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Abstract

This paper develops a signaling theory where brain drain as well as the opposite of brain drain, a phenomenon we call "lame-drain" can result. In particular, we assume there are three types of agents according to their intrinsic abilities; education (with endogenous intensity) consists of two stages: undergraduate and graduate. There are two types of jobs: entry level and managerial. It is shown that under some circumstances the equilibrium is semi-pooling where the medium type chooses to work after undergraduate education while (a fraction of) both high and low types pursue graduate studies at home and abroad. Some high and low ability students return to work in the indigenous country in equilibrium. However, our model differs from the traditional brain drain models in that some low ability agents also go abroad in equilibrium and work in the host country after graduation, resulting in the recipient country hiring low ability agents, a phenomenon we call lame-drain. We then provide empirical evidence that lame-drain is indeed happening using U.S. Census data.

Keywords: Brain Drain; Lame Drain; Signalling
JEL: C72; F22; J61

1 Introduction

In their recent survey on the development of the literature on Brain Drain, Gibson and McKenzie (2011) show that there is a strong positive empirical association between skilled and unskilled migration both in the cross section and over time. The voluminous immigration economics literature has been mostly centered around the issue of immigration's impact on the wages in the U.S. labor market, especially for low skilled natives, ie., high school dropouts or workers with only a high school education. There is however, still a great deal of disagreement on whether immigration has lowered the earnings of native workers. For example, Borjas (2003) and Aydemir-Abdurrahman-Borjas (2007) showed that immigration does reduce wages, while Card (2005, 2009) on the other hand argues that the earnings of low skilled natives are not much affected. But overall little attention has been paid to the group of high skilled employment-based immigrants. Nor is there any study we know of that looks at the quality and particularly the variation in quality over time of this type of immigration.

Employment-based immigration, which is usually filed by aliens with advanced education degrees, accounts for nearly 40% of the total immigrant visas issued each year in the U.S. The lack of attention to this cohort is presumably rooted in the implicit assumption that these are world talents that U.S. should wholeheartedly embrace with open arms. In fact it is sometimes argued that American greatness stems from and still depends on immigration and assimilation of talent brains from around the world.

The separate brain drain literature however, looks at the same issue from an opposite perspective, the perspective from developing countries on factors explaining causes why talents from developing countries who have acquired advanced degrees from universities in developed countries would like to continue to stay and find employment in host countries, and how to prevent the brain drain phenomenon from happening. Causes include lack of jobs for returning graduates, lower salary levels in the home country and preference for higher living standards abroad, e.g., Kwok and Leland (1982).[1] While these factors seem to be consistent with historic observations, the brain drain literature, similar to the immigration literature, by and large has been built on the premises that what is drained from developing countries to developed countries is indeed talent brain. In this paper we provide empirical evidences that this premise may not always be true. At the very least, our study identifies a trend of deteriorating quality in employment-based immigration under some circumstances.

One needs to look no further than to China to understand the issue we propose, the country that exports most students to the developed world. China currently has about 400,000 university students abroad, most of whom are not expected to return. A 2007 report by the Chinese Academy of Social Sciences (CASS) found that of the

[1] Other explanations of brain drain include in the following: Miyagiwa (1991) argues that there are scale economies in high education, hence brain drain may raise the efficiency of educational institutions and income levels of the source country. Mountford (1997) claims that when the immigration decision is random in that the visa issuance by US immigration authority to applicants is a noisy function of their productivity, it may increase the average productivity in the home country. In Lien and Wang (2005), a two-dimensional decision on language skill and knowledge education levels is considered.

one million Chinese students who had studied overseas from 1978 to 2006, 70% did not return.[2] The large overseas student population from China needs to be viewed in the context of the largest high education expansion in Chinese history. In the 1980s, only 2-3% of high school graduates went on to college education. The figure increased to 17% in 2003. The watershed year was 1999, when the number of students enrolled jumped by almost half. Since the late 1990s, the breakneck expansions of overall campuses and enrollment are at an amazing rate – increasing by six-fold in the last six years.[3]

The Great Leap Forward in high education in China is largely driven by the Chinese government that sets ambitious employment goals in a burgeoning urbanization period. It increases substantially college admission quota over the years via administrative orders in its almost entirely publicly owned higher education sector. On the other hand, tuition rates are deregulated. Universities once almost entirely dependent on government funding during the planned economy era are now able to boost their revenues from fast-rising tuitions and fees. As a result, universities are admitting more and more less-qualified students.

The proliferation of high education to such a large population in such a short period of time inevitably leads to the degrading of education qualities and the generation of a pool of less qualified college graduates. A well-known 2005 study by McKinsey revealed a paradox of shortages amid plenty.[4] Of the country's 1.6 million young engineers, it is estimated only 10% were sufficiently well trained to work in multinational companies, a talent pool no larger than that in the UK. As the number of college graduates balloons, the value of their degrees has plummeted. It has been reported that many recent graduates have found only menial jobs or none at all. The average starting salary of college graduates of some majors is even less than that of migrant workers.

The adverse impact of the high education expansion in China evidently spills over to the other side of the Pacific, as many college graduates, including obviously those unskilled, unqualified and unemployed go abroad for graduate studies. In addition, a large number of Chinese students who failed in the competitive national college entrance exams went onto universities in developed countries including the US.[5] And many of them are unlikely to return to China. And this emmigration of unskilled, unqualified and unemployed studetns to developed countries seems to be the exact opposite of the brain-drain issue, or that of lame-drain, a term we coined and will use in the rest of the paper.

We first propose a theory to explain that the lame-drain phenomenon is quite

[2] In the last decade of the 20th century, 460,000 people from the Chinese mainland settled in the U.S. From 2000 to 2005, some 355,000 more Chinese immigrated to the United States, the CASS report found.

[3] Helen Joyce and James Miles, "China Goes to School," Far Eastern Economic Review, Hong Kong: Nov 2008. Vol. 171(9); pg. 47

[4] Diana Farrell and Andrew Grant, "Addressing China's looming talent shortage," McKinsey Global Institute, October 2005

[5] "China Props Up Foreign Students' Numbers in U.S.," the Chronicle of Higher Education, November 15, 2010. For example, Michigan State University went from having 4 Chinese freshmen in 2005 out of 202 incoming foreign students, to 445 out of 678 the fall of 2010.

possible, especially when the home country that exports students is fast developing and the wage levels between the home and the host country tend to equalize. The theory also shows that international flow of both talent-brains and lame-brains can be driven by factors other than differences in wage levels and living standards.

We then go on to present an empirical study to validate the lame-drain phenomenon. In particular, we use the 2010 U.S. Census data and provide two pieces of collaborating empirical evidence: for Chinese students who moved to the U.S. after the higher education expansion in China, (1) the return to a graduate degree is lower than those who moved before; (2) those with low abilities are more likely to obtain a graduate degree. The first point suggests a deteriorating quality of employment-based immigration from China, suggesting what is drained from China to the US in recent years may not be the brightest brains but very likely the result of the high education expansion in China spilled over to the US. The second point reinforces the theme that low-ability students tend to use higher education merely as a signaling instrument to find employment, an observation consistent with the Spence model.

Our model uses a modified Spence model as the basic setup. Since the seminal papers by Spence (1973, 1974), economists understand that educational credentials serve as perfect signals of their intrinsic abilities for employers in an adverse selection environment. There are three basic conclusions drawn from the original papers: (i) no pooling equilibrium can sustain; (ii), at most there is one separating equilibrium; and (iii) equilibrium does not always exist. In the original Spence model, high ability students must accept completely unproductive and costly education merely to distinguish themselves from their less competent counterparts, which leads to the over-education equilibrium. However, the analysis was purely from the labor market's point of view, in which the schools play a passive role in providing education without strategic interactions with either students or employers. The implications on education quality or signaling content of education would change however, if such an assumption is relaxed. Ostrovsky and Schwarz (2003) find that when the assignment function from the student's ability to job desirability is concave, then a school will be better off to mix the high-ability students with low ability ones through coarsing information content of grades. In that case, high ability students suffer as the value of a good education becomes diluted.[6]

Our paper is related to the strand of literature that extends the original Spence model. Ortin-Angel and Salas-Fumas (2007) show that ability and competence of a worker are not observable at the time he enters the labor market, but can be learned by employers from job performance over time, and the salary then changes. One important modification of the original Spence model is that education can improve agents' productivity in addition to the signaling purpose. Indeed, Fang (2006) estimates that education enhances attendees' productivity by 40%, and this amounts to a two thirds of the college wage premium. Swinkels (1999) shows that when education improves productivity, pooling equilibrium may arise. Hence less able workers tend to be over-educated, and more able ones are under-educated, compared with the benchmark case where education has no productivity improvement. Lee (2007)

[6] In a recent working paper, Yue and Yang (2011) discovered, using survey data, that 36% and 42% of master and PhD graduates in China respectively are overeducated.

considers the impact of timing of signaling on the education quality and intensity at different stages of education, which may partially explain why Asian students work harder in high schools but Americans work harder in universities.

The current paper offers interpretations when and why brain drain may happen, in a two country model with different education systems (planned vs. market oriented) and otherwise identical settings. Aside from the new empirical findings, our theory provides validation for international flows of both talent and lame brains. The mixed bag of both types of brains from developing countries to developed countries indicates that this is not always detrimental to the source country, as it is effectively exporting low productivity workers. The previous literature (Mountford (1997), Stark, Helmenstein and Prskawetz (1998), Vidal (1998) and Beine, Docquier and Rapaport (2001)) attempted to rationalize this result based on uncertainty about the ability to migrate and the assumption that firms cannot screen effectively immigrants' innate ability due to information asymmetry. In contrast, our analysis suggests that brain drain may be globally welfare worsening, because of the more costly semi-pooling in developed countries compared with the case of no international talent flows at all. This brings about important policy implications with respect to the recent immigration reform debate in the US. Our analysis indicates the importance of effective screening of entering foreign students by universities and the federal government. It also stresses the federal government's initiative to help private firms with the job screening process with respect to foreign graduates, and improve upon the process of how H-1 visas and work permits are issued.

The rest of the paper is organized as follows. Section 2 provides a model respectively for a developed country and a developing country. Section 3 presents our empirical results. Section 4 looks at the issue of talent flows between those two countries. Conclusions and remarks are contained in section 5.

2 The Model

In this section, we first build two closed economy models for a developed and developing country respectively, where students are not allowed to pursue overseas education. We establish equilibrium education intensities, tuition levels, and wage rates for different types of agents pursuing different types of jobs in these two models. In the rest of this paper, the terms, the developed country, or the North, or the market oriented economy refer to the same concept. Likewise, the terms, the developing country, the South, and the transition economy are used interchangeably.

2.1 Model Setup

Assume that there are three types of agents in an economy, *i.e.*, type H, type M and type L, denoting respectively high ability, medium ability and low ability agents. The difference among them is the intrinsic ability (which eventually affects productivity), θ_i, $i = H, M, L$, where $\theta_H > \theta_M > \theta_L$. An agent's instrinc ability is his private information. The entire population is normalized to 1, and the proportion of type i agents is denoted by ϕ_i, with $\sum_{i=H,M,L} \phi_i = 1$.

Universities provide two vertically separate education programs at undergraduate and graduate levels. Use $j = 1, 2$ to denote undergraduate and graduate education, respectively. Let the quality of education level j be e_j, and the corresponding tuition be γ_j. Similar to Spence (1974), we assume students of higher ability incur less private costs in pursuing a given degree. Specifically, the total cost of education for agent i to pursue education level j, $C_i(e_j)$, is the sum of effort, or the disutility of receiving education plus the tuition paid:

$$C_i(e_j) = \frac{e_j^2}{2\theta_i} + \gamma_j.$$

Note that the above formulaton implies that the educational cost is inversely related to an agent's ability, and convex in education intensity.

