]^{1-\eta}$.

Proof. Since $\hat{\theta}_{a'} = \hat{\theta}_{s'} = \tilde{\theta}$, and $\tilde{\theta}_{a'} = \tilde{\theta}_{s'} < \tilde{\theta}$, we can conlude that $X_{a'} = X_{s'} = X$, and $Y_{a'} = Y_{s'} < Y$. Moreover, $p_{a'} = e(n_{a'})X_{a'}^{-\eta} = e_0(1+hn_{a'})X^{-\eta} = p + e_0hn_{a'}X^{-\eta}$, which implies that $GDP_{a'} = GDP - (Y - Y_{a'}) + e_0hn_{a'}X^{1-\eta}$. Therefore, $GDP_{a'} > GDP$ if and only if $e_0hn_{a'}X^{1-\eta} > (Y - Y_{a'})$. Recall that $n_{a'} = \frac{(\hat{\theta}_{a'}^2-\tilde{\theta}_{a'}^2)L}{2\bar{\theta}} = \frac{(\tilde{\theta}-\tilde{\theta}_{a'})(\tilde{\theta}+\tilde{\theta}_{a'})L}{2\bar{\theta}}$, and $Y - Y_{a'} = \frac{(\tilde{\theta}-\tilde{\theta}_{a'})L}{\bar{\theta}}$, the necessary and sufficient condition can be simplified as $e_0hX^{1-\eta} > \frac{2}{(\tilde{\theta}+\tilde{\theta}_{a'})}$, which is equivalent to $h > \frac{2w^*}{e_0(c\bar{\theta}w^*+1+F)}\left[\frac{2}{(1-c^2)LA\bar{\theta}}\right]^{1-\eta} \equiv h^{g'}$. The statements in the proposition are true. ■

5 Concluding Remarks

This paper has explored the role of migration networks in promoting trade and home country development. We modeled the phenomenon that the home country may transit from a mainly agrarian economy to a manufacturing one, if the emigration networks can sufficiently help home firms access foreign markets. As the development in the home country kicks off, some talented emigrants may return to their home country to start new businesses, resulting in "reverse migration". It is shown that such "reverse migration" may result in "brain gain" in the long run when migration networks become strong. We also find that sufficient knowledge spillover or remittance may also bring "brain gain". In particular, we identify two equilibria. One is that the most talented emigrate, and the other equilibrium is that the most talented choose to stay home as managers while the intermediate-talented emigrate.

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Figure 1: Benchmark Case

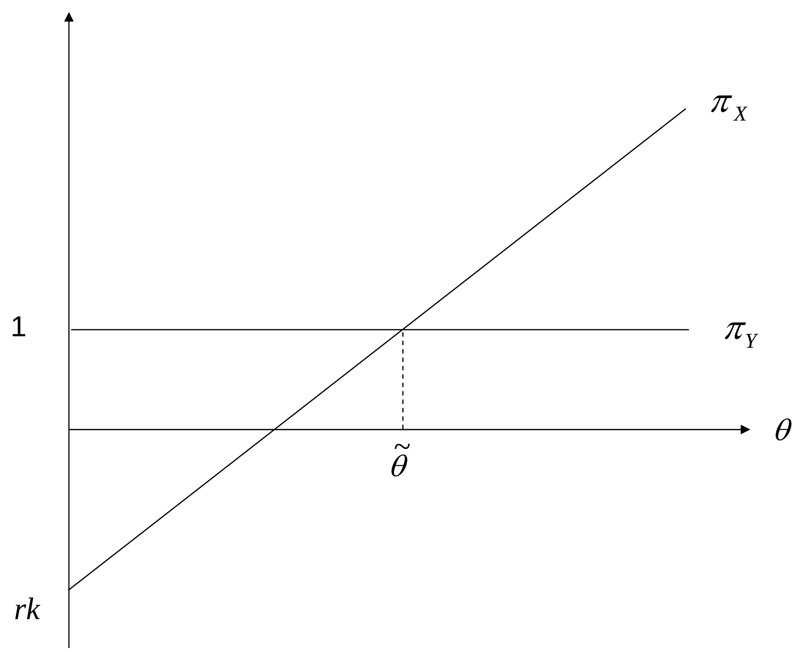

Figure 2: Short Run Equilibrium (s)

