Native Students and the Gains from Exporting Higher Education: Evidence from Australia

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Abstract

This paper proposes a general equilibrium model with non-profit publicly subsidized universities to show that native applicants do not have to lose from exporting higher education, as suggested by standard trade models. The gains from exporting higher education that initially accrue to universities will be redistributed to natives through increased investment in research and teaching. With Australian university-level data from 2001 to 2007, the empirical investigation identifies the impact of exporting higher education on native enrollment using the instrumental variable approach: the enrollment of one more foreign student leads to the enrollment of about 0.75 more Australian native students.

JEL classification: F14, H52, I23

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1 Introduction

In the past twenty years, the number of international students in higher education has increased from 1.1 million in 1985 to 3.0 million in 2007 (Indicators (2009)). Higher education providers (HEPs) in developed countries collect a significant amount of money through tuition fees from foreign students: US$3.8 billion for UK HEPs in 2003/2004,[1] US$7.4 billion for US HEPs in 2007/2008,[2] and US$2.4 billion for Australian HEPs in 2007/2008.

Besides contributing to tuition revenue for universities, foreign students and their families, similar to tourists, also contribute to the local economy through their living expenditure. However, exporting higher education is a more controversial issue than tourism. The main concern is that foreign students may crowd native students out of universities. In December 2008, an article in *The Australian* states that "the over-reliance on foreign students has led to an undercurrent of resentment among many young Australians, who feel these students are depriving them and their mates of places at good universities." Given the limited number of universities that a country has, it is natural for natives to perceive foreign students as competitors.

The conventional wisdom from the trade literature also suggests that native applicants in education-exporting countries should be concerned. Trade in education is driven by differences in relative abundqnce of educational capital. The Stolper-Samuelson theorem (Stolper & Samuelson (1941)) implies that in a world where countries differ in the relative abundance of educational capital, exporting higher education will benefit the owners of the educational capital — universities, and will hurt the owners of uneducated labor — native applicants to higher education.[3] However, we cannot accept this implication without further investigation, because the higher education sector is not in perfect competition and is not composed of profit-maximizing firms, as assumed in standard trade models.

Most universities in the education-exporting countries are non-profit publicly subsidized institutions, and they behave very differently from competitive profit-maximizing firms. In a survey of three representative Australian universities, university executives unanimously claim that foreign students' tuition revenue subsidizes native students and enables "better services and facilities" (Marginson & Eijkman (2007)). Furthermore, *The Review of Aus-*

tralian Higher Education (?, p. 5) states that "we [universities] use international student fees to finance the education of Australian undergraduates, with no mechanism for making up the difference should Australia lose international market share." The evidence suggests that Australian universities do redistribute the gains from exporting higher education to native students through their internal resource allocation, and that we should take into account the structure of the higher education sector to understand the impact of exporting higher education.

The contribution of this paper is to theoretically introduce non-profit public universities into a model of trade in higher education to investigate the impact of exporting higher education and empirically identify the impact on the enrollment of native students using data from Australia during the period 2001 to 2007.

Section 2 presents a North-South two-sector general equilibrium model with utility-maximizing public universities, which I adopt from the higher education literature (Ehrenberg (2004), Ehrenberg *et al.* (1993), Garvin (1980), and James (1990)). Universities are assumed to have a utility function that depends on two elements: the education quality they provide to students and the number of native students they educate. Education quality of a university is determined by its endowment of education capital and its spending on quality-enhancing activities/research. To enroll an additional student, a university has to incur an enrollment cost. We can think of this enrollment cost as a custodial cost related to instruction (education core services) and ancillary services (transport, meals, housing). Universities receive funding from the government and collect tuition fees from students, and they allocate their income to research and education of native students to maximize their utility.

The North has more educational capital in the higher education sector than the South. In autarky, the South will have a lower education quality and fewer efficient units of skill per unskilled labor in the perfectly competitive production sector. With complementarity between skill workers and unskilled labor in production, the South will have a higher marginal value of skill and a lower marginal value of unskilled labor, which means education has a higher return and a lower opportunity cost in the South. Therefore, students born in the South are willing to pay more than what students bron in the North are willing to pay to attend Northern universities.

Trade in higher education is not free: Northorn HEPs are required to charge Southern students tuition fees higher than the marginal enrollment cost. The "extra revenue" from Southern students will expand the budgets of universities and increase spending on research and teaching native students. Because it allows HEPs to spend more on research, exporting higher education increases the quality of education and makes it more attractive to native students. And because it leads to increased subsidy to the education of natives, exporting higher education decreases the post-subsidy enrollment cost and increases effective supply of university places to native students.

If the marginal enrollment cost is constant, then exporting higher education will improve natives' access to higher education because the two mechanisms, through HEPs, both lead to higher native enrollment. If the marginal enrollment cost increases with enrollment, then exporting higher education will have an ambiguous impact on native enrollment, because the inflow of foreign students will drive up the marginal enrollment costs in the North and will decrease the supply of university places to native students. The theoretical ambiguity of the impact of exporting higher education on native enrollment, even with university-level redistribution of gains from exporting higher education to native students, calls for empirical identification.

Section 3 investigates the impact of foreign enrollment on Australian native enrollment at the university level during the period 2001 to 2007. Australia is economically an important case because it has the most open higher education sector in the whole world (measured by the share of foreign enrollment in total higher education enrollment). It also is one of the two countries that report enrollment data by students' country of origin at the institution level for a long period of time,[4] a necessary requirement for implementing the instrumental variable approach used in this paper.

The key identification problem is the endogeneity of foreign enrollment. If for some exogenous reason some universities accumulate more education capital and can provide better education quality, they will attract more native students and more foreign students. In this case, native enrollment and foreign enrollment would be positively correlated, but foreign enrollment does not cause native enrollment to increase. On the other hand, if universities that experience a negative shock in public funding seek to raise revenue by serving more foreign students, and at the same time digest the funding cut by serving fewer native students, we would observe a negative correlation between native enrollment and foreign enrollment, though the decrease in native enrollment is not caused by foreign students.

To solve the endogeneity problem, I construct an instrumental variable using the variation in foreign demand for university places at the Australian institution level. This identification strategy is inspired by Card's papers (Card (2001) and Card (2009)) on the city-level labor market impact of immigrants in the US, in which Card constructs an instrumental variable for city-level immigrant inflow using the settlement pattern of immigrants: immigrants are more likely to settle in a city that has a large immigrant stock from their home country (Bartel (1989)). Other things equal, a city with a larger stock of immigrants from major immigrant-sending countries (e.g., Mexico, China, and India) will experience a larger inflow of immigrants than a city with similar labor demand but a smaller immigrant stock from major-immigrant sending countries. In this paper, the focus is the change in foreign enrollment in Australian universities.

For foreign students, existing ethnic networks reduce both the informational and mental costs associated with pursuing a degree in a foreign environment. Foreign students have the tendency to attend universities that enrolled a large number of students from the same country. For example, Monash University historically enrolled a large share of Hong Kong students, so current applicants from Hong Kong find Monash University more attractive than other Australian universities, because it is easier for them to get information about this university and they expect more help from the Hong Kong student network once they enroll.

The network theory suggests that a university with better-established networks by students from major student-sending countries (e.g., China and India) will have a bigger increase in demand for its education. Based on this theory, I create a variable by summarizing the interaction of the existing country-specific student networks in Australian universities established from 1989 to 1994 and the country-specific demand for Australian higher education over all student-sending countries. As long as the supply to foreign enrollment is not perfectly inelastic and country-specific networks do affect foreign students' choice of universities, this variable will be positively correlated with the observed foreign enrollment.

This variable is used as an instrument for foreign enrollment in a regression that uses foreign enrollment in an Australian HEP to explain the native enrollment in this university with controls for HEP-fixed effects, HEP-fixed trends, and year-fixed effects. The constructed variable should not be correlated with the HEP- and year-specific errors in native enrollment for the following reasons: First, the country-specific student networks were determined during the period 1989 to 1994, seven years from the beginning of the sample period. They do not vary with time. Also, for individual universities, this was a period when exporting higher education offered windfall income and was not of strategic importance, which means that the student networks are not the results of individual universities' long-run strategic recruiting.[5] Second, each university is small relative to the Australian higher education sector. During the entire sample period, no university has a market share higher than 9% of the Australian exporting market. As long as each HEP has a small market share, the number of foreign students in Australia on average should not be correlated with unobserved HEP- and year-specific errors in native enrollment. The IV estimate suggests that the enrollment of one more foreign student in a particular Australian university increases that university's enrollment of native students by 0.75 with a standard error of 0.29.[6]

Section 4 estimates the impact of foreign tuition revenue on native enrollment with the same instrumental variable. In a regression that relates HEP-level native enrollment to tuition revenue from foreign students with the same set of controls, the IV estimate shows that an increase of $A\$10,000$ (constant 2,000) in tuition revenue collected from foreign students by a university would lead to the enrollment of 0.9 more native students in that university. During the sample period, each foreign student brought about $A\$8,000$ on average. The estimated impact of foreign students' revenue on native enrollment implies that the enrollment of one more foreign student leads to the enrollment of about 0.72 more native students.

In aggregate, my calculation shows that, given the realized public funding, if there had been no increase in foreign enrollment, Australian native enrollment would have seen an annually decline of about 5,000 on average during the period 2001 to 2007, as opposed to observed annual growth of about 7,000.[7]

2 Theoretical model

2.1 A closed economy with a publicly subsidized higher education sector

I consider a closed economy with N identical individuals, a competitive production sector and a publicly-subsidized higher education sector. The production sector uses skilled and unskilled labor to produce a composite good, Y. The technology is $Y = F(L_s, L_u) = L_s^{\alpha} L_u^{1-\alpha}$ where $0 < \alpha < 1$. Factors are paid at their marginal value: W_s, the return to one unit of skill equals $\alpha \left(\frac{L_s}{L_u}\right)^{\alpha-1}$, and W_u, the return to unskilled labor, equals to $(1-\alpha)\left(\frac{L_s}{L_u}\right)^{\alpha}$.

Individuals are identical and are endowed with one unit of time. If an individual chooses to remain unskilled, then he or she will supply one unit of unskilled labor and earn the unskilled wage $W_u = (1-\alpha)\left(\frac{L_s}{L_u}\right)^{\alpha}$. If an individual chooses to attend a publicly subsidized university and become a skilled worker, she has to pay tuition p and spend a fixed share θ of her time in school; the result is that she acquires q units of skill when she graduates from college and gets paid $(1-\theta)qW_s = (1-\theta)q\alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1}$.