In the labor market, assume that only two types of jobs are offered in each economy, i.e., blue-collar jobs for undergraduate degree holders (job type $k = 1$) and white-collar jobs for graduate degree holders (job type $k = 2$). The true ability of an agent hunting type k job is detected by the employer with a probability p_k, $k = 1, 2$.[7] Assume that it is easier for an employer offering blue-collar jobs to learn the true ability of an agent than one offering white-collar jobs, i.e., $p_1 > p_2$. This may be justified by the fact that the nature of a blue-collar job is more simplistic and repetitive, requiring less creative intrinsic abilities. Detection is assumed to be costless. The labor market is assumed to be employer competitive, i.e., employers make zero expected profit in equilibrium. The wage rate is denoted by ω_k.

Let the productivity of type i agents be y_i, where $i = H, M, L$. y_i is the sum of intrinsic ability θ_i and the education intensity of the corresponding level that type i pursues,[8] i.e.,

$$y_i = \theta_i + \sum_{j=1,2} \varepsilon_{ij} e_j, \tag{2.1}$$

where $i = H, M, L$, and ε_{ij} is a binary variable such that

$$\varepsilon_{ij} = \begin{cases} 1, & \text{if } i \text{ pursues education level } j; \\ 0, & \text{if } i \text{ does not pursue education level } j. \end{cases}$$

Note that our formulation above makes an agent's productivity to be dependent on education intensity, whereas in Spence (1974) productivity is independent of eductioin, only serving as a signalling instrument in the job-seeking process.

University revenues are the sum of all the tuitions collected,[9] namely,

$$R = \sum_{i=L,M,H} \sum_{j=1,2} \varepsilon_{ij} \phi_i \gamma_j.$$

[7] Ortin-Angel and Salas-Fumas (2007) argue that an employee's ability is not observable at the time he enters the labor market. Our model, on the contrary, assumes that an employer has a probability to detect an employee's ability during the interview, since our model is a static model and our focus is not on labor contracting issues.

[8] This is where we differ from most first generation education models (Spence 1973, 1974) where the agent's productivity is intrinsic ability alone and it does not vary in response to education received. Education then serves as a signalling instrument only.

[9] For simplicity, assume that there is no cost for universities to provide education.

Universities maximize their revenues through optimally setting tuitions as a functions of education intensities.

Agents choose education levels, or determine ε_{ij}. Assuming agents are risk neutral, the utility of type i agents, U_{ij}, is:

$$U_{ij} = \begin{cases} 0, & \text{if } i \text{ pursues no education;} \\ \mathrm{E}_i[\omega_1] - C_i(e_1), & \text{if } i \text{ pursues education 1 } (j=1); \\ \mathrm{E}_i[\omega_2] - \sum_{j=1,2} C_i(e_j), & \text{if } i \text{ pursues both education 1 and 2 } (j=2), \end{cases} \tag{2.2}$$

where $i = H, M, L$, and $\mathrm{E}_i[\omega_k]$ is the expected wage rate of type i agents working at type k jobs. Figure 1 shows a schematic representation of the reservation utilities of agents pursuing different education intensities. The indifference curves show the positive relationship between wages and education intensities. Any point above each indifference curve represents corresponding utility surplus and *vice versa*.

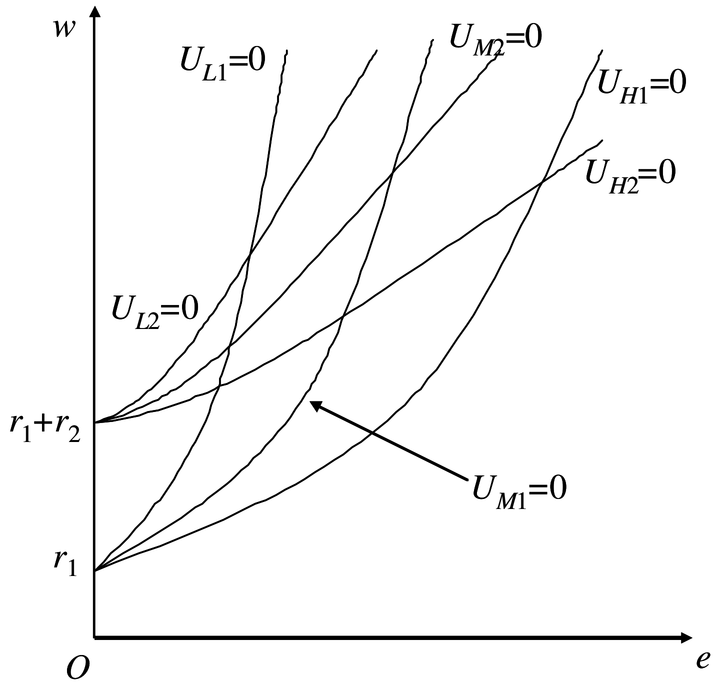

Figure 1. Indifference Curves with Reservation (Zero) Utilities

2.2 The North Model

Let us first consider a market oriented economy where a revenue-maximizing university faces no external mandates or restrictions on admissions. The assumption that schools play an active role in admission, acting as profit-maximizing agents, is in line with the reality of both developed and developing countries. For example, Winston (1999) asserts, "high education is a business: it produces and sells educational services to customers for a price it buys inputs with which to make that product."

As customary in this type of signaling setup, there could be multiple types of equilibrium arising, depending on the parametric values of the model. For example in one extreme case, the university could set tuition levels so low such that all types of students are admitted for both undergraduate and graduate education. Since our focus in this paper is on human talent flows between the North and the South, we only focus on two types of equilibrium that resemble respectively stylized facts of each country. In the North, a separating equilibrium arises, where type L agents do not pursue university education and thus are not employed, where type M agents only pursue undergraduate education and are employed for blue-collar jobs, and where type H agents pursue both undergraduate and graduate education and are employed for white-collar jobs.

The equilibrium of interest in the South model is a semi-pooling one, where all the agents choose to receive undergraduate education in equilibrium, but type M agents choose to take blue-collar jobs after undergraduate studies while type L and H agents pursue graduate education and are able to take white-collar jobs. We characterize necessary conditions for both types of equilibrium in the North as well as in the South.

The North model is essentially a minor extension of the Spence (1974) model by incorporating an additional type of L agents who in equilibrium are not employed anyway, and nor do they invest in education at all. Our South model is tailored to capture some of the defining characteristics of the education system in fast developing countries such as China, where universities have gone through a period of rapid expansion, granting degrees of inflated value to a vast number of under-qualified graduates, many of whom are unemployed or underemployed, greatly suppressing the wage level for white-collar workers.

When type M agents only pursue undergraduate education and type H agents pursue both undergraduate and graduate education in equilibrium, $\varepsilon_{M1} = \varepsilon_{H1} = \varepsilon_{H2} = 1$. Type L agents would have no incentive to pursue any type of education at all due to high education intensities and high tuitions [10]. Hence type L agents are unemployed.

The separating equilibrium in the North suggests that employers can definitely tell the type of a candidate job seeker from his/her academic degree. From an employer's perspective, blue-collar workers are recognized as type M agents pursuing only undergraduate education and contributing $y_M|_{e_1}$ in productivity. The corresponding wage is then ω_1. Meanwhile, employers gain $y_H|_{e_2}$ from those white-collar workers who are recognized as type H agents holding graduate degrees. ω_2 would be their corresponding wage level. The employer's profit is the difference between productivity gains and wage payments. Then the non-negative profit constraints, or individual rationality constraints, on the part of the employers are:

$$y_M|_{e_1} - \omega_1 \geq 0, \tag{2.3}$$

[10] Theorem 7 in subsection 3.4 indicates that assumption 1 exclude the possibility that colleges have any incentive to decrease the education intensities and tuitions and admit type L agents without external restrictions on admissions. theorem 7 here, correct assumption 1, proof put in the appendix

and

$$y_H|_{e_2} - \omega_2 \geq 0. \tag{2.4}$$

In an employer-competitive labor market, constraints (2.3) and (2.4) are binding. Substituting equation (2.1) into binding constraints (2.3) and (2.4) to substitute $y_M|_{e_1}$ and $y_H|_{e_2}$ yields the expression for equilibrium wages:

$$\omega_1 = \theta_M + e_1, \tag{2.5}$$

and

$$\omega_2 = \theta_H + e_1 + e_2. \tag{2.6}$$

Next, we present a set of incentive compatible constraints of the separating equilibrium in this signaling game, meaning the agents have no incentive to mimic other types. Specifically, for type M agents, working for blue-collar jobs brings them ω_1 and costs $C_M(e_1)$. Hence, the expected income of type M agents working for white-collar jobs is $[(1-p_2)\omega_2 + p_2 \cdot 0]$, that is, $(1-p_2)\omega_2$, compensating for the cost $[C_M(e_1) + C_M(e_2)]$. Therefore type M's incentive compatibility constraint is as follows. Note that (2.7) implies that type M agents have no incentive to pursue graduate education.

$$\omega_1 - C_M(e_1) \geq (1-p_2)\omega_2 - C_M(e_1) - C_M(e_2). \tag{2.7}$$

For the type H agents, they will gain ω_2 when working for white-collar jobs. The cost of education is $[C_H(e_1) + C_H(e_2)]$. Mimicking type M agents to work for blue-collar jobs however will incur a wage ω_1. But the cost of education is reduced to $C_H(e_1)$. Then the *incentive compatibility* constraint of type H agents becomes:

$$\omega_2 - C_H(e_1) - C_H(e_2) \geq \omega_1 - C_H(e_1). \tag{2.8}$$

We next assume the university has bargaining power over students in setting tuitions and consequently determines agents' education intensities in equilibrium. Therefore the set of individual rationality constraints requires non-negative utility for type M and type H agents:

$$\omega_1 - C_M(e_1) \geq 0, \tag{2.9}$$

and

$$\omega_2 - C_H(e_1) - C_H(e_2) \geq 0. \tag{2.10}$$

It is then straightforward to obtain the following:

1. Constraint (2.8) is binding. Because the university has bargaining power and can raise graduate education tuitions to increase $C_H(e_2)$ without affecting other inequalities. The binding constraint (2.8) implies that in equilibrium, type H agents are indifferent between pursuing both education levels and pursuing undergraduate education only.

2. Constraint (2.7) must hold in strict inequality. This can be seen by substituting ω_1 in the binding constraint (2.8) into constraint (2.7), meaning that type M agents will never mimic type H agents to pursue graduate education.

3. Constraint (2.9) is also binding, for the same reason that the university can raise undergraduate education tuition level to increase $C_M(e_1)$ without affecting other inequalities. That is to say, type M agents have no rent in equilibrium.

4. Constraint (2.10) always holds if constraints (2.9) and (2.8) are satisfied. Hence, constraint (2.10) is excessive, suggesting that type H agents have informational rent in equilibrium.

Expanding constraints (2.8) and (2.9) and solving simultaneously for γ_1 and γ_2 yields

$$\gamma_1 = \omega_1 - \frac{e_1^2}{2\theta_M}, \tag{2.11}$$

and

$$\gamma_2 = \omega_2 - \omega_1 - \frac{e_2^2}{2\theta_H}. \tag{2.12}$$

Substituting ω_1 and ω_2 in equations (2.5) and (2.6) into equations (2.11) and (2.12) yield the relationship between the tuition levels and education levels, i.e.,

$$\gamma_1 = \theta_M + e_1 - \frac{e_1^2}{2\theta_M}, \tag{2.13}$$

and

$$\gamma_2 = (\theta_H - \theta_M) + e_2 - \frac{e_2^2}{2\theta_H}. \tag{2.14}$$

The separating equilibrium suggests that $(\phi_M + \phi_H)$ agents pursue undergraduate education, and only ϕ_H agents pursue graduate education. Thus, the university's maximization problem becomes

$$\max_{\gamma_1,\gamma_2} R = (\phi_M + \phi_H)\gamma_1 + \phi_H\gamma_2 \tag{2.15}$$

subject to equations (2.13) and (2.14).

In equations (2.13) and (2.14), tuitions are quadratic functions of corresponding education levels. Thus the objective function in the maximization problem in (2.15) is concave, guaranteeing the unique existence of the optimal education intensities that maximize tuition levels. The solution to (2.15) is summarized in Table 1 below, and we summarize the main separating equilibrium result in Proposition 1.