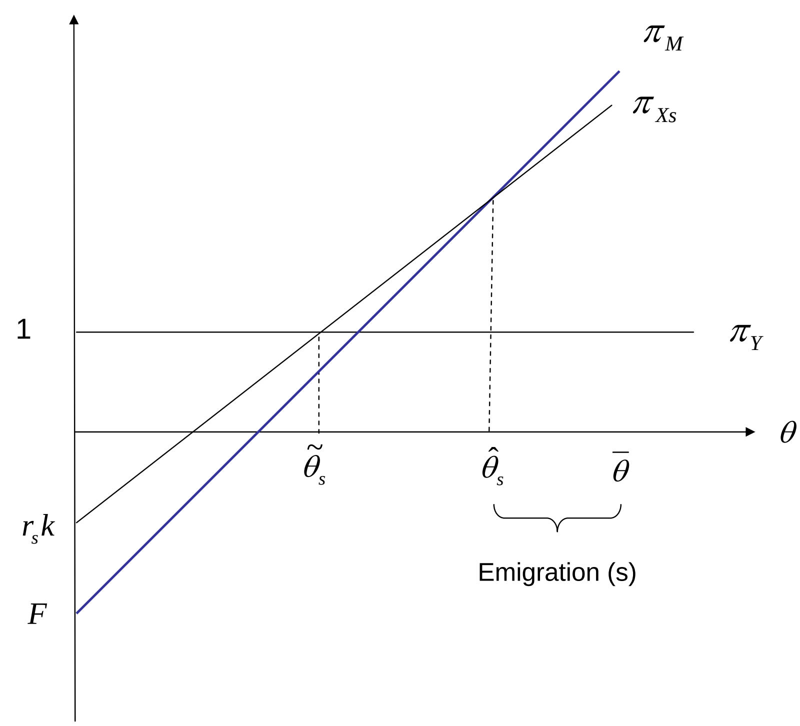

Figure 3: Short Run Equilibrium (s')

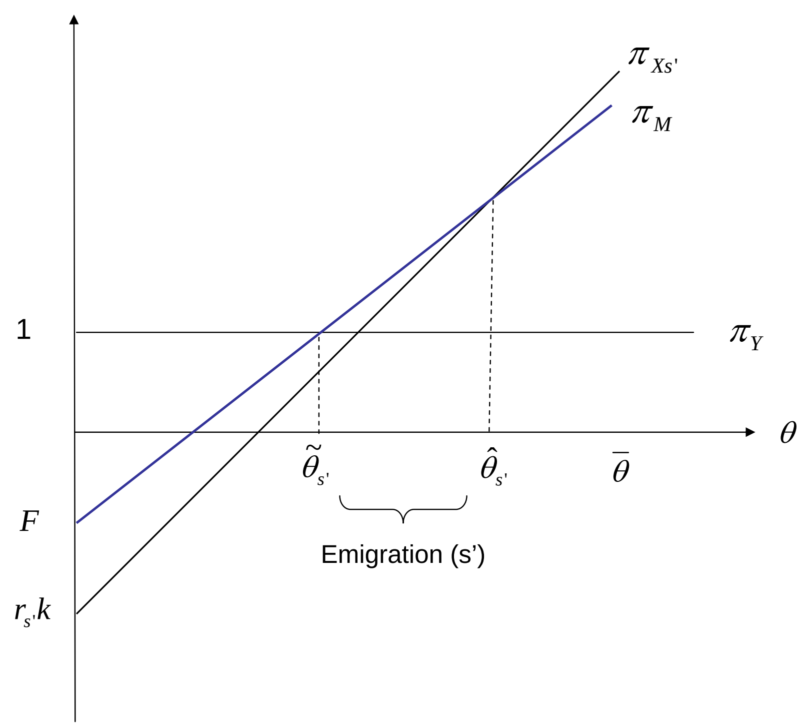

Figure 4: Long Run Equilibrium (a)