Because individuals are identical, in equilibrium they will have the same net lifetime income regardless of their education choices, which means that p will be the difference between the wage income of the two types of workers:

$$p = (1-\theta)qW_s - W_u = (1-\theta)q\alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1} - (1-\alpha)\left(\frac{L_s}{L_u}\right)^{\alpha} \tag{1}$$

The higher education sector is composed of n identical HEPs, each endowed with education capital K and receiving public funding g from the government as a block grant.[8] The education quality of an HEP is determined by $q(K, R) = KR^{\beta}$ with $0 < \beta < 1$.

The HEPs derive utility from the quality of their education, q, and the number of students they educate, S. I assume their utility function takes the form $U(q, S) = q^{\sigma} S^{1-\sigma}$, where σ indicates the preference towards quality. A higher σ means that the university cares more about education quality.

For each student they enroll, HEPs incur an enrollment cost c and receive tuition p from the student. The representative HEP behaves as a price-taker, treating tuition p, marginal cost c, and government subsidy g as given, and chooses quality investment R and student enrollment S to maximize its utility:

$$\max_{R,S} q^{\sigma} S^{1-\sigma} = K^{\sigma} R^{\beta\sigma} S^{1-\sigma}$$
$$\text{s.t. } R + cS \leqslant g + pS.$$

The research investment of the representative HEP is given by

$$R = \frac{\beta\sigma g}{1-(1-\beta)\sigma}. \tag{2}$$

As expected, the research investment R is increasing in β and σ, which means that if an HEP is more productive in quality improvement (corresponding to a bigger β) or has a stronger preference for quality (corresponding to a bigger σ), it will devote more revenue to quality-improving activities.

The enrollment of the representative HEP is determined by the following equation:

$$c - \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S} = p. \tag{3}$$

The left-hand side of this equation is the post-subsidy marginal enrollment cost. Notice that the tuition p is less than the marginal enrollment cost c; i.e., students are subsidized by the block grant g. Here the block grant affects the enrollment of native students because HEPs are utility maximizers and they value student enrollment; therefore, when HEPs get more funding, they will support more students.

2.1.1 Equilibrium in a closed economy

An equilibrium for this economy is an investment in quality improvement R, an educational quality q, an enrollment of students S, a tuition p, a set of skills and uneducated labor $\{L_s, L_u\}$, and a return to skills and unskilled labor $\{W_s, W_u\}$, such that 1) HEPs maximize their utility subject to their budget constraints; 2) individuals are indifferent between the two education choices; 3) production firms maximize their profits; and 4) the two factor markets clear.

The investment in quality improvement, R, is given by equation (2), independent of other endogenous variables. And it determines the educational quality, q.

The rest of the six unknowns, $\{S, p, L_s, L_u, W_s, W_u\}$, are determined by equations (1),(3), competitive factor prices ($W_u = (1-\alpha)\left(\frac{L_s}{L_u}\right)^{\alpha}$, $W_s = \alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1}$), and the two factor market clearing conditions $L_s = (1-\theta)qnS$ and $L_u = N - nS = N - \frac{L_s}{(1-\theta)q}$.

We can solve the six-equation system by plugging in (3) the rest of the equations:

$$c - \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S} = (1-\theta)^{\alpha}q^{\alpha}\left(\frac{nS}{N-nS}\right)^{\alpha}\frac{N\alpha - nS}{nS}. \tag{4}$$

The left-hand side of equation (4) is the marginal enrollment cost minus the per-student public subsidy. In other words, it is the representative HEP's inverse post-subsidy supply of university places. The post-subsidy supply is upward-sloping in S, assuming the marginal enrollment cost is non-decreasing in S.[9] The right-hand side of equation (4) is the willingness to pay for a higher education place. It is a decreasing function of S because more students in higher education mean more efficient units of skill per uneducated labor in production, and lower return to skill and higher return to unskilled labor. Equation (4) shows that the equilibrium level of student enrollment S is determined when the individual's willingness to pay for higher education equals the post-subsidy marginal enrollment cost. The existence and uniqueness of the equilibrium are proved in the appendix.

Once S is determined, p L_s, L_u ,W_s, and W_u will be pinned down in turn by (3), the factor market clearing conditions, and competitive wage conditions.

2.1.2 Comparative statics

We can now analyze the comparative statics of the model. I will discuss how a change in K, the education capital,[10] changes the equilibrium outcome.

An increase in K, the education capital that each HEP owns, increases the quality of education, so the inverse demand curve for university places shifts up. Since the increase in K has no impact on the HEPs' revenue allocation, the inverse post-subsidy supply curve does not change given the marginal enrollment cost and government subsidy. Therefore, the equilibrium number of students S and tuition p will both increase. The amount of unskilled labor, L_u, decreases as a consequence of more individuals choosing to pursue higher education. The aggregate level of efficient units of skill, L_s, increases because both education quality q and the number of skilled workers nS increase. The increase in efficient units of skill per unskilled worker, $\frac{L_s}{L_u}$, leads to a decrease in the marginal value of skill, W_s, and an increase in the wage of unskilled labor, W_u. This means that the net lifetime income of all workers increases.[11] (The derivation of the comparative statics can be found in the appendix.)

2.2 Trade pattern

I now examine trade in higher education in a world with two countries, the North and the South. From here on, I will use x^* to indicate variables associated with the South and x to indicate variables associated with the North. Suppose the only difference between the North and the South is that HEPs in the North own more education capital, i.e., $K > K^*$. The comparative statics in the previous section suggest that, in autarky, the North has a higher educational quality ($q > q^*$), more students per HEP ($S > S^*$), higher tuition ($p > p^*$), more skilled labor per unskilled worker ($\frac{L_s}{L_u} > (\frac{L_s}{L_u})^*$), a higher lifetime income per person ($W_u > W_u^*$), and a lower return to skill ($W_s < W_s^*$). I demonstrate in this section that once the two countries open to trade, the North will export educational services and will import the numeraire good.

Individuals' willingness to pay for education depends on three things: the amount of skill (quality) they will get from the education, the marginal return to skill, and the opportunity cost. People born in the South have a higher marginal return to skill ($W_s < W_s^*$) and a lower opportunity cost ($W_u > W_u^*$) than people born in the North. For Northern education with quality q, individuals from the South are willing to pay $\widetilde{p}_f = (1-\theta)qW_s^* - W_u^*$, more than the prevailing tuition in the North for native students, $p = (1-\theta)qW_s - W_u$. For Southern education with quality q^*, individuals from the North are willing to pay $\widetilde{p}_f^* = (1-\theta)q^*W_s - W_u$, less than the prevailing tuition in the South, $p^* = (1-\theta)q^*W_s^* - W_u^*$.

If individuals are allowed to choose between universities in the North and universities in the South, people from the South will apply to HEPs in the North while no one from the North will apply to HEPs in the South, assuming they have to pay at least the prevailing tuition paid by native students. The trade pattern is consistent with what we observe in reality: the flow of full fee-paying international students is from developing countries to developed countries.

2.3 Trade equilibrium

The trade equilibrium is characterized by, in addition to variables that are analyzed in the closed economy for both countries, a number S_f of Southern students studying in a representative Northern HEP, and the tuition fees p_f these students need to pay.

2.3.1 Equilibrium conditions

In the North, the HEPs now face the demand from people born in both the North and South. People from the South are willing to pay p_f for Northern education while natives in the North are willing to pay p.

How the HEPs in the North supply higher education places to the two groups of students depends on both their objectives and the structure of the higher education sector. Suppose opening to trade does not change the objective of HEPs in the North, which means that HEPs in the North only care about education quality and educating native students, and they treat serving foreign students as a way to raise funding. The objective of HEPs in the international market is to maximize "extra revenue," i.e., $(p_f - c)S_f$.[12]

If HEPs are competitive in the international market, the competition among HEPs for foreign students will drive the tuition fees down to the marginal enrollment cost, and Southern students will pay tuition $p_f = c$, which is still higher than the tuition that Northern natives pay. The impact on natives' access to higher education in the North will be negative if the marginal enrollment cost increases with students enrolled, and will be zero if the marginal enrollment cost is constant. The above argument suggests that individuals in the North have a reason to worry if Northern HEPs compete for foreign students through tuition.

In Australia, the higher education sector is regulated by the Department of Education, Science, and Training (DEST). DEST sets minimum indicative fees for foreign students, which is supposed to reflect the full average cost of providing a place.[13] HEPs are not allowed to charge a fee lower than the minimum indicative fee. The UK had the same regulation until 1993/1994, and according to the United Kingdom Committee of Vice-Chancellors and Principals, the tuition levels in 1997 were clustered around the recommended minimum fees at the time, suggesting that without regulation UK universities did not compete for foreign students by reducing tuition.[14]

How HEPs compete in the international market is an interesting issue that need more investigation. In this paper, I choose to abstract from the experience of Australia and the UK. Specifically, I assume that foreign students need to pay the marginal enrollment cost c and a positive markup π, so the inverse supply of higher education places to individuals from the South is given as

$$p_f = c + \pi, \pi > 0.$$

Northern HEPs will accept all Southern students who are willing to pay p_f for their education. Trade will occur if $p_f < \widetilde{p}_f$. In the North, the representative HEP now has three revenue sources: government funding, tuition from native Northern students, and tuition from Southern students $p_f S_f$. The HEP spends cS_f on activities associated with the education of Southern students and collects πS_f as extra revenue from serving Southern students. The budget constraint of representative HEPs becomes

$$R + (c - p)S \leqslant g + \pi S_f$$

As in the closed economy, the representative HEP allocates the total revenue $g + \pi S_f$ to quality improvement and the education of native students. The investment in quality improvement and the resulting education quality in the North are determined by the following equations:

$$R = \frac{\beta\sigma(g + \pi S_f)}{1 - (1-\beta)\sigma} \tag{5}$$

$$q = K \left[\frac{\beta\sigma(g + \pi S_f)}{1 - (1-\beta)\sigma} \right]^{\beta}. \tag{6}$$

Native enrollment S in the Northern representative HEP is determined by

$$c[n(S+S_f)] - \frac{(1-\sigma)(g+\pi S_f)}{1-(1-\beta)\sigma}\frac{1}{S} = p = (1-\theta)^{\alpha} q^{\alpha} \left(\frac{nS}{N-nS}\right)^{\alpha} \frac{N\alpha - nS}{nS}. \tag{7}$$

In the South, the investment in quality improvement R^* and education quality q^* are determined independently in the higher education sector, because the HEPs receive no application from individuals born in the North and the public funding to HEPs does not change by trade. The aggregate efficient units of skill now equals the sum of efficient units of skill embodied in Northern-educated individuals and Southern-educated individuals, i.e., $L_s^* = (1-\theta)(nqS_f + nq^*S^*)$, and the uneducated labor equals $L_u^* = N^* - nS^* - nS_f$.