Table 1: Equilibrium Education Intensities, Wages and Tuitions in a Market-oriented Economy

Variable Subscripts	Education Level (j)	1	2
	Job Type (k)	1	2
Education Intensities $\left(e_j^*\right)$		θ_M	θ_H
Wages (ω_k^*)		$2\theta_M$	$2\theta_H + \theta_M$
Tuitions $\left(\gamma_j^*\right)$		$\frac{3}{2}\theta_M$	$\frac{3}{2}\theta_H - \theta_M$

Proposition 1 *In a separating equilibrium of the North model, type M agents only pursue undergraduate education, type H agents pursue both undergraduate and graduate education, and type L agents do not pursue any higher education. The equilibrium education intensities, wages, and tuitions are provided in Table 1.*

Proof. The analysis so far shows the results for types H and M agents as summarized in Table 1. Here we show that type L agents choose to receive no education at all. As is defined in equation (2.2), the utility of type L agents receiving undergraduate education and working for blue-collar jobs is

$$U_{L1} = (1 - p_1)\omega_1^* - C_L(e_1^*).$$

From Table 1, we have that $e_1^* = \theta_M$, $\omega_1^* = 2\theta_M$ and $\gamma_1^* = \frac{3}{2}\theta_M$. Then,

$$\begin{aligned} (1 - p_1)\omega_1^* - C_L(e_1^*) &= 2(1 - p_1)\theta_M - \frac{\theta_M^2}{2\theta_L} - \frac{3}{2}\theta_M \\ &= -\frac{1}{2}\frac{\theta_M - \theta_L}{\theta_L}\theta_M - 2p_1\theta_M < 0, \end{aligned}$$

which implies that type L agents have no incentive to pursue undergraduate education.

Similarly, the utility of type L agents receiving both undergraduate and graduate education and working at white-collar jobs is

$$(1 - p_2)\omega_2^* - C_L(e_1^*) - C_L(e_2^*) = -\frac{1}{2}\frac{\theta_M - \theta_L}{\theta_L}\theta_M - \frac{1}{2}\frac{\theta_H - \theta_L}{\theta_H}\theta_H - 2p_2\theta_H < 0,$$

which implies that type L students have no incentive to pursue graduate education either. ■

Proposition 1 implies that the university sets the tuition levels and determines the corresponding equilibrium education levels. This separating equilibrium indirectly excludes type L agents from education and employment. In Figure 2, we provide a schematic representation of the separating equilibrium in this model, which is labeled as A and B. The equilibrium education intensities, e_1^* and e_2^*, as well as equilibrium tuition levels, γ_1^* and γ_2^*, are also depicted along the two axes.

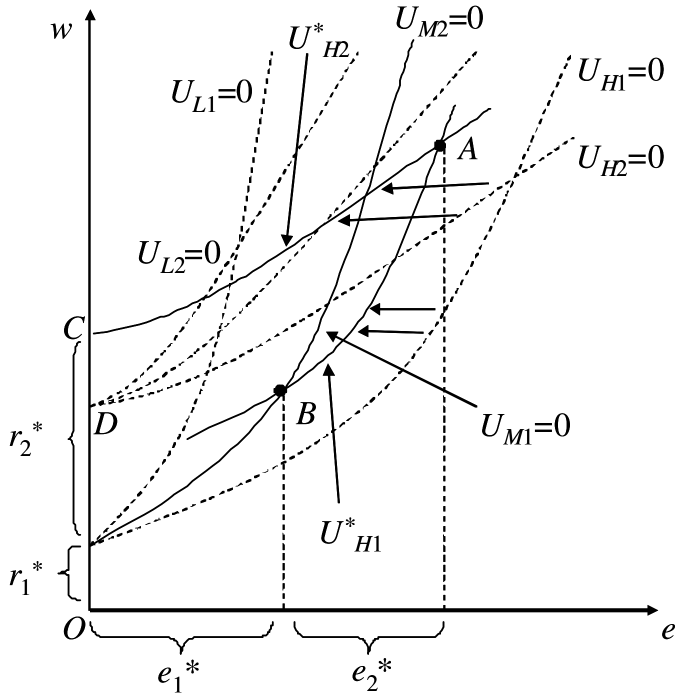

Figure 2. A Separating Equilibrium in the North model

Five observations are worth noting from Figure 2.

- Point A is at the intersection of U^*_{H1} and U^*_{H2}, which are in parallel with curves $U_{H1} = 0$ and $U_{H2} = 0$, respectively. This suggests that in equilibrium, type H agents are indifferent between pursuing both education levels and pursuing only undergraduate education;

- Point A is above curves $U_{H1} = 0$ and $U_{H2} = 0$, indicating that type H agents have informational rent in equilibrium;

- Point A is below curve $U_{M2} = 0$, indicating that type M agents will not mimic type H agents to pursue graduate education;

- Point B is on the curve $U_{M1} = 0$, indicating that type M agents have no informational rent in equilibrium;

- Both points A and B are below curves $U_{L1} = 0$ and $U_{L2} = 0$. This suggests that type L agents are unemployed. The reason is that tuitions are too high for a type L agent, which is reflected by the fact that point C is above point D.

2.3 The South Model

In this section we consider a transition economy where the education system is subject to government intervention to meet certain social goals. Suppose the government authority places high priority on social stability and attempts to achieve universal undergraduate education for all citizens. This entails an aggressive expansionary policy of the education industry to meet mandatory university enrollment for all types of agents. This scenario is actually not unreal in China as the college student population grows at an astonishing rate in recent years.

Under this circumstance, universities have to decrease their tuition level to attract type L agents to college as well. It can be shown that under certain conditions a semi-pooling equilibrium emerges, where type M agents only pursue undergraduate education, while both type L and H agents pursue not only undergraduate but graduate education as well.

In this semi-pooling equilibrium, an employer is able to tell the type of candidates seeking blue-collar jobs, i.e., θ_M, pay them a wage of ω_1 and reap productivity gains of $y_M|_{e_1}$. His profit is calculated as the difference between productivity gains and wage payments. The non-negative profit constraint, or individual rationality constraint, is then:

$$y_M|_{e_1} - \omega_1 \geq 0. \tag{2.16}$$

From the employers' perspective, candidates of white-collar jobs may be type L or type H agents. The probability to detect the true type is p_2. Obviously, the productivity of type L agents is lower than the average productivity of pooling type L and type H agents. Consequently, the probability of taking white-collar jobs for type L agents is $(1-p_2)$. Type H agents will always be employed because their productivity is above the average. Then the probability that agents taking white-collar jobs are type L agents is $\frac{(1-p_2)\phi_L}{(1-p_2)\phi_L+\phi_H}$. For type H agents, their probability is $\frac{\phi_H}{(1-p_2)\phi_L+\phi_H}$. The expected productivity of a white-collar worker is $\left(\frac{(1-p_2)\phi_L}{(1-p_2)\phi_L+\phi_H} y_L|_{e_2} + \frac{\phi_H}{(1-p_2)\phi_L+\phi_H} y_H|_{e_2}\right)$ and the corresponding wage is ω_2. Then in the white-collar sector, the non-negative profit constraint requires:

$$\left(\frac{(1-p_2)\phi_L}{(1-p_2)\phi_L+\phi_H} y_L|_{e_2} + \frac{\phi_H}{(1-p_2)\phi_L+\phi_H} y_H|_{e_2}\right) - \omega_2 \geq 0. \tag{2.17}$$

An employer-competitive labor market induces constraints (2.16) and (2.17) to be binding. Substituting $y_L|_{e_2}$, $y_M|_{e_1}$ and $y_H|_{e_2}$ in equation (2.1) into constraints (2.16) and (2.17) and solving for ω_1 and ω_2, one obtains

$$\omega_1 = \theta_M + e_1, \tag{2.18}$$

and

$$\omega_2 = \frac{(1-p_2)\phi_L\theta_L + \phi_H\theta_H}{(1-p_2)\phi_L+\phi_H} + e_1 + e_2. \tag{2.19}$$

Type M agents may not want to take white-collar jobs, because their wage is diluted by low ability type L agents. If type M agents pursue only undergraduate education and take blue-collar jobs with a wage ω_1, the incentive compatibility condition requires that:

$$\omega_1 - C_M(e_1) \geq \omega_2 - C_M(e_1) - C_M(e_2). \tag{2.20}$$

For type L agents, the probability for securing a white-collar job offer is $(1-p_2)$. Likewise, if a type L agent pursues only undergraduate education and applies for a blue-collar job, the probability of getting such a job will be $(1-p_1)$. Then taking white-collar jobs brings type L agents an expected wage level of $(1-p_2)\omega_2$ at an education cost of $[C_L(e_1)+C_L(e_2)]$. Working as a blue-collar worker however, earns $(1-p_1)\omega_1$ at an education cost of $C_L(e_1)$. Then the incentive compatibility constraint for a type L agent to pursue both education levels is:

$$(1-p_1)\omega_1 - C_L(e_1) \leq (1-p_2)\omega_2 - C_L(e_1) - C_L(e_2). \tag{2.21}$$

For type H agents, taking white-collar jobs earns ω_2 after an education cost of $[C_H(e_1)+C_H(e_2)]$. But if they mimic type M agents as blue-collar workers, they earn ω_1 with a corresponding education cost of $C_H(e_1)$. Then the incentive compatibility condition for type H agents to pursue both education levels requires that:

$$\omega_2 - C_H(e_1) - C_H(e_2) \geq \omega_1 - C_H(e_1). \tag{2.22}$$

The individual rationality constraints are straightforward, as they need to guanrantee non-negative utility for each type of agents, as shown in the following:

$$\omega_1 - C_M(e_1) \geq 0, \tag{2.23}$$

$$(1-p_2)\omega_2 - C_L(e_1) - C_L(e_2) \geq 0 \tag{2.24}$$

and

$$\omega_2 - C_H(e_1) - C_H(e_2) \geq 0. \tag{2.25}$$

Since the defining feature of the South model is the government's mandate of universal undergraduate education for all types of agents and furthermore type L agents also pursue both education levels as type H agents do, the university needs to maximize the following objective function:

$$\max_{\gamma_1,\gamma_2} R = \gamma_1 + (\phi_L + \phi_H)\gamma_2 \tag{2.26}$$

subject to (2.20), (2.21), (2.22), (2.23), (2.24), and (2.25).

Obviously this is a linear programming problem. We use the graph below to illustrate what conditions are binding, while others are not.

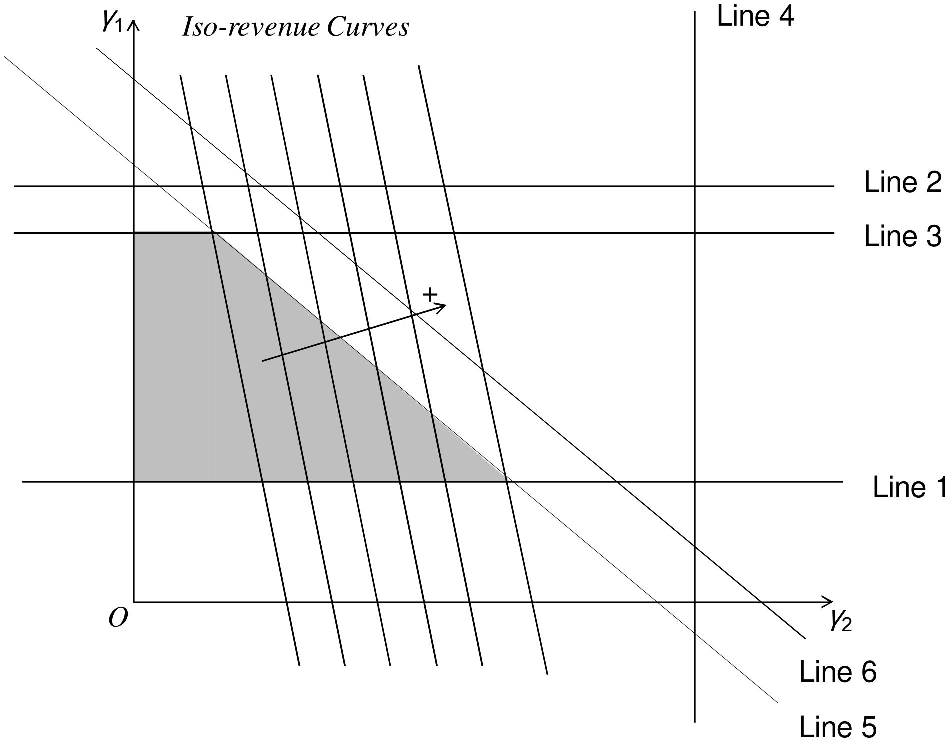

Figure 3. Linear Programming for the South model

In Figure 3, Line 1 to Line 6 correspond to constraints (2.20) to (2.25). The shaded area in Figure 3 represents the feasible solution set of the problem (2.26). In order to assure that this feasible set is not empty, line 3 must lie above line 1. Mathematically this translates into the following simple condition:

Assumption 1. *For type L agents, the detection loss of entry level job, $p_1\omega_1$, is smaller than the detection loss of managerial level job, $p_2\omega_2$, in particular, in equilibrium the following holds,*

$$p_1\omega_1 > p_2\omega_2. \tag{2.27}$$

Condition (2.27) ensures that the solution to (2.26) is nonempty, since when p_1 and p_2 are too close, a binding (2.20) is in conflict with (2.21) and (2.22). Intuitively, additional conditions (on p_1 and p_2) must be imposed to ensure that the white-collar wages/education costs combo is not attractive enough for type M agents, but still attractive enough for type L agents. In other words, p_2 must be sufficiently small compared to p_1 such that type L agents would pursue graduate studies.