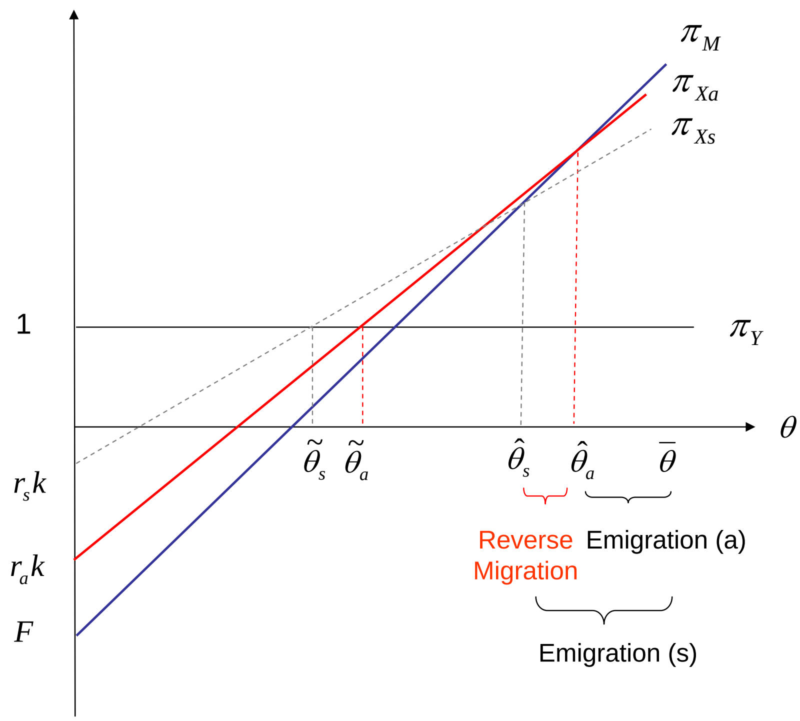

Figure 5: Equilibrium $\hat{\theta}_a$

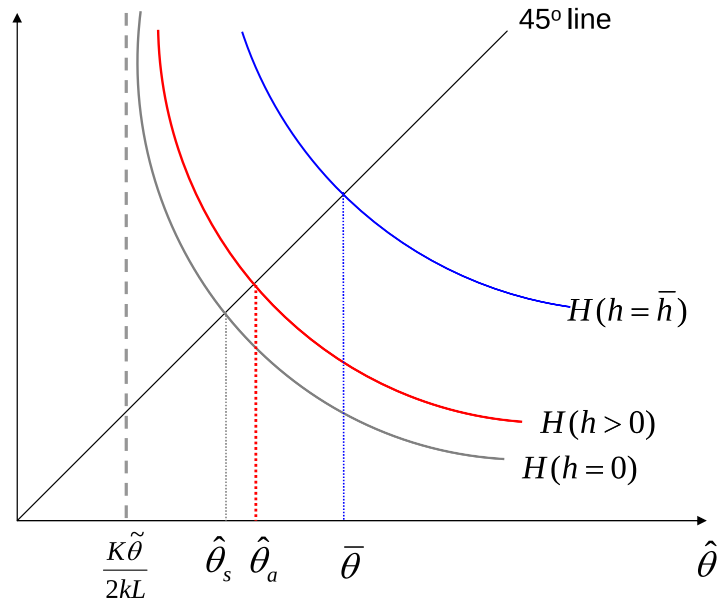

Figure 6: Equilibrium $\hat{\theta}_a$

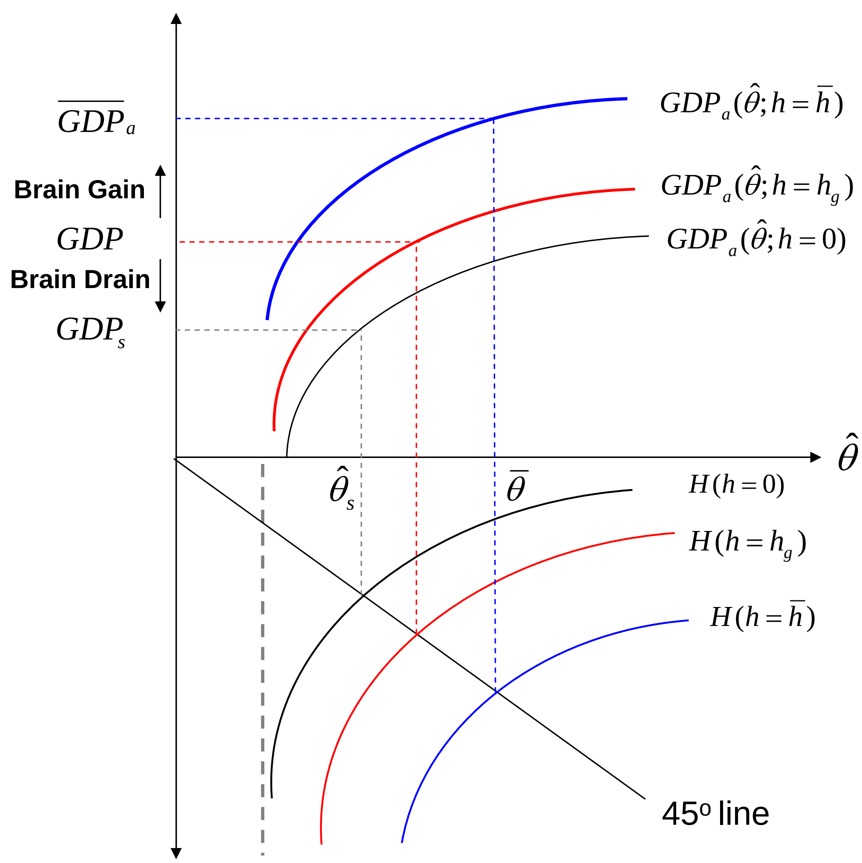

Figure 7: Long Run Equilibrium (a')