The South's domestic higher education market clears when the inverse supply of the Southern HEPs, $c(nS^*) - \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S^*}$, equals to the inverse demand for Southern higher education, $(1-\theta)q^*W_s^* - W_u^*$, as given by the following equation

$$c(nS^*) - \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S^*} = (1-\theta)^{\alpha}\left(\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right)^{\alpha-1}\left(\alpha q^* - (1-\alpha)\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right) \tag{8}$$

The international higher education market clears when the inverse supply of the Northern HEPs, $c[n(S+S_f)] + \pi$, equals the inverse demand from the South, $(1-\theta)qW_s^* - W_u^*$, as described in the following equation:

$$c[n(S+S_f)] + \pi = (1-\theta)^{\alpha}\left(\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right)^{\alpha-1}\left(\alpha q - (1-\alpha)\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right) \tag{9}$$

Equilibrium conditions (7), (8), and (9) determine the number of native students enrolled in a representative HEP in both countries, S^* and S, and the number of Southern students enrolled in a Northern HEP, S_f. Northern investment in quality improvement R and education quality q, the tuition $\{p,\, p^*,\, p_f\}$, the distribution of workers $\{L_s^{(*)}, L_u^{(*)}\}$, and the marginal value of skill and unskilled labor $\{W_h^{(*)}, W_u^{(*)}\}$ in both countries are associated with $\{S^*, S,\, S_f\}$. The existence of a unique trade equilibrium is proved in the appendix.

2.3.2 Comparative Statics

I now turn to comparative statics of the trade equilibrium. My focus is how changes in the South (K^*, g^*, and N^*) affect the number of Southern students enrolled in Northern HEPs, S_f, Northern HEPs' research investment R, native enrollment S, and per capita income W_u.

Proposition 1 *The number of Southern students enrolled in North HEPs will increase if there is an increase in Southern population, and will decrease if Southern HEPs accumulate more educational capital or Southern HEPs receive more public funding from the government.*
Proof. *In the appendix.* ■

A rise in the South's population[15] increases Southern demand for higher education and leads to an enrollment increase of Southern students in both the South and North countries. An increase in educational capital increases Southern education quality. Individuals in the South are more willing to attend Southern HEPs, which leads to a higher skill-to-labor ratio in the South, hence lower returns to skill and a higher opportunity cost of acquiring skill (through higher education), therefore, Southern demand for Northern higher education decreases. An increase in public funding to HEPs in the South increases investment in research and improves education quality in the South, leading to a higher level of demand for Southern education. At the same time, it increases subsidy to students and effectively increases the supply of university spaces in the South. The equilibrium level of higher education enrollment increases. Combined with the education quality improvement, this results in an increase in the the skill-to-labor ration in the South. Southern demand for Northern higher education will decrease. The decrease of demand for Northern higher education induced by accumulation of educational capital and increasing public funding in the South will decrease the number of Southern students enrolled in Northern HEPs in equilibrium.

Changes in the South affect North through their impact on trade in higher education; more specifically, the number of Southern students enrolled in the North.

Proposition 2 *(On research investment and education quality.) An increase in Southern population increases research investment and education quality of HEPs in the North. An increase in educational capital or public funding of HEPs in the South decreases research investment and education quality of HEPs in the North.*

Proof. *In the appendix.* ■

An increase of Southern students in Northern HEPs increases the net revenue to Northern HEPs. With increased revenue, Northern HEPs spend more on research, and experience an improvement in education quality. Combined with Proposition 1, changes in the South will induce changes in the research investment and education quality in the North through the number of Southern students enrolled in the North.

Proposition 3 *(On native enrollment.) If the marginal enrollment cost in the North is constant, an increase in Southern population increases native enrollment in Northern HEPs, and an increase in educational capital or public funding of Southern HEPs decreases native enrollment in the Northern HEPs.*

Proof. *In the appendix.* ■

When the marginal enrollment cost in the North is constant, Southern students enrolled in Northern HEPs affect equilibrium outcome in the North only through their impact on Northern HEPs' revenue. Any change in the South that results more Southern students in the North will increase the institution level subsidy to native education in the North, which effectively increases the supply of higher education places to native students. The supply increase combined with natives' demand increase due to improved education quality leads to an increase in native enrollment in Northern HEPs.

Note that a constant marginal enrollment cost is a sufficient condition for natives in the North to benefit from increased Southern demand for Northern education due to changes in the South. A constant marginal enrollment cost means that the Northern higher education sector can keep expanding at the same marginal cost, which is a rather strong assumption. For instance, supposing that only people who have doctorate degrees can serve as instructors, and they can work as R&D workers in non-academic sectors, then the marginal cost to extract instructors from non-academic sectors will eventually rise.

Proposition 4 *(On native enrollment.) If the marginal enrollment cost in the North increases with enrollment, changes in the South that increase its demand for Northern education will have an ambiguous impact on native enrollment.*

Proof. *In the appendix.* ■

If the marginal cost increases with enrollment, an increase in Southern demand will drive up the marginal enrollment cost in the North and effectively "crowd out" native Northern students. Combined with the "crowd-in" effect through increased university investment in quality and subsidy to natives, the overall impact of an increase in Southern demand for Northern education on native enrollment in the North will be ambiguous.

Proposition 5 *(On per capita income.) If an increase in foreign enrollment induces an increase in native enrollment, then per capita income in the exporting country increases.*
Proof. *In the appendix.* ■

According to Proposition 2, an increase in foreign enrollment induced by an increase in Southern demand will lead to higher research investment and better education quality in the North. If an increase in foreign enrollment induces an increase in native enrollment, then the crowd-in effect of foreign students dominates the crowd-out effects. The North will have more educated workers who have more efficient units of skill and fewer uneducated workers in production. The increase in skill to unskilled worker ratio means that the wage of unskilled workers, i.e., per capita income, will increase. All native workers benefit from the increased export of higher education to the South.

3 Native and foreign enrollment in Australian HEPs from 2001 to 2007

The comparative statics of the trade equilibrium suggest that changes in the South will affect Northern research investment, education quality, enrollment of native students, and per capita income through the number of Southern students enrolled in Northern higher education sector.

In the empirical investigation, I move from the theoretical world that has two countries and identical universities within a country to a world that has many importing countries and one exporting country, Australia, which has the most open higher education sector in the world. In 2007, foreign students accounted for 27% of total higher education enrollment in Australia. The increase of foreign students in Australia is the result of both Australian universities' reaction to public funding cuts started in 1996 and the increase in international demand for their education, mostly from Asian countries.

We want to identify the impact of foreign enrollment induced by changes in the student-sending countries on Australian native enrollment. Usually, the identification strategy under this circumstance will be to predict foreign enrollment using demand-side variables that do not affect Australian native enrollment through channels other than foreign enrollment. These variables, as suggested by the comparative statics of the trade equilibrium, could be population and the public funding to higher education of the student-sending countries. However, in a university-level regression with year fixed effects, these country-level variables alone cannot provide identification, because they only generate demand variation across time for Australian higher education at the country level and will be sucked into the year-fixed effects. Inspired by David Card's work on the impact of immigrants on wages in US cities (Card 2001, 2009), I construct an instrumental variable using established country-specific foreign student networks across Australian universities and the sending-country-level demand variation across time. The rest of the section discusses the identification strategy in detail.

3.1 Enrollment in Australia at the institution level

Consider the following equation that seeks to explain the number of Australian native students in HEP i in academic year t (S_{it}). This specification relates the number of native students to the number of foreign students ($S_{f,it}$) :

$$S_{it} = \delta + \phi_{1i} + \phi_{2i}t + \gamma S_{f,it} + \lambda_t + \varepsilon_{it} \tag{10}$$

Here ϕ_{1i} and ϕ_{2i} are HEP-fixed effects and fixed trends; λ_t are year-fixed effects; ε_{it} are the unobserved HEP- and year-specific errors.

The HEP-fixed effects and fixed trends absorb any time-invariant HEP-specific factors (e.g., selectivity, preference towards research and enrollment) that may affect the size and growth of native enrollment. The year-fixed effects absorb any year-specific factors (e.g., funding available to the higher education sector, college-aged native population, and labor market conditions).

If $S_{f,it}$ is not correlated with ε_{it}, we can interpret γ as the impact of foreign enrollment on native enrollment. But $S_{f,it}$ is an endogenous variable in the model: the education capital and funding from the government affect the attractiveness to foreign students just as they do to native students; fundamental supply factors — for example, the marginal enrollment cost in the model — affect the enrollment of foreign students as well; and an HEP that improves its efficiency in educating students will have lower tuition fees and enroll more of both native students and foreign students. These mechanisms suggest that we can expect a positive correlation between $S_{f,it}$ and ε_{it}.

Also, HEPs may enroll more foreign students due to institution- and time-specific shocks in public funding. In a case study of three representative Australian universities,[16] Marginson & Eijkman (2007) found "as at the other universities, at South Australia it was noted that the rapid growth of international education had been driven by the reductions in per capita public funding." A financially distressed HEP may have to cut the enrollment of native students; however, its ability to serve foreign students does not change, because foreign students pay the full cost of their education. This HEP may become more active in the international market and enroll more foreign students in order to generate income. This mechanism suggests a negative correlation between $S_{f,it}$ and ε_{it}.

To solve the endogeneity problem, I construct an instrumental variable using established sending-country-specific student networks in Australian HEPs and year- and sending-country-specific demand for Australian higher education (detailed analysis in the next subsection).