Because the iso-revenue curves of the universities are steeper than lines 5 and 6, the equilibrium should lie in the intersecton of line 1 and line 5, which means constraints (2.20) and (2.24) are binding, while others are excessive. To summarize:

1. Constraint (2.20) is binding. This is because the university can decrease graduate tuition and increase undergraduate tuition by the same or even a larger amount to increase its revenue without affecting all other inequalities. Thus

the equilibrium graduate tuition is determined by the binding condition (2.20) so as to avoid type M agents to mimic other types.

2. Both constraints (2.21) and (2.22) are excessive, indicating that both type H agents and L agents prefer to pursue graduate education.

3. Constraint (2.23) holds in strict inequality. Compared to (2.9) in the North model where individual rationality constraint for the type M agents is binding, here it is not. And type M agents in fact gain informational rent. This is because the university would decreases tuition to attract type L agents such that their individual rationality constraint is binding.

4. Constraint (2.24) is binding. This is because the university can raise undergraduate and education tuition to increase $C_L(e_2)$. This implies that in equilibrium type L agents have no rent.

5. Constraint (2.25) is excessive. This is a common result in the adverse selection literature in that type H agents usually have informational rent in equilibrium.

Provided that constraints (2.20) and (2.24) are binding, solving for constraints (2.20) and (2.24) for γ_1 and γ_2 yields

$$\gamma_1 = \omega_1 - p_2\omega_2 - \frac{e_1^2}{2\theta_L} - \frac{e_2^2}{2\theta_L} + \frac{e_2^2}{2\theta_M}, \tag{2.28}$$

and

$$\gamma_2 = \omega_2 - \omega_1 - \frac{e_2^2}{2\theta_M}. \tag{2.29}$$

Substituting ω_1 and ω_2 in equations (2.18) and (2.19) into equations (2.28) and (2.29), one obtains the relationship between the tuition and education intensities, that is,

$$\begin{aligned}\gamma_1 &= \theta_M - p_2e_2 + (1-p_2)e_1 - \frac{e_1^2}{2\theta_L} \\ &\quad - \frac{(\theta_M-\theta_L)e_2^2}{2\theta_L\theta_M} - p_2\frac{(1-p_2)\phi_L\theta_L + p_2\phi_H\theta_H}{(1-p_2)\phi_L+\phi_H},\end{aligned}$$

and

$$\gamma_2 = -\theta_M + e_2 - \frac{e_2^2}{2\theta_M} + \frac{(1-p_2)\phi_L\theta_L + \phi_H\theta_H}{(1-p_2)\phi_L+\phi_H}.$$

Table 2 lists the equilibrium education intensities, wages and tuitions of the maximization problems (problem (2.26)), which jointly make up Proposition 2.

Table 2: Equilibrium Education Intensities, Wages and Tuitions in a Transition Economy

Variables	Education (j)	1	2
Subscripts	Job (k)	1	2
Education Intensities (e_j^*)		$(1-p_2)\theta_L$	$\frac{\theta_L-(\phi_M+p_2)\theta_L}{\theta_M-\phi_M\theta_L}\theta_M$
Wages (ω_k^*)		$\theta_M+(1-p_2)\theta_L$	$(1-p_2)\theta_L + \frac{(1-p_2)\phi_L\theta_L+\phi_H\theta_H}{(1-p_2)\phi_L+\phi_H} + \frac{\theta_L-(\phi_M+p_2)\theta_L}{\theta_M-\phi_M\theta_L}\theta_M$
Tuitions (γ_j^*)		$\theta_M+\frac{(1-p_2)^2}{2}\theta_L - p_2\frac{(1-p_2)\phi_L\theta_L+p_2\phi_H\theta_H}{(1-p_2)\phi_L+\phi_H} - \frac{(1-\phi_M-p_2)(1-\phi_M)(\theta_L+\theta_M)}{2(\theta_M-\phi_M\theta_L)^2} + \frac{(1-\phi_M-p_2)[(2\phi_M+1)\theta_L-\theta_M]p_2}{2(\theta_M-\phi_M\theta_L)^2}$	$\frac{(1-p_2)\phi_L\theta_L+\phi_H\theta_H}{(1-p_2)\phi_L+\phi_H}-\theta_M - \frac{(1+\phi_M-p_2)^2\theta_L^2\theta_H}{2(\theta_M-\phi_M\theta_L)^2} + \frac{(1-\phi_M-p_2)\theta_L\theta_M\theta_H}{(\theta_M-\phi_M\theta_L)^2}$

Proposition 2 *In an equilibrium of the South model, where all agents receive undergraduate education, and both type L and H agents receive both undergraduate and graduate education, the equilibrium education intensities, wages and tuitions are provided in Table 2.*

Points A^* and B^* in Figure 4 represent the semi-pooling equilibrium in this model. U_{M1}^* and U_{M2}^* are in parallel with curves represented by $U_{M1}=0$ and $U_{M2}=0$ respectively. The sum of equilibrium tuitions, $\gamma_1^*+\gamma_2^*$, is depicted along the vertical axis. The equilibrium education intensities, e_1^* and e_2^* lie along the horizontal axis.

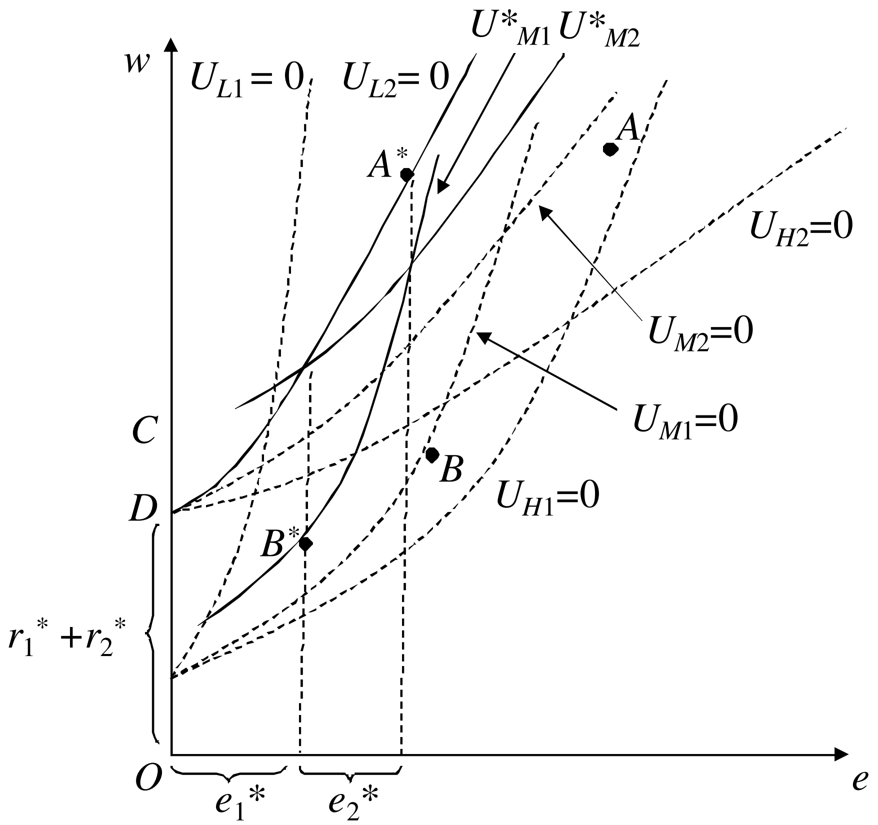

Figure 4. A Semi-pooling Equilibrium in the South model

Several observations follow from Figure 4:

- That A^* is at the intersection of U^*_{M1} and U^*_{M2} suggests that in equilibrium, type M agents are indifferent between pursuing both education levels and pursuing only undergraduate education;

- Point A^* is above the curve represented by $U_{H2} = 0$, which indicates that type H agents have informational rent in equilibrium;

- That point A^* is on the curve represented by $U_{L2} = 0$ indicates that type L agents have no rent in equilibrium;

- Point B^* is below the curve represented by $U_{L1} = 0$, indicating that type L agents also pursue both education levels;

- Point B^* is above the curve represented by $U_{M1} = 0$, indicating that type M agents have informational rent in equilibrium.

To compare to the North model, we also show the North's separating equilibrium in Figure 4, which is labeled as A and B. Clearly, education intensities decrease, considering that points A and B are to the right of points A^* and B^* respectively. An algebraic proof of this observation is provided in the following proposition.

Proposition 3 *Education intensities of both undergraduate and graduate education in the North model are higher than those in the South model.*

Proof. The undergraduate education intensity in the North model, given by Table 1, equals θ_M, which is obviously greater than one in a transition economy, given by Table 2, $(1 - p_2)\theta_L$.

The graduate education intensity in the South model, given by Table 2, is $\frac{\theta_L - (\phi_M + p_2)\theta_L}{\theta_M - \phi_M \theta_L}\theta_M$. Note that

$$\theta_L - (\phi_M + p_2)\theta_L < \theta_L - \phi_M\theta_L < \theta_M - \phi_M\theta_L,$$

and thus $\frac{\theta_L - (\phi_M + p_2)\theta_L}{\theta_H - \phi_M \theta_L}$ is smaller than 1, leading to $\frac{\theta_L - (\phi_M + p_2)\theta_L}{\theta_M - \phi_M \theta_L}\theta_M$ being less than θ_M, and hence θ_H, which is the graduate education intensity in the North model. Hence, education intensities for both undergraduate and graduate levels are higher in the North model. ■

Proposition 2 suggests that admission of type L agents into college dilutes the overall ability of university graduates and thus "inflates" the education value. Indeed, admission of type L agents can increase the employment rate and may also increase revenues of the university due to a larger student enrollment base. Nevertheless, more students admitted on the other hand may also entail a negative impact in that the deterioration of education intensity caused by type L agents will consequently decrease tuition levels and thus adversely affect university revenues. The following corollary provides a condition for which the negative effect of admitting type L agents (lowered tuition levels) dominates the positive effect (enlarged enrollment base).

Corollary 4 *University revenues in the market-oriented economy are higher, conditional on that the ability of type H agents is sufficiently high, i.e.,*

$$\theta_H > \frac{(1+\phi_L)(\theta_M - \phi_M\theta_L)^2 + (1+2\phi_M)p_2}{[(1-p_2)\phi_L + \phi_H](\theta_M - \phi_M\theta_L)^2\phi_H}\theta_L - \frac{\phi_M + \phi_H}{\phi_H}\theta_M, \tag{2.30}$$

and the detection rate of managerial level job, p_2, is smaller than $(1-\phi_M)$, i.e.,

$$p_2 < 1 - \phi_M. \tag{2.31}$$

The proof is relegated to the appendix. Corollary 4 indicates that universities in a free economy benefit from the invisible hand in regulating efficiently optimal choices of both undergraduate and graduate degree holders. More specifically, when abilities of type M and type H agents are relatively high, universities in a free economy would reject type L agents and maintain high productivity reputations of their graduates. On the other hand, expected productivities of the graduates suffer in universities in the South model, because admission of type L agents is mandatory by government policies. Hence, graduates in a free economy earn relatively more compared to the same level graduates in a transitional economy, and universities in a free market economy therefore can extract more rents from students.

Proposition 5 *Suppose* (2.30) *and the ability of the M-type agents is high enough, i.e.,*

$$\theta_M - \phi_L\theta_L - \phi_H\theta_H > 0,$$

then social welfare is higher in a market-oriented economy than that in a transition economy.

Proof. See appendix. ■

To summarize, we derive the equilibrium education intensities and tuition levels in two closed economies, one for the North and one for the South. What sets these two economies apart is the government's policy towards universal undergraduate education in the South. The result of a mandatory enrollment expansion in a transition economy is decreased education intensities. Furthermore, if the abilities of type M and type H agents are relatively high, universities earn less and social welfare loss results in a transition economy. In the next section, we allow for student flows between the two economies.

3 International Talent Flow

In this section, we consider a two-country model, where one is a developing country, or the South, while the other, is a developed country, or the North. Propositions 1 and 2 imply respectively that the equilibrium in the North could be separating and the equilibrium in the South could be semi-pooling. Assume that students must pursue undergraduate education in their home country.[11] Denote α as the percentage of

[11] This is generally true because of cultural, language and other barriers.

undergraduate students in the South who go to the North for further graduate studies. Some of them would return to the South, whom we call overseas returnees, while others enter the labor market in the North. Denote β as the proportion of the overseas graduates that go back to their home country. Thus firms in the South can have three types of payrolls: one blue-collar, one managerial type taken by overseas returnees, and another managerial type for indigenously trained graduates. Let decoration $\tilde{}$ denote association with overseas returnees. Let S and N to denote respectively the South, or the transition economy, and the North, or the free market economy. Let $\widetilde{\omega}_{2S}$ to be the wage offered to overseas returnees, $\widetilde{p}_{2S}$ be the detection rate of jobs taken by overseas returnees. By detection rate, we mean the firm's probability of inferring correctly a job seeker's true type.

We assume that the detection rate is larger for a blue-collar job than for a managerial job, i.e., $p_1 > p_2$. This is because the performance of a managerial worker is often more difficult to ascertain and sometimes subject to uncertainties of external factors. For simplicity, we normalize p_1 to 1.

The detection rate is also assumed to be monotonically increasing in the excellence ratio, δ, which is defined as the ratio between the number of type H agents and type L agents. Specifically, the excellence ratio of an agent pursuing graduate education in the South, δ_{2S}, is

$$\delta_{2S} = \frac{(1-\alpha_L)\phi_L}{(1-\alpha_H)\phi_H}.$$

For agents in the South but pursuing graduate education in the North and join its labor force afterwards, the excellence ratio, δ_{2N}, is

$$\delta_{2N} = \frac{(1-\beta_L)\alpha_L\phi_L}{(1-\beta_H)\alpha_H\phi_H + \phi_H}.$$

For agents in the South but pursuing graduate education in the North and yet return to work in the South, the excellence ratio, $\widetilde{\delta}_{2N}$, is

$$\widetilde{\delta}_{2N} = \frac{\beta_L\alpha_L\phi_L}{\beta_H\alpha_H\phi_H}.$$

For a type L overseas graduate, the education cost is $C_L(e_{1S}) + C_L(e_{2N})$. If he returns to the South, the expected wage is $(1-\widetilde{p}_{2S})\widetilde{\omega}_{2S}$, and the utility is $(1-\widetilde{p}_{2S})\widetilde{\omega}_{2S} - C_L(e_{1S}) - C_L(e_{2N})$. If he chooses to stay in the North, he would offered a job with an expected wage level of $(1-p_{2N})\omega_{2N}$, and his utility becomes $(1-\widetilde{p}_{2S})\widetilde{\omega}_{2S} - C_L(e_{1S}) - C_L(e_{2N})$. Then he compares the expected wages in both countries to make the return-or-stay decision, i.e.,

$$(1-p_{2N})\omega_{2N} - C_L(e_{1S}) - C_L(e_{2N}) \lesseqqgtr (1-\widetilde{p}_{2S})\widetilde{\omega}_{2S} - C_L(e_{1S}) - C_L(e_{2N}),$$

which can be simplified as

$$(1-p_{2N})\omega_{2N} \lesseqqgtr (1-\widetilde{p}_{2S})\widetilde{\omega}_{2S}. \tag{3.1}$$

Constraint (3.1) indicates that the country residence choice for type L overseas graduates is driven by the trade-off between the detection rates and the wage rates in the two countries. If the LHS of (3.1) dominates, all type L agents will return to the South and vice versa.

Similarly, for a type H overseas graduate, his country residence decision essentially boils down to

$$\omega_{2N} \lesseqqgtr \widetilde{\omega}_{2S} \tag{3.2}$$

which is of course trivial – the type H agent would only choose to stay in a country with a higher wage rate.

We make one more assumption that the education levels of overseas graduates and the native graduates in the North are identical. Then the ex post productivity of a native type H agent must be also identical to that of an overseas type H agent from the South. That is,

$$\widetilde{y}_H = \theta_H + e_{1N} + e_{2N},$$

and similarly for an overseas type L agent from the South, his *ex post* productivity is

$$\widetilde{y}_L = \theta_L + e_{1N} + e_{2N}.$$

From the employers' perspective, their profits from production must be non-negative, and this constraint must hold in both countries, i.e.,

$$\widetilde{\pi}_{2S} = \mathrm{E}_{2S}[\widetilde{y}] - \widetilde{\omega}_{2S} = \frac{\beta_L\alpha_L\phi_L\widetilde{y}_L + \beta_H\alpha_H\phi_H\widetilde{y}_H}{\beta_L\alpha_L\phi_L + \beta_H\alpha_H\phi_H} - \widetilde{\omega}_{2S} \geq 0,$$

and

$$\pi_{2N} = \mathrm{E}_{2N}[y] - \omega_{2N} = \frac{(1-\beta_L)\alpha_L\phi_L\widetilde{y}_L + ((1-\beta_H)\alpha_H\phi_H + \phi_H)\widetilde{y}_H}{(1-\beta_L)\alpha_L\phi_L + (1-\beta_H)\alpha_H\phi_H + \phi_H} - \omega_{2N} \geq 0.$$

But since market competition in both countries would force the above two constraints to be binding, we then have:

$$\frac{\beta_L\alpha_L\phi_L\widetilde{y}_L + \beta_H\alpha_H\phi_H\widetilde{y}_H}{\beta_L\alpha_L\phi_L + \beta_H\alpha_H\phi_H} - \widetilde{\omega}_{2S} = 0, \tag{3.3}$$

and

$$\frac{(1-\beta_L)\alpha_L\phi_L\widetilde{y}_L + ((1-\beta_H)\alpha_H\phi_H + \phi_H)\widetilde{y}_H}{(1-\beta_L)\alpha_L\phi_L + (1-\beta_H)\alpha_H\phi_H + \phi_H} - \omega_{2N} = 0. \tag{3.4}$$

Type L agents have to mix themselves with type H agents to avoid being fully screened by employers. This means either side of constraints (3.1) and (3.2) cannot dominate each other. Hence, constraints (3.1) and (3.2) must be binding. In other words,

$$\omega_{2N} = \widetilde{\omega}_{2S},$$

and

$$p_{2N} = \widetilde{p}_{2S}. \tag{3.5}$$

Then we arrive at the following proposition.

Proposition 6 *Among type L agents, the percentage of type L returnees, β_L, is smaller than that of type H returnees among type H agents, β_H. Furthermore, the percentage of type L returnees, β_L, increases in the proportion of type H agents, α_H.*

Proof. From equation (3.5) we know that the detection rates of the two labor markets are the same. Since the detection rate is assumed as a monotonically increasing function of the excellence ratio, the excellence ratios of the two labor markets must equalize. It is then straightforward to show that the percentage of the type L returnees, β_L, equals $\beta_H\left(1-\frac{1}{1+\alpha_H}\right)$, which is greater than β_H and increases in α_H.

■

An immediate corollary of Proposition 6 is that more type L overseas graduates from the South will stay in the North, seemingly suggesting a brain drain problem. However, when a large proportion of the type L students go to the North (in pooling with type H students), this is neither really brain drain, in which high talents are supposed to outflow permanently, nor really brain bank, in which case most of the type H overseas students are supposed to return. On the contrary, we have an outflow of low talent type L students that dilutes the quality of the North's labor market. We venture to call this phenomenon lame-drain.

To have a better understanding of the lame-drain effect, it is important to derive the equilibrium percentages of overseas graduate students against home endowment for both agent types in a two country general equilibrium model. Note that in addition to the perfect competition labor market conditions (3.3) and (3.4), other IR constraints for employers are

$$\pi_{1k} = y_M|_{e_{1\tau}} - \omega_{1\tau} \geq 0, \tau = N, S, \tag{3.6}$$

and

$$\pi_{2S} = \left(\frac{\phi_L(1-\alpha_L)}{\phi_L(1-\alpha_L)+\phi_H(1-\alpha_H)} y_L|_{e_{2S}} + \frac{\phi_H}{\phi_L(1-\alpha_L)+\phi_H(1-\alpha_H)} y_H|_{e_{2S}}\right) - \omega_{2S} \geq 0. \tag{3.7}$$

Constraint (3.6) indicates that employers in both the North and the South have incentives to offer blue-collar jobs to type M agents. Condition (3.7) implies that employers in the South offering managerial jobs have incentives to hire a pool of type H and L agents. Because it is an employer-competitive labor market, both constraints (3.6) and (3.7) must be binding. Then the equilibrium wages of the various types of jobs are listed as follows:

$$\omega^*_{1\tau} = y_M|_{e_{1\tau}}, \quad \tau = N, S,$$

$$\omega^*_{2S} = \left(\frac{\phi_L(1-\alpha_L)}{\phi_L(1-\alpha_L)+\phi_H(1-\alpha_H)} y_L + \frac{\phi_H}{\phi_L(1-\alpha_L)+\phi_H(1-\alpha_H)} y_H\right)|_{e_{2S}},$$

and

$$\widetilde{\omega}^*_{2S} = \omega^*_{2N} = \frac{(1-\beta_L)\alpha_L\phi_L\widetilde{y}_L + ((1-\beta_H)\alpha_H\phi_H+\phi_H)\widetilde{y}_H}{(1-\beta_L)\alpha_L\phi_L + (1-\beta_H)\alpha_H\phi_H + \phi_H}.$$

The IC constraints can be rewritten as the following:

$$\omega_{1S} - C_L(e_{1S}) \leq (1-p_{2S})\omega_{2S} - C_L(e_{1S}) - C_L(e_{2S}), \tag{3.8}$$

$$\omega_{1N} - C_H(e_{1N}) \leq \omega_{2N} - C_H(e_{1N}) - C_H(e_{2N}), \tag{3.9}$$

and

$$\omega_{1S} - C_H(e_{1S}) \leq \omega_{2S} - C_H(e_{1S}) - C_H(e_{2S}). \tag{3.10}$$