3.2 Instrumental variable

The key identification problem is the potential correlation between the institution- and year-specific foreign enrollment $S_{f,it}$ and the institution- and year-specific error in native enrollment ε_{it}. A relevant and valid instrumental variable should be correlated with the former but not with the latter. As such a variable is hard to find, I construct one using the same technique that Card used in creating the instrument for city-specific immigrant inflows in the US (Card (2001) and Card (2009)). This method has two fundamental assumptions: First, situations in the student-sending countries (e.g., China, India, Hong Kong, and Singapore, etc.) affect the country- and year-specific demand for Australian higher education, but these factors do not directly affect native enrollment in Australia. Second, established sending-country-specific student networks affect foreign students' choice of universities within Australia.

3.2.1 Country- and year-specific demand for Australian higher education

The theoretical analysis suggests that changes in student-sending countries — college-aged population, educational capital in the higher education sector, and public funding to higher education — will affect the demand for oversea higher education, and therefore affect the equilibrium number of students enrolled in the education-exporting country as long as supply of places to foreign students is not perfectly inelastic (e.g., limited by quotas).

Figure 1 shows the number of foreign students studying in Australia from top sending countries from 2001 to 2007. Overall, across countries, there is a variation not only in level but also in growth (graphs of other countries are available upon request). This variation is mostly driven by economic factors in these student-sending countries. For example, China and India, whose numbers of students in Australia have been increasing throughout the seven-year period, both have a large and fast-growing population, fast-developing economy, and a relatively underdeveloped domestic higher education sector. Just from looking at these two countries, one may argue that the rapid increase in foreign students may be the results of Australian HEPs' increased willingness to supply to foreigners. This argument is contradicted by the decrease in the number of students from Singapore, Hong Kong, and some other European countries not shown in the graph. The number of students from Singapore decreased from 2002 to 2005, and the number of students from Hong Kong decreased from 2003 to 2006. Singapore and Hong Kong used to have a high demand for Australian higher education, but their demand decreased when they decided to develop their higher education sectors and become Asian higher education hubs.

These country-specific time-varying factors in the student-sending countries should not directly affect native Australians' college education decisions or choices of universities.

3.2.2 Country-specific student networks in Australian HEPs

Just as immigrants from different countries cluster in different US cities, foreign students from different countries cluster in different Australian universities. For example, in 2001, the University of New South Wales enrolled 10% of all Chinese students in Australia and only 2.2% of Indian students and 2.8% of Malaysian students. Monash University enrolled 11% of students from Singapore and only 2.3% of students from the US. Why do we observe these clusters?

There are at least two different explanations. One explanation is from the supply side: different HEPs choose to promote their education in different countries. For example, Central Queensland University enrolled 2% of students from Singapore in 2001 but successfully attracted 18% of all Indian students studying in Australia in 2001. The other explanation is from the demand side: different sending countries have different social networks in different HEPs and therefore have different preferences towards Australian HEPs.

Social networks have been found important in determining the settlement pattern of new immigrants (Card (2001) and Card (2009)). Foreign students, though not usually legally categorized as immigrants, are a population of young people who leave their home country and live in a foreign country for a significant amount of time. They have to apply to institutions in a different higher education system, live in a foreign environment, and very possibly study in a different language. An existing student network from the same sending country may offer valuable information and other benefits. The help that foreign students can get from existing student network starting from the application process to the initial orientation, to forming study groups, to finding internships, and to graduating with a job. In many ways, social networks may lower mental and physical costs of pursuing higher education in a foreign country. For example, students from Hong Kong are more likely to go to Monash University because they know people who go (or went) to this university and will be able to share their information and experience.

For the purpose of providing identification, I would like to use the country-specific student clusters in an Australian university — as a measure of country-specific student social network — to predict country-specific demand for this university in a given year, then summarize over all the sending countries to get university- and year-specific foreign demand for enrollment.

An immediate concern is that current country-specific student clusters in an Australian university also reflects HEPs' strategic recruiting. If an HEP suffering from public funding reduction is forced to cut its native enrollment, and promotes more intensively in large student-sending countries and enrolls more foreign students, then we may observe a negative correlation between foreign enrollment and native enrollment, introducing negative bias into the estimator. The way I deal with the problem is to use the clustering pattern established during the period 1989 to 1994. This was a period right after Australia opened its higher education sector to foreign students and before the unanticipated cut of public funding to higher education in 1996, when the Australian Labor Party lost the election after thirteen years of governance. During this period, exporting higher education offered windfall income but was not of strategic importance for individual HEPs.

Using the foreign student clustering pattern established during the period 1989 to 1994 instead of the one established during the sample period (2001 to 2007) allows us to avoid the problem associated with university strategic recruiting. It was almost impossible that, during 1989 to 1994, Australian universities foresaw their funding situation during 2001 to 2007 and strategically cultivated student networks. For that to happen, we would have to believe that Australian HEPs had a ten- to fifteen-year growth plan, felt the need to use the international market as an income source when it had stable public funding, and had the information and ability to predict the future developments in the international market.

If instead we believe that, during the period 1989 to 1994, Australian HEPs were not active individually in the international higher education market, then the country-specific student clusters had to be determined by other historical incidences, such as country-specific immigrant population in the city where the university was located, and the openness of the university and/or its international academic communication before 1989. These past circumstances do not vary over time and should not directly affect native enrollment during the sample period.

3.2.3 Constructed university- and year-specific foreign demand for university places

With the country- and year-specific demand for Australian higher education and the historical country-specific student social network in Australian HEPs, I can construct the university-year-specific foreign demand for university places.

To measure the country-specific student social network in Australian HEPs, I calculate the share fraction of foreign students from country j enrolled in HEP i in year t, indicated by η_{ijt}, using the number of students from country j enrolled in HEP i divided by the total number of students from country j in that year; then I average η_{ijt} over the period 1989 to 1994 to get η_{ij}, the average share fraction of foreign students from country j enrolled in HEP i during that period.

Since we cannot directly observe country j's demand for Australian higher education in year t, I use two different proxies: the first proxy is the number of foreign students from sending country j who study in Australian universities in year t, denoted by F_{jt}.

Summarizing country-specific student-network-predicted demand for HEP i's education in year t, $\eta_{ij}F_{jt}$, over student-sending countries, gives student-network-predicted demand for HEP i's education in year t,

$$\widehat{S}_{f,it} = \sum_{j} \eta_{ij} F_{jt}. \tag{11}$$

Of course, F_{jt} is the equilibrium outcome jointly determined by the demand factors and the supply of the Australian higher education sector in year t. However, the involvement of Australian higher education sector as a whole will not cause a validity problem. In an institution-level regression with year-fixed effects, we should not expect institution- and year-specific errors in native enrollment ε_{it} to be correlated with country- and year-specific variables F_{jt}, as long as individual universities are small on average.

The second proxy is the number of country j's student enrolled in all oversea higher education institutions, denoted by F'_{jt}. This variable is determined by demand factors in country j and the supply of all higher education-exporting countries in year t. F'_{jt} will not be correlated with ε_{it} if individual Australian HEPs are small suppliers in the international higher education market.[17] In 2007, the thirty-nine Australian HEPs as a whole, even with fast-growing higher education exporting during 2001 to 2007, had only 11% of the international higher education market. Thus, we should expect any of the thirty-nine Australian HEPs as an individual institution to be small in the international market and to have no influence over F'_{jt}.

Compared to $\widehat{S}_{f,it} = \sum_j \eta_{ij} F_{jt}$, the validity assumptions of $\widehat{S}'_{f,it} = \sum_j \eta_{ij} F'_{jt}$ are much weaker and more likely to hold. Using F'_{jt} to construct the instrument has two potential disadvantages: First, F'_{jt} theoretically has more irrelevant information from other international higher education suppliers like the US and the UK. Second, the variable used to measure F'_{jt} — "students from a given country studying abroad (outbound mobile students)", one of the student mobility indicators from the UNESCO website — has more noises because it is constructed from statistics from all the student-receiving countries.[18] Thus, the relevance of $\widehat{S}'_{f,it}$ will be weaker than that of $\widehat{S}_{f,it}$. For this matter, I use $\widehat{S}_{f,it}$ for the main regression and $\widehat{S}'_{f,it}$ as a robustness check of the validity of $\widehat{S}_{f,it}$.

3.3 Empirical specification

With the student-network-predicted university-year-specific foreign demand for university places $\widehat{S}_{f,it}$, I then estimate a system of equations of the following form:

$$\begin{aligned} S_{f,it} &= \eta + \theta_{1i} + \theta_{2i} t + \gamma_1 \widehat{S}_{f,it} + \psi_t + \upsilon_{it} \\ S_{it} &= \delta + \phi_{1i} + \phi_{2i} t + \gamma_2 S_{f,it} + \lambda_t + \varepsilon_{it} \end{aligned} \tag{12}$$

Using $\widehat{S}_{f,it}$ as an instrument for the actual foreign enrollment $S_{f,it}$, along with HEP-fixed effects, HEP-fixed trends, and year-fixed effects in equation system (12), the impact of foreign enrollment γ_2 on native enrollment is identified by demand-driven variation in foreign enrollment that leads to deviation in the native enrollment around the HEP-fixed time trend, under the assumption $cov\left(\widehat{S}_{f,it}, \varepsilon_{it}\right) = 0$.

3.4 Data

The main regression uses the Australian Student Enrollment Data from 2001 to 2007 collected by Department of Education, Science and Training (DEST).[19] Since 1989, DEST has collected a wide range of data on student characteristics in higher education, including the number of students by institution, by detailed classification of fields, and by country of birth. During the period 2001 to 2007, there are between 47 and 105 HEPs each year that reported their enrollment data, for a total potential sample of 459 observations. The analysis is restricted to the 39 HEPs that have reported enrollment data every year since 2001. The 39 HEPs enrolled 92.6% of students who enrolled in the 105 HEPs in the year 2007.[20] In this paper, enrollment is an unduplicated count of the number of students who enrolled in at least a major or minor course in the reference school year, regardless of their type or mode of enrollment.

The instrumental variable is constructed using foreign enrollment data by country of origin and by institution for the period 1989 to 2007. I use the enrollment of foreign students by country of birth during the period 1989 to 1994 to calculate the institution share distributions for the ninety countries and regions[21] that had students in Australian higher education institutions during that period. The institution-level foreign demand is then constructed using the historical institution share distributions and the number of foreign students from the ninety sending countries and regions from 2001 to 2007.