Constraints (3.8), (3.9) and (3.10) rule out the possibility that type L agents in the South and type H agents both in the North and the South pursue only an undergraduate education. The IC constraints of type M agents in the South are given in the inequalities (3.11) and (3.12), reflecting the fact that type M agents in the South do not pursue graduate education in either country. Similarly, type M agents in the North also do not pursue graduate education as illustrated in (3.13), i.e.:

$$\omega_{1S} - C_M(e_{1S}) \geq (1 - p_{2S})\omega_{2S} - C_M(e_{1S}) - C_M(e_{2S}), \tag{3.11}$$

$$\omega_{1S} - C_M(e_{1S}) \geq (1 - p_{2N})\omega_{2N} - C_M(e_{1S}) - C_M(e_{2N}), \tag{3.12}$$

and

$$\omega_{1N} - C_M(e_{1N}) \geq (1 - p_{2N})\omega_{2N} - C_M(e_{1N}) - C_M(e_{2N}). \tag{3.13}$$

Since not all type L and H agents in the South go overseas, they must be indifferent between pursuing graduate education at home and abroad. That means their payoff function should be the same staying at home or going abroad, leading to constraints (3.14) and (3.15) as a result:

Two more IC constraints are also considered in this section, which are

$$(1 - p_{2S})\omega_{2S} - C_L(e_{1S}) - C_L(e_{2S}) = (1 - p_{2N})\omega_{2N} - C_L(e_{1S}) - C_L(e_{2N}), \tag{3.14}$$

and

$$\omega_{2S} - C_H(e_{1S}) - C_H(e_{2S}) = \omega_{2N} - C_H(e_{1S}) - C_H(e_{2N}). \tag{3.15}$$

The IR constraints of type L agents in the South are

$$(1 - p_{2S})\omega_{2S} - C_L(e_{1S}) - C_L(e_{2S}) \geq 0, \tag{3.16}$$

and

$$(1 - p_{2N})\omega_{2N} - C_L(e_{1S}) - C_L(e_{2N}) \geq 0, \tag{3.17}$$

which indicate that they have incentives to pursue graduate education either at home or abroad. Type M agents in both countries only pursue undergraduate education in their respective home country, leading to IR constraints (3.18) and (3.19) as below:

$$\omega_{1S} - C_M(e_{1S}) \geq 0, \tag{3.18}$$

and

$$\omega_{1N} - C_M(e_{1N}) \geq 0. \tag{3.19}$$

As for type H agents, those in the South would pursue graduate education either at home or abroad, leading to their IR constraints (3.20) and (3.21), while those in the North would do the same but only in their home country as governed by (3.22).

$$\omega_{2S} - C_H(e_{1S}) - C_H(e_{2S}) \geq 0, \tag{3.20}$$

and

$$\omega_{2N} - C_H(e_{1S}) - C_H(e_{2N}) \geq 0. \tag{3.21}$$

The IR constraint of native type H agents in the North is

$$\omega_{2N} - C_H(e_{1N}) - C_H(e_{2N}) \geq 0, \tag{3.22}$$

which indicates that native type H agents in the North have incentive to pursue graduate education.

The process of finding binding conditions from constraints (3.8) to (3.22) is similar to the excercise in section 2 in that given conditions (2.27), (2.30) and (2.31) to hold, constraints (3.9), (3.10), (3.16) and (3.19) should be binding. Condition (3.14) implies that constraint (3.17) must be binding. Other conditions are satisfied automatically under conditions (2.27), (2.30), and (2.31) given in section 3. These findings suggest the general equilibrium in an open economy will entail:

1. Type M agents both in the North and the South only pursue undergraduate education in their respective home country; type M agents in the North gain zero utility, while those in the South have utility surplus;

2. Type L agents in the North receive no education and hence are unemployed;

3. Some of the type L agents in the South go abroad for graduate study, while other type L agents in the South stay at home country to pursue graduate education; they all gain zero utility;

4. Some of the type H agents in the South go abroad to pursue graduate education, while others stay at home for graduate study; they all gain some utility surplus;

5. Type L and H agents in the South are indifferent between staying at home or going abroad when pursuing graduate education and finding employment afterwards;

6. Native type H agents in the North pursue both graduate and undergraduate education and gain some positive rent.

Now, constraints (3.9), (3.10), (3.16) and (3.19) can be simplified as the following:

$$\gamma_{1S} = \omega_{1S} - C_M(e_{1S}), \tag{3.23}$$

$$\gamma_{1S} + \gamma_{2S} = (1 - p_{2S})\omega_{2S} - C_L(e_{1S}) - C_L(e_{2S}), \tag{3.24}$$

$$\gamma_{1N} = \omega_{1N} - C_M(e_{1N}), \tag{3.25}$$

and

$$\gamma_{1N} + \gamma_{2N} = (1 - p_{2N})\omega_{2N} - C_L(e_{1S}) - C_L(e_{2N}). \tag{3.26}$$

Under these constraints, universities are faced with the problem of maximizing their revenues. Specifically, universities in the South maximize (3.27) and those in the North maximize (3.28):

$$\max_{\gamma_{1S}, \gamma_{2S}} R_S = \gamma_{1S} + ((1 - \alpha_L)\phi_L + (1 - \alpha_H)\phi_H)\gamma_{2S}. \tag{3.27}$$

subject to equations (3.23) and (3.25).

The solutions to the two maximization problems above are listed in the following table:

$$\max_{\gamma_{1N},\gamma_{2N}} R_N = (\phi_M + \phi_H)\gamma_{1N} + (\alpha_L\phi_L + \alpha_H\phi_H + \phi_H)\gamma_{2N}. \tag{3.28}$$

subject to equations (3.24) and (3.26).

The solutions to the two maximization problems above are listed in the following table:

Table 3: Equilibrium Education Intensities, Wages and Tuitions in an Open Economy

Variables	Location (τ)	S	S	N	N
	Job (k)	1	2	1	2
Subscripts	Education (j)	1	2	1	2
Education Intensities $\left(e^*_{j\tau}\right)$		Ψ_1	$(1-p_{2S})\theta_L$	θ_M	$(1-p_{2N})\theta_L$
Wages $(\omega^*_{k\tau})$		$\theta_M + \Psi_1$	$\Psi_1 + \Psi_2$ $+(1-p_{2S})\theta_L$	$2\theta_M$	$\Psi_3 + \theta_M$ $+(1-p_{2N})\theta_L$
Tuitions $\left(\gamma^*_{j\tau}\right)$		$\Psi_1 + \theta_M$ $-\frac{1}{2\theta_M}\Psi_1^2$	$\frac{1}{2}(1-p_{2S})^2\theta_L$ $+(1-p_{2S})\Psi_2$ $-\theta_M - p_{2S}\Psi_1$ $-\frac{\theta_M-\theta_L}{2\theta_L\theta_M}\Psi_1^2$	$\frac{3}{2}\theta_M$	$\frac{1}{2}(1-p_{2N})^2\theta_L$ $+(1-p_{2N})\Psi_3$ $-(\frac{1}{2}+p_{2N})\theta_M$ $-\frac{1}{2\theta_L}\Psi_1^2$

where

$$\Psi_1 = \frac{\theta_M - ((1-\alpha_L)\phi_L + (1-\alpha_H)\phi_H)p_{2S}\theta_M}{\theta_L + ((1-\alpha_L)\phi_L + (1-\alpha_H)\phi_H)(\theta_M - \theta_L)}\theta_L,$$

$$\Psi_2 = \frac{(1-\alpha_L)\phi_L\theta_L + (1-\alpha_H)\phi_H\theta_H}{(1-\alpha_L)\phi_L + (1-\alpha_H)\phi_H},$$

and

$$\Psi_3 = \frac{(1-p_{2N})\alpha_L\phi_L\theta_L + \alpha_H\phi_H\theta_H + \phi_H\theta_H}{\alpha_L(1-p_{2N})\phi_L + \alpha_H\phi_H + \phi_H}.$$

Combining (3.14), (3.15) and the equilibrium results in Table 3 leads to the following proposition whose proof is straightforward and therefore omitted.

Proposition 7 *When the proportion of type H student going abroad for graduate study is $\frac{1}{2}$, the equilibrium proportion of type L students going abroad solves the following equation:*

$$\frac{2\theta_L + ((1-\alpha_L)\phi_L + \frac{1}{2}\phi_H)(\theta_M - 2\theta_L)}{\theta_L + ((1-\alpha_L)\phi_L + \frac{1}{2}\phi_H)(\theta_M - \theta_L)} + \frac{(1-p_{2N}(\alpha_L))\phi_H}{\phi_H + \phi_M} = \frac{2\theta_L}{\theta_M - \theta_L}.$$

Recall that β_L, the proportion of the type L overseas graduates that return to work in their home country, is $\frac{1}{2}\frac{\alpha_H}{1+\alpha_H}$, given by proposition 4. From this proposition, we have $\alpha_H = \frac{1}{2}$, and consequently $\beta_L = \frac{1}{6}$.

We now depict the general equilibrium in Figure 4. The equilibrium in the North, as is shown, moves from A to A^N, due to the dilution of type L agents from the South.

In Figure 4, variables with superscript N refer to corresponding variables of agents from the North and with superscript S refer to corresponding variables of agents from the South. The figure illustrates that the equilibrium graduate education intensity in the North decreases such that some of the type L agents from the South have incentives to pursue graduate education in the North. Moreover, that A^N is below A implies that wages for graduate degree holders in the North are lowered (compared to the close economy case).

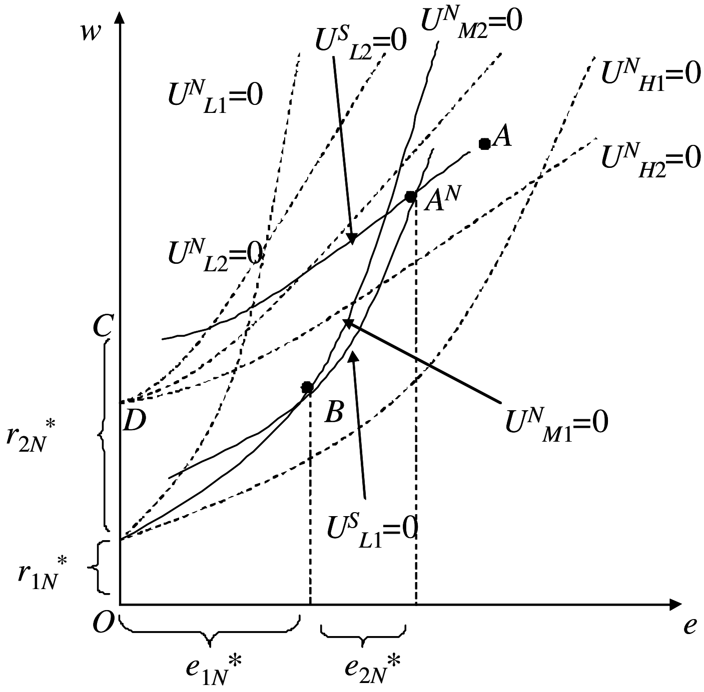

Figure 5. Non-Brain Drain Equilibrium in the North

Our theory suggests that the brain drain phenomenon is not just restricted to talents, but also low-ability students as well. Although this may appear novel and striking at a first glance, it is actually in line with the existing literature. For instance, Commander et al (2003) argue that screening of immigrant by the receiving country is key for the indigenous country's human capital accumulation, because if only the best are selected, low skill ones will have little incentive to acquire human capital at home. In our model, the low ability ones' incentive to pursue graduate studies is similar, although our focus is the ability mismatch problem.

Regarding our theory's relationship with recently observed empirical patterns, our model offers some good intuition. For instance, our theory is consistent with the empirical finding by Reitz (2001) who estimates that the earning deficit in 1996 in Canada was largely due to immigrants earning a lower rate of return on their education compared to natives. Hunter et al (2009) find that immigrants in the UK and US win Nobel Prizes less frequently than before. They use the low mobility cost to interpret such a trend but are unable to explain why US has more Nobel Laureates now. Our theory is congruent with this observation as a larger (recipient) country is able to maintain a higher average productivity level, since it has a larger population base against a given lame brain dilution from developing countries.

4 Empirical Evidence

In this section we use the 2010 U.S. Census data and provide three pieces of collaborating empirical evidence: for Chinese students who moved to the U.S. after the higher education expansion in China, (1) the return to a graduate degree is lower than those who moved before, suggesting that their overall quality may be lower; (2) low-wage earners are more severely penalized in labor market while high-wage earners are not, suggesting more "lames" immigrants among them; (2) those with low abilities are more likely to obtain a graduate degree.

We use the 2010 American Community Survey (ACS) data. The ACS is a 1-in-100 national random sample of the U.S. population. The data are downloaded from www.ipums.org (Ruggles, et al., 2010). We construct a Chinese, college-educated worker sample tailored for our theoretical model. Specifically, we select an employed worker who:

1) was born in China,
2) has a Chinese ethnicity identity,
3) has a bachelor degree or above,
4) age less than 40,
5) immigrated in the U.S. in 1990 or after,
6) worked full time last year (weekly hours usually worked is 35 hours or more),
7) reported positive wage and salary income.

We restrict age to less than or equal to 40 years because if a Chinese student graduated from a college in 1990 in China (average age would be 20), his or her age would be around 40 in the 2010 ACS data. We also restrict the year of moving to the US to be 1990 or after because very few Chinese students moved to the U.S. before 1990. The hourly wages are then winsorized at the 1% and 99% levels. The final sample consists of 1477 workers.

Since the higher education expansion in China mainly took place in 1999 and afterwards, and the earliest batch of college graduates after expansion moved to the U.S. in 2003 to pursue a graduate degree, we create a dummy variable, Expansion=1, if the year of moving to the US is 2003 or after. We estimate a standard wage model including the Expansion dummy. The Expansion dummy is expected to be negative and significant if the foreign student cohort from China since the higher education expansion has lower abilities in general.

We specify the wage model as follows:

$$\log Wage = \alpha + \beta \mathbf{X} + \gamma \cdot Expansion + \varepsilon, \tag{1}$$

where $Wage$ is hourly wage calculated as annual wage and salary income divided by the product of hours usually worked per week and weeks worked last year; $\mathbf{X}$ is a set of individual characteristics; α is the constant term, β and γ are coefficient vectors to be estimated; ε is the disturbance term. Individual characteristics are standard demographic variables, including gender, age, age squared to control for work experience, graduate degree dummy, single dummy, years in the U.S., occupation category dummies, and industry category dummies.[12] In a slightly different model, we interact the graduate degree dummy with Expansion. Table 4 reports the summary statistics of key variables and shows that the variations in hourly wages across workers within each education degree group are substantial.

Table 4. Summary Statistics

Variable	Sample size	Mean	S.D.	Minimum	Maximum
Hourly wage	1477	31.29	18.17	3.57	118.04
Hourly wage (Bachelor degree holders)	411	23.52	15.37	3.57	95.24
Hourly wage (Graduate degree holders)	1066	34.28	18.29	3.90	118.04
Log(hourly wage)	1477	3.25	0.66	1.27	4.77
Male (dummy)	1477	0.50	0.50	0	1
Single (dummy)	1477	0.25	0.43	0	1
Age	1477	32.97	5.07	20	40
Bachelor degree (dummy)	1477	0.28	0.45	0	1
Graduate degree (dummy)	1477	0.72	0.45	0	1
Years in the US	1477	9.27	5.19	0	20

Note: sample size is 1477 workers. S.D. stands for standard deviation.

Column 1 of Table 5 reports the results of estimating model (1). The demographic variables have reasonable coefficients and are not of our particular interest. If a college degree holder obtains a graduate degree, his or her hourly wage will increase by about 23.5%. The coefficient of *Expansion*, capturing the cohort effect of higher education expansion in China on foreign students in the U.S. from China, is -0.1754 and significant at the 1% level, suggesting that in our sample consisting of Chinese students with a college degree or above, those who moved to the U.S. since 2003 receive about 18% lower hourly wages than do the cohort that moved to the U.S. before 2003, suggesting that the overall quality of Chinese immigrants since 2003 might be lower.

Column 2 of Table 5 reports the results of estimating model (1) with the interaction of Graduate degree dummy with Expansion. The Expansion cohort with a graduate degree receives about 24% less (0.127-0.364) hourly wages than do the graduate degree holders who moved to the U.S. before 2003. This further confirms that the overall quality of student cohort after the higher education expansion in China may be lower.

We have also considered the possibility of model (1) having the omitted variable bias, because unobserved ability in the disturbance term may be correlated with the education variable, biasing the estimate of Graduate degree coefficient upward. Given

[12] Graduate degrees include master degree, professional degree beyond bachelor degree, and Ph.D. degree.

our data structure, we adopt a strategy proposed by Fu and Ross (2013) and use a worker's residential location as a proxy for unobserved ability since people sort into different residential locations based on income, tastes, and unobserved ability. The smallest geographic unit in the ACS data is the Public Use Microdata Area (PUMA), so we add the residential PUMA fixed effects to model (1).[13] The results are reported in columns 3 and 4 of Table 2. The coefficient of Graduate degree attenuates by 24% in column 3 and by 17% in column 4, consistent with what Fu and Ross (2013) find using the 2000 decennial census data. However, the attenuation of the coefficient of *Expansion* in column 3 is much smaller (11%), and the coefficient of Graduate degree interacting with *Expansion* decreases only slightly (5%), suggesting that the *Expansion* cohort effect is robust to controlling for unobserved abilities.

Table 5. Effect of higher education expansion in China on US Chinese immigrants' wage

Variable	1	2	3	4
Male	0.0820***	0.0844***	0.1002***	0.1023***
	(0.0277)	(0.0274)	(0.0304)	(0.0297)
Single	-0.0014	0.0177	0.0367	0.0546
	(0.0426)	(0.0423)	(0.0587)	(0.0585)
Age	0.2170***	0.2442***	0.2369***	0.2674***
	(0.0406)	(0.0400)	(0.0540)	(0.0538)
Age square	-0.0029***	-0.0034***	-0.0033***	-0.0038***
	(0.0006)	(0.0006)	(0.0008)	(0.0008)
Graduate degree	0.2353***	0.3835***	0.1788***	0.3185***
	(0.0398)	(0.0494)	(0.0503)	(0.0603)
Years in US	0.0203***	0.0256***	0.0235***	0.0287***
	(0.0048)	(0.0049)	(0.0060)	(0.0061)
Expansion	-0.1754***	0.1273*	-0.1547**	0.1353
	(0.0502)	(0.0778)	(0.0683)	(0.0987)
Grad degree×Expansion		-0.3640***		-0.3459***
		(0.0697)		(0.0841)
Constant	-1.0111	-1.5980**	-1.3489	-1.9671**
	(0.6592)	(0.6538)	(0.8850)	(0.8879)
Sample size	1477	1477	1477	1477
Residential location fixed effects	No	No	No	Yes
Adjusted R^2	0.415	0.428	0.466	0.474

Note: Dependent variable is logarithm of hourly wage. Independent variables also include 23 occupation category dummies and 15 industry category dummies. Numbers in parentheses are standard errors (robust estimator). Superscripts "***", "**", and "*" indicate significance at the 1%, 5%, and 10% levels, respectively. Columns 3 and 4 include 342 residential

[13]PUMAs generally follow the boundaries of county groups, single counties, or census-defined "places." A residential PUMA contains at least 100,000 residents. If the population exceeds 200,000 residents, they are divided into as many PUMAs of 100,000+ residents as possible.

PUMA fixed effects and standard errors are clustered at the residential PUMA level.

This decline in overall quality of Chinese immigrants since 2003 could be due to more "lames" or more low-ability students moving into the U.S. after the higher education expansion while high-ability students have always maintained the same quality. To test this hypothesis, we estimate model (1) using simultaneous quantile regression for the 5th and 95th quantiles of wage earners:

$$\begin{aligned} \log Wage_{0.05} &= \alpha_{0.05} + \beta_{0.05}\mathbf{X} + \gamma_{0.05} \cdot Expansion + \varepsilon_{0.05}, \\ \log Wage_{0.95} &= \alpha_{0.95} + \beta_{0.95}\mathbf{X} + \gamma_{0.95} \cdot Expansion + \varepsilon_{0.95}, \end{aligned} \tag{2}$$

where 0.05 and 0.95 denote the 5th and 95th quantiles of the dependent variable. As a robustness check, we also estimate model (2) for the 10th and 90th quantiles and 15th and 85th quantiles. The results are presented in Table 6.

Table 6. Effect of Expansion in China on US Chinese immigrants' wage by quantile

Variable	Quantile of log (hourly wage)					
	0.05	0.95	0.10	0.90	0.15	0.85
Male	0.1121	0.0289	0.1262**	0.0948**	0.1271**	0.1167***
	(0.0902)	(0.0495)	(0.0635)	(0.0396)	(0.0536)	(0.0399)
Single	-0.0917	0.1023	0.0685	0.0270	-0.0915	0.0108
	(0.1033)	(0.0734)	(0.0898)	(0.0731)	(0.0729)	(0.0650)
Age	0.0447	0.2336***	0.2197**	0.216***	0.2081***	0.2509***
	(0.1129)	(0.0789)	(0.0974)	(0.0609)	(0.0818)	(0.0603)
Age^2	-0.0002	-0.0031***	-0.0028*	-0.0030***	-0.0027**	-0.0035***
	(0.0017)	(0.0012)	(0.0015)	(0.0009)	(0.0012)	(0.0009)
Graduate	0.3131**	0.0570	0.2903***	0.1153**	0.2763***	0.1561**
	(0.1338)	(0.0667)	(0.1077)	(0.0566)	(0.0783)	(0.0566)
Years US	0.0024	0.0212***	0.0144	0.0249***	0.0253***	0.0232***
	(0.00185)	(0.0080)	(0.0108)	(0.0068)	(0.0091)	(0.0071)
Expansion	-0.4086***	0.0209	-0.3003***	-0.0329	-0.1819*	-0.0609
	(0.1511)	(0.0747)	(0.1157)	(0.0680)	(0.1063)	(0.0613)
F test	5.53		3.85		1.06	
Sample size	1477					
Pseudo R^2	0.225	0.180	0.269	0.184	0.292	0.195

Note: Dependent variable is logarithm of hourly wage. Independent variables also include 23 occupation category dummies and 15 industry category dummies. Numbers in parentheses are standard errors estimated by bootstrapping with 200 replications. Superscripts "***", "**", and "*" indicate significance at the 1%, 5%, and 10% levels, respectively. The F test is for testing whether or not the coefficients of *Expansion* in the paired quantile regressions are equal.

Table 6 shows that for top wage earners, such as 95th, 90th, and 85th quantile wage earners, the coefficients of *Expansion* are all small (between -0.02 and -0.06) and statistically insignificant, suggesting that high-ability Chinese immigrants in the *Expansion* cohort are similar to the previous cohorts. However, for bottom wage earners, such as 5th, 10th, and 15th quantile wage earners, the coefficients of *Expansion* are relatively large (between -0.18 and -0.41) and statistically significant. A plausible interpretation would be that the low ability Chinese immigrants in the *Expansion* cohort really have lower ability, or put in a different way, more "lames" in the *Expansion* cohort have joined the U.S. labor markets.[14]

To test whether low ability students in the Expansion cohort are more likely to obtain a graduate degree than do the before-Expansion cohort, we employ a two-stage approach as follows. In the first stage we estimate model (1) by dropping the Graduate degree dummy and Expansion, and then predict the residuals, labeled as "wage residuals". The wage residual contains wage components not explained by the independent variables in the first stage regression, and thus can be considered mainly coming from a worker' education level (observed ability), unobserved ability, and the *Expansion* cohort effect. In the second stage, we regress Graduate degree dummy on wage residuals, *Expansion* dummy, and the interaction of wage residuals and *Expansion* dummy:

$$Graduate = \alpha + \beta_1 Wage\ residuals + \beta_2 Expansion + \beta_3 Expansion \times Wage\ residuals + \varepsilon \tag{3}$$

Model (3) is first estimated by ordinary least squares (OLS) method and the result is reported in column 1 of Table 7. Since wage residuals are a proxy for ability, column 1 shows that the coefficient of wage residuals is about 0.23 and significant at the 1% level, suggesting that before *Expansion*, workers with a high ability are more likely to obtain a graduate degree. However, after *Expansion*, it is workers with a low ability that are more likely to obtain a graduate degree (the coefficient of interaction term is about -0.27 and significant at the 1% level). As a robustness check, we also estimate model (3) using a Probit model and the result is reported in column 2 of Table 7. The same pattern still holds. Column 3 reports the marginal effects at the mean wage residual level for the Probit model and the marginal effects are very similar to those in column 1. Specifically, after *Expansion*, at the mean wage residual level, decreasing the residual level by one unit increases the probability of obtaining a degree by 0.27, suggesting that low ability workers in the *Expansion* cohort are more likely to have pursued a graduate degree.