Table 1 presents the historical share distributions of the top ten student sending countries and regions among the Group of Eight[22] institutions (the historical HEP share distributions for all the countries and regions are available on request). We can see that there are differences in the share distributions of different sending countries. For example, the University of New South Wales enrolled 10.8% of US students but only 1.8% and 2.2% of students from Singapore and Japan, respectively; the eight universities enrolled 31.4% of US students but only 12.7% of Indian students. This fact ensures that the historical share distribution will generate variation in $\widehat{S}_{f,it}$ across universities in a given year, a necessary condition for the instrument to work.[23] Also, the shares are relatively small, showing that individual HEPs are small compared to the demand from the listed student-sending countries.

3.5 Main results

Table 2 presents the OLS and IV estimates of the relationship between foreign enrollment and Australian native enrollment at the institution level. The specification is a variant of the system of equations in (12). The dependent variable is native enrollment. The fourth column includes HEP-fixed effects, HEP-fixed trends, and the year-fixed effects. The third column excludes HEP-fixed trends, the second column excludes year-fixed effects, and the first column includes only HEP-fixed effects. The first-stage F-statistics for the instrumental variable from column (1) to column (4) are 59, 72, 19, and 25. The errors are clustered by HEP to adjust for potential serial correlation.

The IV estimates (top row) are positive and are not statistically different from each other. The point estimates in column (3) and in column (4) are 0.73 and 0.75, indicating that the impact identified with demand-induced growth in foreign enrollment within an HEP is very similar to the impact identified with demand-induced deviation around the HEP-fixed trend. A comparison of the point estimates in column (2) and column (4) tells us a slightly different story. Though not statistically different, omitting year-fixed effects increases the point estimate from 0.75 to 1.15, a more than 50% increase. We cannot say for sure if the difference is just because of imprecision in estimation due to the big standard error. If it is not, then the increase suggests that the years when an HEP has a higher than fixed trend increase in foreign enrollment are those when it has a higher than fixed trend increase in native enrollment for other reasons. These year-specific factors, as I discussed earlier in the paper, may be global common factors in demand for higher education or innovations in the Australian higher education sector that reduce the marginal enrollment costs, inducing an increase in the supply to both native and foreign students.

The bottom row in Table 2 depicts the corresponding OLS estimates. The OLS estimates are smaller than the IV estimates in all specifications. Due to the big standard error in the IV estimates, the 95% confidence intervals of the IV estimates and the OLS estimates overlap. However, all the IV estimates are outside the 95% confidence interval of the OLS estimates. The difference between OLS and IV estimates suggests that HEPs become more active in serving foreign students when their ability to serve domestic students is low. This is consistent with the findings in the case study (Marginson & Eijkman (2007)) that attributes the growth in foreign students to the decline of per capita public funding.

The preferred estimate is based on the stringent identification strategy in column (4). Even though the point estimate is almost the same as the one in column (3), the first-stage F-statistic is bigger with HEP-specific trends and leads to a smaller standard error. The interpretation of the estimated coefficient is that the enrollment of an additional foreign student in an Australian HEP will induce this HEP to enroll 0.75 more native students with a standard error of 0.29.

From 2001 to 2007, native enrollment grew annually by about $7,100$ on average in Australia, while foreign enrollment grew by $16,200$ on average each year. The preferred estimate implies that, given the realized public funding to higher education, native enrollment would have declined annually by about $5,000$ on average had there been no increase in the number of foreign students in Australia.

Table 3 presents the estimates with $\widehat{S}'_{f,it}$ as the instrumental variable (they will be called the "modified IV estimates" in the rest of the paper). Just as in Table 2, the specification is a variant of the system of equations in (12). The dependent variable is native enrollment. The columns have the same set of HEP-fixed effects, HEP-fixed trends, and year-fixed effects as in Table 2. The modified IV estimates (the top row in Table 3) are very similar to the original IV estimates (top row in Table 2). The similarity of the two sets of estimates implies that, if we believe each Australian HEP is small in the international higher education market and $\widehat{S}'_{f,it}$ provides valid identification, then we should accept the validity of $\widehat{S}_{f,it}$ as an instrument.

The first-stage F-statistics for $\widehat{S}'_{f,it}$ are 29, 11, 27, and 10 from column (1) to column (4). Not surprisingly, they are smaller than the first-stage F-statistics using $\widehat{S}_{f,it}$ as the IV, indicating a decline of relevance. The first-stage F-statistics suggest that $\widehat{S}'_{f,it}$ passes the weak IV test, marginally in the most stringent specification in column (4) (Staiger & Stock (1997)).

4 Native enrollment, public funding, and revenue from foreign students in Australia

In Section 3, I measure exporting higher education using foreign enrollment, or the number of university places that sell to foreign students. The method is intuitive, because most people relate exporting higher education to the physical presence of foreign students in universities and want to know if they take seats from natives. Alternatively, we can measure exports of higher education using the value of these university places – revenue collected from foreign students, and identify its impact on native enrollment.

The following specification relates native enrollment in HEP i in year t to the revenue from foreign students, denoted by REV_{it}^f. REV_{it}^f is treated as endogenous and instrumented by $\widehat{S}_{f,it}$.

$$\begin{aligned} REV_{it}^f &= \zeta + \varphi_{1i} + \varphi_{2i}t + \tau_1 \widehat{S}_{f,it} + \psi_t + \upsilon_{it} \\ S_{it} &= \iota + \xi_{1i} + \xi_{2i}t + \tau_2 REV_{it}^f + \vartheta_t + \mu_{it} \end{aligned} \tag{13}$$

The revenue data are taken from the Finance Collection and the Research Expenditure Collection by DEST for the years 2001 to 2007 and measured in 1,000 constant (2000) Australian dollars. The final sample has 34 HEPs that report the student enrollment and finance data every year during the sample period.

Table 4 presents the IV estimates of the relationship between native enrollment and tuition revenue from foreign students. The estimated impact of tuition revenue from foreign students on native enrollment is positive in all three specifications.

The preferred IV estimate is the one in column (3) that includes the HEP-fixed effects, the year-fixed effects, and the HEP-fixed trends. The first-stage F-statistic is 12.6. The interpretation of the estimated coefficient is that an increase of A\$10,000 (constant 2000) in tuition revenue collected from foreign students by an HEP would lead to the enrollment of 0.9 more native students in this HEP. During the sample period, each foreign student brought $A\$8,000$ on average. The estimated impact of foreign students' revenue on native enrollment implies that the enrollment of one more foreign student leads to the enrollment of about 0.72 more native students.

To address the concern that there may be a spurious correlation between the instrumental variable and public funding to universities, I use the instrumental variable to predict the grants from the Commonwealth Government Financial Assistance (CGFA), denoted by REV^g_{it}.[24]

$$REV^g_{it} = \zeta + \varphi_{1i} + \varphi_{2i}t + \tau_1 \widehat{S}_{f,it} + \psi_t + \upsilon_{it} \tag{14}$$

where φ_{1i} , φ_{2i} are HEP fixed effects and fixed trends; and ψ_t are year fixed effects. υ_{it} are the unobserved HEP- and year-specific errors.

Table 5 reports how the revenue from CGFA and tuition revenue from foreign students respond to demand-driven variations in foreign students. The dependent variable in column (1) to (3) is tuition revenue from foreign students. Column (1) includes only HEP-fixed effects, column (2) adds year-fixed effects, and column (3) adds HEP-fixed trends. The dependent variable in columns (4) to (6) is the revenue from CGFA. The estimated coefficients on tuition from foreign students are significantly positive and similar across different specifications, while the estimated coefficients on revenue from the CGFA are mostly insignificant and jump around across different specifications. The results show that the impact of exporting higher education on native enrollment is not falsely identified by some spurious correlation between public funding and the demand-driven variation in foreign enrollment.

5 Conclusion

Education capital is not evenly distributed across countries. Developed countries have accumulated more education capital over time and have better universities than developing countries. The fast-growing population and economy in developing countries generate a demand for high-quality higher education that cannot be satisfied by their domestic higher education system. The fierce competition for a domestic university place and the very undesirable alternative — being an uneducated worker in a labor abundant country — makes seeking international higher education an attractive option for the college-aged population in developing countries. According to an Australian government report in 2005, the world's demand for international higher education could increase to 8 million in 2025.

Education capital abundant countries like the UK, Australia, and New Zealand respond to this international demand by opening their higher education sector to fullffee-paying foreign students: Quotas on the number of foreign students were eliminated; Foreign students are charged tuition and fees higher than the marginal costs of educating them. Exporting higher education has becoming an important revenue source for universities in these countries.

It is important to know how the revenue gains of universities from exporting higher education affect native students. Theoretically, with non-profit publicly subsidized universities, the gains from exporting higher education will be redistributed to native students, and foreign students may improve natives' access to higher education. The empirical investigation of Australian higher education sector during the period 2001 to 2007 confirms the theoretical positive impact of exporting higher education on native enrollment — the enrollment of one more foreign student in a university increased that university's enrollment of Australian native students by 0.75.

The model and the empirical evidence have important implications for public universities in the US. The US has accumulated a lot of educational capital in their public universities. Traditionally, high quality public universities act as a magnet for the US to attract high-ability students from other countries. Serving foreign students for revenue is not common.[25] Compared to Australia, the US higher education sector is not very open. As of 2007, foreign students account for 3.5% of US total higher education enrollment but account for 27% of Australian total higher education enrollment. While 13 Australian HEPs have foreign enrollment above 8,000, the top foreign student-receiving public institution in the US, the University of Illinois at Urbana-Champaign, has 5,922 foreign students. In recent years, most US public universities face serious public funding cuts and have had significant enrollment reductions and tuition increases (Hebel (2010)), a situation similar to the one that Australian universities have been facing since 1996. The Australian experience suggests that the US could use its comparative advantage in the higher education sector to recruit full fee-paying foreign students and help more native students gain access to higher education. This calls policy makers to smooth the process of student visa application and university administrators to be more open to the idea of exporting higher education services.

Notes

[1]The $3.8 billion is tuition fees paid by non-EU students who are charged at a price higher than native UK students and students from EU countries (Pamela Lenton 2007 "The value of UK education and training exports: an update").

[2]The $7.4 billion does not include financial supports from US institutions. It is tuition fees paid by foreign students with non-US sources (US Open Doors 2008, Economic Impact Statement).