[14] We also estimate models with graduate dummy interacting with *Expansion* dummy using simultaneous quantile regressions and the patterns of the results are very similar.

Table 7. Probability of obtaining a graduate degree

	1	2	3
Variable	OLS	Probit	Marginal Effect
Expansion	-0.0129	-0.0662	-0.0221
	(0.0244)	(0.0732)	(0.0246)
Wage residuals	0.2325***	0.6974***	0.2373***
	(0.0288)	(0.0951)	(0.0331)
Expansion×Wage residuals	-0.2659***	-0.7949***	-0.2704***
	(0.0477)	(0.1468)	(0.0507)
Sample size	1477	1477	
R^2 or Pseudo R^2	0.044	0.036	

Note: Dependent variable is the Graduate dummy. Wage residuals are predicted residuals from regressing logarithm of hourly wage on male dummy, age, age squared, single dummy, years in the U.S., occupation and industry category dummies. Column 1 is the ordinary least squares regression; column 2 is the Probit regression. Numbers in parentheses are standard errors (robust estimator). Column 3 reports the marginal effects at the mean wage residual level for the Probit model. Constant term is included in both models but is not reported. Superscripts "***", "**", and "*" indicate significance at the 1%, 5%, and 10% levels, respectively.

In summary, our econometric exercises provide empirical validation for the lame-drain phenomenon with respect to Chinese immigrants. We find students who moved to the U.S. after the higher education expansion in China incur returns to a graduate degree lower than those who moved before. This suggests a deteriorating quality of immigration most likely diluted by the pool of unskilled, unqualified and previously unemployed college graduates who went onto the US for graduate studies. For those students with low abilities, they are more likely to obtain a graduate degree in the US.

5 Conclusions

This paper proposes a phenomenon exactly the opposite of brain drain, or lame drain as we call it, meaning that employment-based immigration from developing countries to developed countries may not always be the smartest and brightest as they used to be. This is an issue that has been largely neglected so far in the brain drain literature. We formulate the brain drain problem from a general equilibrium perspective where the impact on both originating and receiving countries are considered.

Our model indicates that the lame drain phenomenon is quite possible driven largely by the rapid expansion of the higher education sector in developing countries measured by enrollment, especially in China. The Great Leap Forward in higher education as mandated by the government inevitably leads to low-ability workers entering the labor force. On top of the expected overall degradation of education qualities and relaxation of graduation standards, we show the presence of a serious mismatch problem, where those low-ability students pursue higher education that they would not have under an education system that is free from government interventions. This brings about an adverse impact on the quality of the labor force and the long term prospect of economic growth.

Our model also indicates the adverse impact in terms of education quality degradation and education-skill mismatch in a developing country can spill over to a developed country, as a result of the international flow of human capital. This is because a deteriorating quality of immigration can be diluted by the pool of unskilled, unqualified and previously unemployed college graduates from a developing country who go onto a developed country such as the US for graduate studies.

We then conduct an econometric exercise to provide empirical validation for the lame drain phenomenon with respect to Chinese immigrants. We find students who moved to the U.S. after the higher education expansion in China incur returns to a graduate degree lower than those who moved before.

The mixed bag of drains of both brains and lames to developed countries indicates that this is not always detrimental to the source country, as effectively the source country is exporting low productivity workers. The previous literature (Mountford, 1997; Stark, Helmenstein and Prskawetz, 1998; Vidal, 1998; and Beine, Docquier and Rapaport, 2001) attempted to rationalize this result based on uncertainty about the ability to migrate and the assumption that foreign firms cannot screen effectively emigrants' innate ability due to information asymmetry. In contrast with conclusions from the current literature, brain drain may be globally welfare worsening, because of the more costly semi-pooling in the developed country compared with the case of no international talent flows. This brings about important policy implications with respect to the recent immigration reform debate in the US. Our analysis indicates the importance of effective screening of entering foreign students by universities and the federal government. It also stresses the federal government's initiative to help private companies with the job screening process with respect to foreign graduates, and improve upon the process of how H-1 visas and work permits are issued.

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6 Appendix

Proof of Corollary 4.. It is not difficult to obtain the revenue of universities in the market-oriented economy in equilibrium, that is,

$$R_1 = \frac{3}{2}\phi_M\theta_M + \frac{1}{2}\phi_H\theta_M + \frac{3}{2}\phi_H\theta_H.$$

and the revenue of universities in the transition economy, that is

$$R_2 = \gamma_1^* + (\phi_L + \phi_H)\gamma_2^*,$$

where γ_1^* and γ_2^* is given in table 2. Then the difference between universities revenues in the two economies is

$$\begin{aligned} R_1 - R_2 \; &= \; \frac{1}{2}\phi_M\theta_M - \frac{(1-p_2)^2}{2}\theta_L - (\phi_L + \phi_H - p_2)\frac{(1-p_2)\phi_L\theta_L + \phi_H\theta_H}{(1-p_2)\phi_L + \phi_H} + \frac{1}{2}\phi_H\theta_M \\ &\quad -(1-\phi_M - p_2)\frac{(\phi_M - 1)(\phi_M - p_2 + 1)\theta_M{\theta_L}^2 + 2(\phi_M - 1)\theta_M^2\theta_L}{2(\theta_M - \phi_M\theta_L)^2} + \frac{3}{2}\phi_H\theta_H \\ &\quad -(1-\phi_M - p_2)\frac{(\phi_M + p_2 - 1 + 2p_2\phi_M)\theta_L + (\phi_M - 1 - p_2)\theta_M}{2(\theta_M - \phi_M\theta_L)^2}. \end{aligned} \tag{A-1}$$

By (2.31), one learns that $1-\phi_M-p_2=\phi_L+\phi_H-p_2>0$. Together with $\phi_M-1<0$, it implies that

$$-(1-\phi_M-p_2)\frac{(\phi_M-1)(\phi_M-p_2+1)\theta_M{\theta_L}^2+2(\phi_M-1)\theta_M^2\theta_L}{2(\theta_M-\phi_M\theta_L)^2}>0,$$

and

$$-(1-\phi_M-p_2)\frac{(\phi_M+p_2-1+2p_2\phi_M)\theta_L+(\phi_M-1-p_2)\theta_M}{2(\theta_M-\phi_M\theta_L)^2}>-(1-\phi_M-p_2)\frac{(1+2\phi_M)p_2\theta_L}{2(\theta_M-\phi_M\theta_L)^2}.$$

And simplifying the RHS of equation (A-1) yields

$$\begin{aligned}R_1-R_2 &> (\frac{3}{2}-\frac{\phi_L+\phi_H-p_2}{(1-p_2)\phi_L+\phi_H})\phi_H\theta_H+\frac{1}{2}(\phi_M+\phi_H)\theta_M-\frac{(1-p_2)^2}{2}\theta_L\\ &\quad -(\phi_L+\phi_H-p_2)\frac{(1-p_2)\phi_L\theta_L}{(1-p_2)\phi_L+\phi_H}-(1-\phi_M-p_2)\frac{(1+2\phi_M)p_2\theta_L}{2(\theta_M-\phi_M\theta_L)^2}.\end{aligned}$$

Note that $\phi_L+\phi_H-p_2\phi_L>\phi_L+\phi_H-p_2>0$, which implies $\frac{\phi_L+\phi_H-p_2}{(1-p_2)\phi_L+\phi_H}<1$. Then

$$R_1-R_2>\frac{1}{2}\phi_H\theta_H+\frac{1}{2}(\phi_M+\phi_H)\theta_M-\frac{(1+\phi_L)(\theta_M-\phi_M\theta_L)^2+(1+2\phi_M)p_2}{2[(1-p_2)\phi_L+\phi_H](\theta_M-\phi_M\theta_L)^2\phi_H}\theta_L>0,$$

which is implied by

$$\phi_H\theta_H+(\phi_M+\phi_H)\theta_M-\frac{(1+\phi_L)(\theta_M-\phi_M\theta_L)^2+(1+2\phi_M)p_2}{[(1-p_2)\phi_L+\phi_H](\theta_M-\phi_M\theta_L)^2\phi_H}\theta_L>0,$$

which is (2.30) after some algebra. ■

Proof of Proposition 5.. According to the definition, in equilibrium, the social welfare of a market-oriented economy is

$$SW_1=\frac{3}{2}\phi_M\theta_M+\frac{3}{2}\phi_H\theta_H+\phi_H\left(\theta_M-\frac{\theta_M^2}{2\theta_H}\right),$$

and that of a transition economy is

$$\begin{aligned}SW_2 &= \phi_L\theta_L+\phi_M\theta_M+\phi_H\theta_H+(1-p_2)\theta_L+(\phi_L+\phi_H)\frac{\theta_L-(\phi_M+p_2)\theta_L}{\theta_M-\phi_M\theta_L}\theta_M\\ &\quad -(\frac{\phi_L}{2\theta_L}+\frac{\phi_M}{2\theta_M}+\frac{\phi_H}{2\theta_H})(1-p_2)^2\theta_L^2-(\frac{\phi_L}{2\theta_L}+\frac{\phi_H}{2\theta_H})\frac{(1-\phi_M-p_2)^2}{(\theta_M-\phi_M\theta_L)^2}\theta_L^2\theta_M^2.\end{aligned}$$

Then the welfare difference is

$$\begin{aligned}SW_1-SW_2 &= \frac{1}{2}\left[\phi_H\theta_H+\phi_M\theta_M+\phi_H\theta_M-\frac{(1+\phi_L)(\theta_M-\phi_M\theta_L)^2}{[(1-p_2)\phi_L+\phi_H](\theta_M-\phi_M\theta_L)^2}\right]\\ &\quad +\frac{\theta_M-\theta_L+p_2\theta_L}{\theta_M-\phi_M\theta_L}\phi_H\theta_M+\left(\frac{\phi_L}{2\theta_L}+\frac{\phi_M}{2\theta_M}+\frac{\phi_H}{2\theta_H}\right)(1-p_2)^2\theta_L^2\\ &\quad +\left(\frac{\phi_L}{2\theta_L}+\frac{\phi_H}{2\theta_H}\right)\frac{(1-\phi_M-p_2)^2}{(\theta_M-\phi_M\theta_L)^2}(\theta_M-\phi_L\theta_L-\phi_H\theta_H)\theta_L^2\theta_M.\end{aligned}$$

Note that (2.30) implies

$$\phi_H\theta_H + \phi_M\theta_M + \phi_H\theta_M - \frac{(1+\phi_L)(\theta_M - \phi_M\theta_L)^2\theta_L}{[(1-p_2)\phi_L + \phi_H](\theta_M - \phi_M\theta_L)^2} > 0,$$

Assume

$$\theta_M - \phi_L\theta_L - \phi_H\theta_H > 0,$$

which ensures

$$\left(\frac{\phi_L}{2\theta_L} + \frac{\phi_H}{2\theta_H}\right)\frac{(1-\phi_M-p_2)^2}{(\theta_M - \phi_M\theta_L)^2}(\theta_M - \phi_L\theta_L - \phi_H\theta_H)\theta_L^2\theta_M > 0.$$

Therefore, because $\frac{\theta_M - \theta_L + p_2\theta_L}{\theta_M - \phi_M\theta_L}\phi_H\theta_M > 0$ and $(\frac{\phi_L}{2\theta_L} + \frac{\phi_M}{2\theta_M} + \frac{\phi_H}{2\theta_H})(1-p_2)^2\theta_L^2 > 0$ we have $SW_1 - SW_2 > 0$. ■