[3]Any model with privately owned educational capital and a competitive education sector will predict that trade in higher education will hurt native applicants in the exporting country. Findlay & Kierzkowski (1983) present a two-country model with a for-profit competitive education sector and two goods production sectors that differ in human capital intensity. They show that the educational capital abundant country will export human capital intensive good and will have an increase in the return to educational capital. If we allow the two countries to trade in higher education directly in the Findlay & Kierzkowski (1983) model, trade again will drive up the return to educational capital in the educational capital abundant country and will hurt native applicants through increased price for higher education.

[4]The UK is the other country that has the same type of enrollment data. The UK is a large higher education exporting country and would be a good case to study. The UK data are fifty times more expensive than the Australian data.

[5]Revenue from foreign students has become more and more important for Australian universities since 1996, in which year the Australian Labor Party lost the election to the Liberal-National Coalition and the new government significantly cut public funding to higher education.

[6]The estimate is from the instrument that uses the total number of students studying in Australia from a specific sending country as a proxy of this sending country's demand for Australian higher education. As a robustness check, I use the number of students studying

anywhere abroad by country to substitute the number of students in Australia by country in constructing the instrument. This IV is slightly weaker than the original one, but point estimates are almost the same as the original IV estimate, suggesting that individual Australian universities are small relative to the Australian higher education market.

[7]The average annual increase of native enrollment induced by foreign students equals the average annual increase of foreign student enrollment multiplied by 0.75. The HEP level enrollment gain is similar to the state-level gain identified with a similar instrument, suggesting that there is no spillover across HEPs within a state.

[8]In Australia, HEPs receive both block grants from the Commonwealth Government and a per-student subsidy through Higher Education Contribution Scheme (HECS). As long as the per-student subsidy does not cover the marginal enrollment cost, we can, without loss of generality, normalize it to be zero.

[9]The marginal enrollment cost will increase if there is a limited pool of potential instructors, classroom and office space, etc.

[10]Notice that K is at the HEP level, and the aggregate education inputs is nK. An increase in K is equivalent to an increase of the relative abundance of education inputs nK/N.

[11]The net lifetime income of a skilled worker with education quality q equals $(1-\theta)qW_s-p$. Its increase implies that the decrease in W_s and increase in p are offsetted by the increase in q.

[12]The "extra revenue" is the profit from serving foreign students. I use "extra revenue" to avoid confusion about the nature of HEPs.

[13]The full average cost of providing a place has different components, including teaching and research, administration, overhead, and capital facilities, course-specific (e.g., lab) or common-used (library).

[14]The information is mostly from a report on comparative costs of international students by Beck, Davis, and Olsen (1997), in which they discussed how the fees for international students were set for Australia, the UK, the US, New Zealand, and Canada.

[15]In the model, all individuals are elligible for higher education, so an increase in population is the same as an increase in elligible college applicants. In reality, the improvement of primary and secondary education will increase the number of elligible applicants even if

college-aged population remains the same.

[16]University of Melbourne, University of South Australia, and University of Ballarat.

[17]Just like the original instrument, the validity of this instrument relies on the assumption that the country-specific student networks established during 1989 to 1994 are not correlated with the institution-year-specific errors in native enrollment during 2001 to 2007, $cov(\eta_{ij}, \varepsilon_{it}) = 0$. As discussed before, it is very unlikely that this assumption is false.

[18]The UN data do not have statistics regarding Taiwan. The reported estimate treats Taiwan as missing. As a check, I use the number of Taiwanese students in the US to measure Taiwan's demand for international higher education, and the estimate is not affected.

[19]Department of Education, Employment, and Work Relations (DEEWR) since December 2007.

[20]A list of the HEPs included in the analysis is available from the author on request.

[21]Before 2000, some small countries were not individually coded. The country of birth code I obtained from the DEST has a total of ninety-five countries and regions coded. The list of countries and regions is available from the author upon request.

[22]The Group of Eight (Go8) is a coalition of leading Australian universities, intensive in research and comprehensive in general and professional education.

[23]If each HEP gets an equal share of foreign students from different sending countries, i.e.,$\eta_{i,j} = \eta$, then there will be no variation in the predicted foreign enrollment across institutions in a given year. All the variation in foreign students will be across years and will be sucked into the year-fixed effects.

[24]This is the block grant that HEPs receive from the Commonwealth Government, which does not include the revenue from the Higher Education Contribution Scheme (HECS).

[25]Groen & White (2004) find US public universities set higher admission standard for out-of-state students than in-state students even though out-of-state students pay higher tuition, which implies that generating revenue is not the main purpose to admit out-of-state students.

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6 Appendix

6.1 Proof of existence and uniqueness of the autarky equilibrium

The following is proof that equation (4) identifies a unique S. Rewrite equation (4) as

$$c - \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S} - (1-\theta)^{\alpha}q^{\alpha}\left(\frac{nS}{N-nS}\right)^{\alpha}\frac{N\alpha - nS}{nS} = 0 \tag{15}$$

Define $\Phi \equiv c - \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S} - (1-\theta)^{\alpha}q^{\alpha}\left(\frac{nS}{N-nS}\right)^{\alpha}\frac{N\alpha-nS}{nS}$. I show that Φ is a monotone increasing function from $(-\infty, \infty)$ on $(0, \frac{N}{n})$.

Differentiate Φ with respect to S, we get

$$\frac{\partial \Phi}{\partial S} = \frac{\partial c}{\partial S} + \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S^2} + (1-\theta)^{\alpha}q^{\alpha}\left(\frac{nS}{N-nS}\right)^{\alpha-1}\frac{N^2\alpha(1-\alpha)}{(N-nS)^2 S}$$

$\frac{\partial c}{\partial S} \geqslant 0$ is a sufficient condition for $\frac{\partial \Phi}{\partial S} > 0$. Furthermore, $\lim_{S\to 0}\Phi = -\infty$ and $\lim_{S\to\frac{N}{n}}\Phi = \infty$. Therefore, $\Phi(S) = 0$ has a unique solution on $(0, \frac{N}{n})$.

6.2 Comparative statics of the autarky equilibrium enrollment

The following shows the comparative statics of the autarky equilibrium enrollment $R, q, S, p, L_s, L_u, W_s, W_u$ with respect to K. (The comparative statics with respect to g and N are available upon request.)

First, R is not a function of K, so $\frac{\partial R}{\partial K} = 0$ and $\frac{\partial q}{\partial K} = R^{\beta} > 0$.

Differentiate Φ with respect to K, we get

$$\frac{\partial \Phi}{\partial K} = -\alpha(1-\theta)^{\alpha} q^{\alpha-1} \left(\frac{nS}{N-nS}\right)^{\alpha} \frac{N\alpha - nS}{nS} R^{\beta}$$

Assume $\alpha > \frac{nS}{N}$, then $\frac{\partial \Phi}{\partial K} < 0$. Using the implicit function theorem, we get $\frac{\partial S}{\partial K} = -\frac{\frac{\partial \Phi}{\partial S}}{\frac{\partial \Phi}{\partial K}} > 0$.

From $p = c - \frac{1-\sigma}{1-(1-\beta)\sigma} \frac{g}{S}$, we get

$$\frac{\partial p}{\partial K} = \frac{1-\sigma}{1-(1-\beta)\sigma} \frac{g}{S^2} \frac{\partial S}{\partial K} > 0$$

From the two factor market clearing conditions $L_s = (1-\theta)qnS$ and $L_u = N - nS$, we get

$$\frac{\partial L_s}{\partial K} = (1-\theta)qn\frac{\partial S}{\partial K} + (1-\theta)nS\frac{\partial q}{\partial K} > 0$$

$$\frac{\partial L_u}{\partial K} = -n\frac{\partial S}{\partial K} < 0$$

From the competitive wage conditions ($W_u = (1-\alpha)\left(\frac{L_s}{L_u}\right)^{\alpha}$, $W_s = \alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1}$),

$$\frac{\partial W_s}{\partial K} = \alpha(\alpha-1)\left(\frac{L_s}{L_u}\right)^{\alpha-2} (\frac{1}{L_u}\frac{\partial L_s}{\partial K} - \frac{L_s}{L_u^2}\frac{\partial L_u}{\partial K}) < 0$$

$$\frac{\partial W_u}{\partial K} = (1-\alpha)\alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1} (\frac{1}{L_u}\frac{\partial L_s}{\partial K} - \frac{L_s}{L_u^2}\frac{\partial L_u}{\partial K}) > 0$$

Proof of existence and uniqueness of the trade equilibrium

Equilibrium conditions (7), (8), and (9) determines the number of native students enrolled in a representative HEP in both countries, S^* and S, and the number of Southern students enrolled in a Northern HEP, S_f.

Rewrite equations (7), (8), and (9) as

$$c[n(S+S_f)] - \frac{(1-\sigma)(g+\pi S_f)}{1-(1-\beta)\sigma}\frac{1}{S} - (1-\theta)^{\alpha} q^{\alpha}\left(\frac{nS}{N-nS}\right)^{\alpha}\frac{N\alpha - nS}{nS} = 0 \tag{16}$$

$$c(nS^*)-\frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g^*}{S^*}-(1-\theta)^\alpha\left(\frac{nqS_f+nq^*S^*}{N^*-nS^*-nS_f}\right)^{\alpha-1}\left(\alpha q^*-(1-\alpha)\frac{nqS_f+nq^*S^*}{N^*-nS^*-nS_f}\right)=0 \tag{17}$$

$$c[n(S+S_f)]+\pi-(1-\theta)^\alpha\left(\frac{nqS_f+nq^*S^*}{N^*-nS^*-nS_f}\right)^{\alpha-1}\left(\alpha q-(1-\alpha)\frac{nqS_f+nq^*S^*}{N^*-nS^*-nS_f}\right)=0 \tag{18}$$

Denote the left side of equation (17) and equation (18) Φ^* and $\Phi^{'}$ respectively. Differentiate equations (16), and (17) and equation (18) with respect to $\{S, S^*, S_f)$, we get

$$A=\begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix}$$

where

$$
\begin{aligned}
a_{11} &= \frac{\partial \Phi}{\partial S} \\
&= \frac{\partial c}{\partial S} + \frac{1-\sigma}{1-(1-\beta)\sigma}\frac{g}{S^2} + (1-\theta)^\alpha q^\alpha \left(\frac{nS}{N-nS}\right)^{\alpha-1} \frac{N^2\alpha(1-\alpha)}{(N-nS)^2 S} \\
&> 0 \\
a_{12} &= \frac{\partial \Phi}{\partial S^*} = 0 \\
a_{13} &= \frac{\partial c}{\partial S_f} - \frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S} - \alpha(1-\theta)^\alpha q^{\alpha-1} \left(\frac{nS}{N-nS}\right)^{\alpha} \frac{N\alpha - nS}{nS}\frac{\partial q}{\partial S_f} \\
a_{21} &= \frac{\partial \Phi^*}{\partial S} = 0 \\
a_{22} &= \frac{\partial \Phi^*}{\partial S^*} \\
&= \frac{\partial c}{\partial S^*} + \frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S^{*2}} \\
&+ n\alpha(1-\alpha)(1-\theta)^\alpha \left(\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right)^{\alpha-2} \frac{[N^*q^* - nS_f(q-q^*)]^2}{(N^*-nS^*-nS_f)^3} \\
&> 0 \\
a_{23} &= \frac{\partial \Phi^*}{\partial S_f} \\
&= n\alpha(1-\theta)^\alpha \left(\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right)^{\alpha-2} \frac{[N^*q^* - nS^*(q-q^*)]}{(N^*-nS^*-nS_f)^2} \\
&[(1-\alpha)q + (1-\alpha - \frac{\partial q}{\partial S_f})\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}] \\
a_{31} &= \frac{\partial \Phi'}{\partial S} = \frac{\partial c}{\partial S} \geqslant 0 \\
a_{32} &= \frac{\partial \Phi'}{\partial S^*} \\
&= n\alpha(1-\alpha)(1-\theta)^\alpha \left(\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right)^{\alpha-2} \frac{[N^*q^* - nS_f(q-q^*)]^2}{(N^*-nS^*-nS_f)^3} \\
&> 0 \\
a_{33} &= \frac{\partial \Phi'}{\partial S_f} = \frac{\partial c}{\partial S_f} + a_{23}
\end{aligned}
$$

The determinant of A equals

$$
\begin{aligned}
|A| &= a_{11}a_{22}a_{33} - a_{11}a_{23}a_{32} - a_{13}a_{22}a_{31} \\
&= a_{11}(\frac{\partial c}{\partial S^*} + a_{32})(\frac{\partial c}{\partial S_f} + a_{23}) - a_{11}a_{23}a_{32} - a_{13}(\frac{\partial c}{\partial S_f} + a_{23})a_{31} \\
&= a_{11}(\frac{\partial c}{\partial S^*}\frac{\partial c}{\partial S_f} + \frac{\partial c}{\partial S^*}a_{23} + a_{32}\frac{\partial c}{\partial S_f}) - \frac{\partial c}{\partial S_f}\frac{\partial c}{\partial S}(\frac{\partial c}{\partial S_f} + a_{23}) \\
&+ [\frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S} + \alpha(1-\theta)^\alpha q^{\alpha-1}\left(\frac{nS}{N-nS}\right)^\alpha \frac{N\alpha - nS}{nS}\frac{\partial q}{\partial S_f}]a_{22}a_{31} \\
&> \frac{\partial c}{\partial S}(\frac{\partial c}{\partial S^*}\frac{\partial c}{\partial S_f} + \frac{\partial c}{\partial S^*}a_{23} + a_{32}\frac{\partial c}{\partial S_f}) - \frac{\partial c}{\partial S_f}\frac{\partial c}{\partial S}(\frac{\partial c}{\partial S_f} + a_{23}) \\
&+ [\frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S} + \alpha(1-\theta)^\alpha q^{\alpha-1}\left(\frac{nS}{N-nS}\right)^\alpha \frac{N\alpha - nS}{nS}\frac{\partial q}{\partial S_f}]a_{22}a_{31} \\
&= \frac{\partial c}{\partial S}(\frac{\partial c}{\partial S^*}a_{23} + a_{32}\frac{\partial c}{\partial S_f}) - \frac{\partial c}{\partial S_f}\frac{\partial c}{\partial S}a_{23} \\
&+ [\frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S} + \alpha(1-\theta)^\alpha q^{\alpha-1}\left(\frac{nS}{N-nS}\right)^\alpha \frac{N\alpha - nS}{nS}\frac{\partial q}{\partial S_f}]a_{22}a_{31} \\
&= \frac{\partial c}{\partial S}\frac{\partial c}{\partial S_f}a_{32} + [\frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S} + \alpha(1-\theta)^\alpha q^{\alpha-1}\left(\frac{nS}{N-nS}\right)^\alpha \frac{N\alpha - nS}{nS}\frac{\partial q}{\partial S_f}]a_{22}a_{31} \\
&> 0
\end{aligned}
$$

Therefore, there exists $\{S, S^*, S_f)$ such that (16), (17), and equation (18) hold. As long as $a_{33} > 0$, the solution is unique according to the Gale-Nikaido Theorem because $a_{22}a_{33} - a_{23}a_{32} > 0$,$a_{11}a_{33} - a_{13}a_{31} > 0$, and $a_{11}a_{22} > 0$.

6.3 Comparative statics of the trade equilibrium

6.3.1 Proof of Proposition 1

Differentiate Φ, Φ^* and Φ' with respect to N^*, we get

$$
\begin{aligned}
\frac{\partial \Phi}{\partial N^*} &= 0 \\
\frac{\partial \Phi^*}{\partial N^*} &= -n\alpha(1-\alpha)(1-\theta)^\alpha \left(\frac{nqS_f + nq^*S^*}{N^* - nS^* - nS_f}\right)^{\alpha-2} \frac{[N^*q^* - nS_f(q-q^*)](qS_f + q^*S^*)}{(N^* - nS^* - nS_f)^3} < 0 \\
\frac{\partial \Phi'}{\partial N^*} &= \frac{\partial \Phi^*}{\partial N^*}\frac{[N^*q^* - nS^*(q-q^*)]}{[N^*q^* - nS_f(q-q^*)]} < 0
\end{aligned}
$$

Substitute the third column of matrix A by $(0, -\frac{\partial \Phi^*}{\partial N^*}, -\frac{\partial \Phi'}{\partial N^*})$ and name the new matrix A_{N^*}. The determinant of A_{N^*} is

$$
\begin{aligned}
|A_{N^*}| &= a_{11}a_{22}(-\frac{\partial \Phi'}{\partial N^*}) - a_{11}(-\frac{\partial \Phi^*}{\partial N^*})a_{32} \\
&= a_{11}\frac{\partial \Phi'}{\partial N^*}(a_{32}\frac{[N^*q^* - nS_f(q-q^*)]}{[N^*q^* - nS^*(q-q^*)]} - a_{22}) \\
&> a_{11}\frac{\partial \Phi'}{\partial N^*}(a_{32} - a_{22}) \\
&= -a_{11}\frac{\partial \Phi'}{\partial N^*}(\frac{\partial c}{\partial S^*} + \frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S^{*2}}) \\
&> 0
\end{aligned}
$$

Differentiate Φ, Φ^* and Φ' with respect to K^*, we get

$$
\begin{aligned}
\frac{\partial \Phi}{\partial K^*} &= 0 \\
\frac{\partial \Phi^*}{\partial K^*} &= \frac{\partial W_u^*}{\partial K^*} - (1-\theta)R^{*\beta}(W_s^* + q^*\frac{\partial W_s^*}{\partial q^*}) \\
\frac{\partial \Phi'}{\partial K^*} &= \frac{\partial W_u^*}{\partial K^*} - (1-\theta)R^{*\beta}q\frac{\partial W_s^*}{\partial q^*} > 0
\end{aligned}
$$

Substitute the third column of matrix A by $(0, -\frac{\partial \Phi^*}{\partial K^*}, -\frac{\partial \Phi'}{\partial K^*})$ and name the new matrix A_{K^*}. The determinant of A_{K^*} is

$$
\begin{aligned}
|A_{K^*}| &= a_{11}[a_{22}(-\frac{\partial \Phi'}{\partial K^*}) - (-\frac{\partial \Phi^*}{\partial K^*})a_{32}] \\
&= a_{11}[\frac{\partial \Phi^*}{\partial K^*}a_{32} - a_{22}\frac{\partial \Phi'}{\partial K^*}] \\
&< a_{11}a_{32}[\frac{\partial \Phi^*}{\partial K^*} - \frac{\partial \Phi'}{\partial K^*}] \\
&= -a_{11}a_{32}(1-\theta)R^{*\beta}(W_s^* + q^*\frac{\partial W_s^*}{\partial q^*} - q\frac{\partial W_s^*}{\partial q^*}) \\
&= -a_{11}a_{32}n(1-\theta)^2R^{*\beta}(\frac{L_s^*}{L_u^*})^{\alpha-2}[(1-\alpha)qS^* + qS_f + \alpha q^*S^*) \\
&< 0
\end{aligned}
$$

Differentiate Φ, Φ^* and $\Phi^{'}$ with respect to g^*, we get

$$
\begin{aligned}
\frac{\partial \Phi}{\partial g^*} &= 0 \\
\frac{\partial \Phi^*}{\partial g^*} &= -\frac{1-\sigma}{[1-(1-\beta)\sigma]S^*} + \frac{\partial W_u^*}{\partial q^*}\frac{\partial q^*}{\partial g^*} - (1-\theta)\frac{\partial q^*}{\partial g^*}(W_s^* + q^*\frac{\partial W_s^*}{\partial q^*}) \\
\frac{\partial \Phi^{'}}{\partial g^*} &= \frac{\partial W_u^*}{\partial q^*}\frac{\partial q^*}{\partial g^*} - (1-\theta)q\frac{\partial W_s^*}{\partial q^*}\frac{\partial q^*}{\partial g^*} > 0
\end{aligned}
$$

Substitute the third column of matrix A by $(0, -\frac{\partial \Phi^*}{\partial g^*}, -\frac{\partial \Phi^{'}}{\partial g^*})$ and name the new matrix A_{g^*}. The determinant of A_{g^*} is

$$
\begin{aligned}
|A_{g^*}| &= a_{11}[a_{22}(-\frac{\partial \Phi^{'}}{\partial g^*}) - (-\frac{\partial \Phi^*}{\partial g^*})a_{32}] \\
&= a_{11}[\frac{\partial \Phi^*}{\partial g^*}a_{32} - a_{22}\frac{\partial \Phi^{'}}{\partial g^*}] \\
&< a_{11}a_{32}[\frac{\partial \Phi^*}{\partial g^*} - \frac{\partial \Phi^{'}}{\partial g^*}] \\
&= -a_{11}a_{32}[\frac{1-\sigma}{[1-(1-\beta)\sigma]S^*} + (1-\theta)\frac{\partial q^*}{\partial g^*}(W_s^* + q^*\frac{\partial W_s^*}{\partial q^*} - q\frac{\partial W_s^*}{\partial q^*})] \\
&< 0
\end{aligned}
$$

By Cramer's rule, we get

$$
\begin{aligned}
\frac{dS_f}{dN^*} &= \frac{|A_{N^*}|}{|A|} > 0 \\
\frac{dS_f}{dK^*} &= \frac{|A_{K^*}|}{|A|} < 0 \\
\frac{dS_f}{dg^*} &= \frac{|A_{g^*}|}{|A|} < 0
\end{aligned}
$$

6.3.2 Proof of Proposition 2

$$
\begin{aligned}
\frac{\partial R}{\partial S_f} &= \frac{\beta\sigma\pi}{1-(1-\beta)\sigma} > 0 \\
\frac{\partial q}{\partial S_f} &= K\beta\left[\frac{\beta\sigma(g+\pi S_f)}{1-(1-\beta)\sigma}\right]^{\beta-1}\frac{\beta\sigma\pi}{1-(1-\beta)\sigma} > 0 \\
\frac{\partial R}{\partial N^*} &= \frac{\partial R}{\partial S_f}\frac{dS_f}{dN^*} > 0 \\
\frac{\partial q}{\partial N^*} &= \frac{\partial q}{\partial R}\frac{\partial R}{\partial S_f}\frac{dS_f}{dN^*} > 0 \\
\frac{\partial R}{\partial K^*} &= \frac{\partial R}{\partial S_f}\frac{dS_f}{dK^*} < 0 \\
\frac{\partial q}{\partial K^*} &= \frac{\partial q}{\partial R}\frac{\partial R}{\partial S_f}\frac{dS_f}{dK^*} < 0 \\
\frac{\partial R}{\partial g^*} &= \frac{\partial R}{\partial S_f}\frac{dS_f}{dg^*} < 0 \\
\frac{\partial q}{\partial g^*} &= \frac{\partial q}{\partial R}\frac{\partial R}{\partial S_f}\frac{dS_f}{dg^*} < 0
\end{aligned}
$$

6.3.3 Proof of Propositions 3 and 4

$$
A_{1N^*} = \begin{bmatrix} 0 & 0 & a_{13} \\ -\frac{\partial\Phi^*}{\partial N^*} & a_{22} & a_{23} \\ -\frac{\partial\Phi'}{\partial N^*} & a_{32} & a_{33} \end{bmatrix}
$$

The determinant of A_{1N^*} is

$$
\begin{aligned}
|A_{1N^*}| &= a_{13}(-\frac{\partial\Phi^*}{\partial N^*})a_{32} - a_{13}a_{22}(-\frac{\partial\Phi'}{\partial N^*}) \\
&= a_{13}(-\frac{\partial\Phi'}{\partial N^*})(\frac{[N^*q^* - nS_f(q-q^*)]}{[N^*q^* - nS^*(q-q^*)]}a_{32} - a_{22}) \\
&> a_{13}(-\frac{\partial\Phi'}{\partial N^*})(a_{32} - a_{22}) \\
&= a_{13}\frac{\partial\Phi'}{\partial N^*}(\frac{\partial c}{\partial S^*} + \frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S^{*2}})
\end{aligned}
$$

Substitute the first column of matrix A with $(0, -\frac{\partial\Phi^*}{\partial K^*}, -\frac{\partial\Phi'}{\partial K^*})$ and name the new matrix A_{1K^*}. The determinant of A_{1K^*} is

$$|A_{1K^*}| = a_{13}[(-\frac{\partial\Phi^*}{\partial K^*})a_{32} - a_{22}(-\frac{\partial\Phi'}{\partial K^*})] = -a_{13}[\frac{\partial\Phi^*}{\partial K^*}a_{32} - a_{22}\frac{\partial\Phi'}{\partial K^*}]$$

From the proof of Proposition 1, we know $[\frac{\partial\Phi^*}{\partial K^*}a_{32} - a_{22}\frac{\partial\Phi'}{\partial K^*}] < 0$.

Substitute the first column of matrix A with $(0, -\frac{\partial\Phi^*}{\partial g^*}, -\frac{\partial\Phi'}{\partial g^*})$ and name the new matrix A_{1g^*}. The determinant of A_{1g^*} is

$$|A_{1g^*}| = a_{13}[(-\frac{\partial\Phi^*}{\partial g^*})a_{32} - a_{22}(-\frac{\partial\Phi'}{\partial g^*})] = -a_{13}[\frac{\partial\Phi^*}{\partial g^*}a_{32} - a_{22}\frac{\partial\Phi'}{\partial g^*}]$$

From the proof of Proposition 1, we know $[\frac{\partial\Phi^*}{\partial g^*}a_{32} - a_{22}\frac{\partial\Phi'}{\partial g^*}] < 0$.

$a_{13} = \frac{\partial c}{\partial S_f} - \frac{(1-\sigma)\pi}{1-(1-\beta)\sigma}\frac{1}{S} - \alpha(1-\theta)^\alpha q^{\alpha-1}\left(\frac{nS}{N-nS}\right)^\alpha \frac{N\alpha-nS}{nS}\frac{\partial q}{\partial S_f} < 0$ is a necessary and sufficient condition for $|A_{1N^*}| > 0$, $|A_{1K^*}| < 0$, and $|A_{1g^*}| < 0$. $\frac{\partial c}{\partial S_f} = 0$ is a sufficient condition for $a_{13} < 0$.

By Cramer's rule, we get

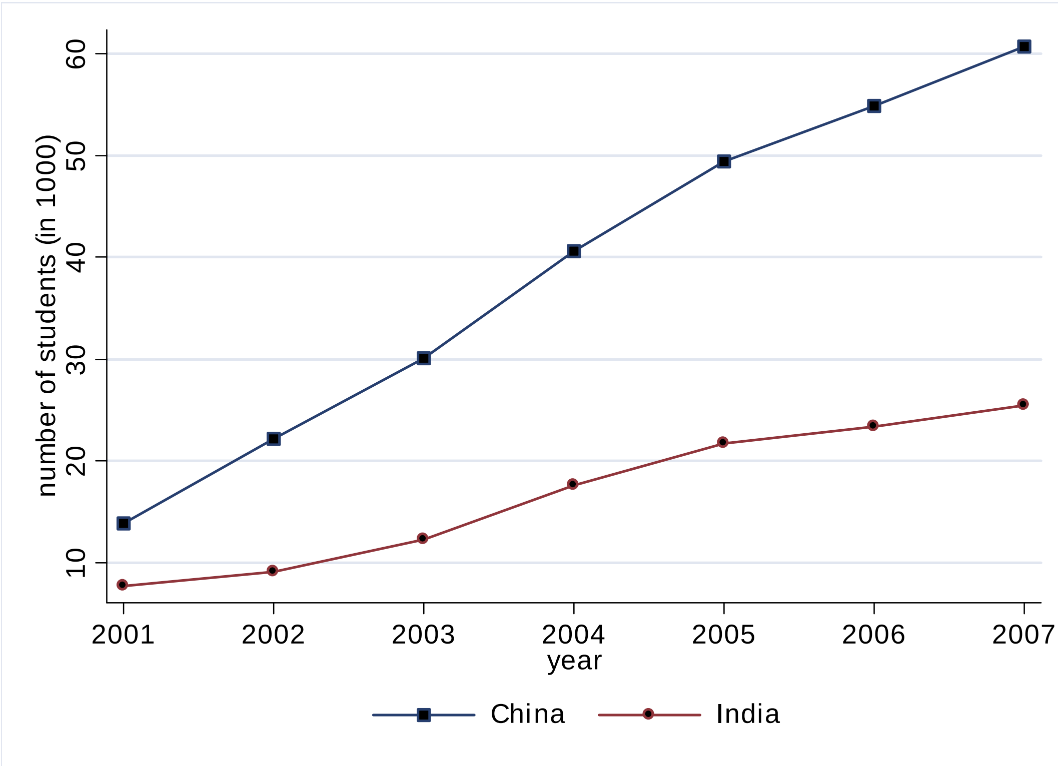
$$\frac{dS}{dN^*} = \frac{|A_{1N^*}|}{|A|} > 0$$
$$\frac{dS}{dK^*} = \frac{|A_{1K^*}|}{|A|} < 0$$
$$\frac{dS}{dg^*} = \frac{|A_{1g^*}|}{|A|} < 0$$

6.3.4 Proof of Proposition 5

$$\frac{\partial W_u}{\partial S} = (1-\alpha)\alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1}(\frac{1}{L_u}\frac{\partial L_s}{\partial S} - \frac{L_s}{L_u^2}\frac{\partial L_u}{\partial S}) = (1-\alpha)\alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1}(\frac{(1-\theta)qn}{L_u} + \frac{nL_s}{L_u^2}) > 0$$
$$\frac{\partial W_u}{\partial q} = (1-\alpha)\alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1}\frac{1}{L_u}\frac{\partial L_s}{\partial q} = (1-\alpha)\alpha\left(\frac{L_s}{L_u}\right)^{\alpha-1}\frac{(1-\theta)nS}{L_u} > 0$$
$$\frac{\partial q}{\partial S_f} = K\beta\left[\frac{\beta\sigma(g+\pi S_f)}{1-(1-\beta)\sigma}\right]^{\beta-1}\frac{\beta\sigma\pi}{1-(1-\beta)\sigma} > 0$$

$\frac{\partial S}{\partial S_f} > 0$ is a sufficient condition for $\frac{dW_u}{dS_f} = \frac{\partial W_u}{\partial S}\frac{\partial S}{\partial S_f} + \frac{\partial W_u}{\partial q}\frac{\partial q}{\partial S_f} > 0$.

Figure 1: Number of Students (in 1000) in Australia from Selected Counties



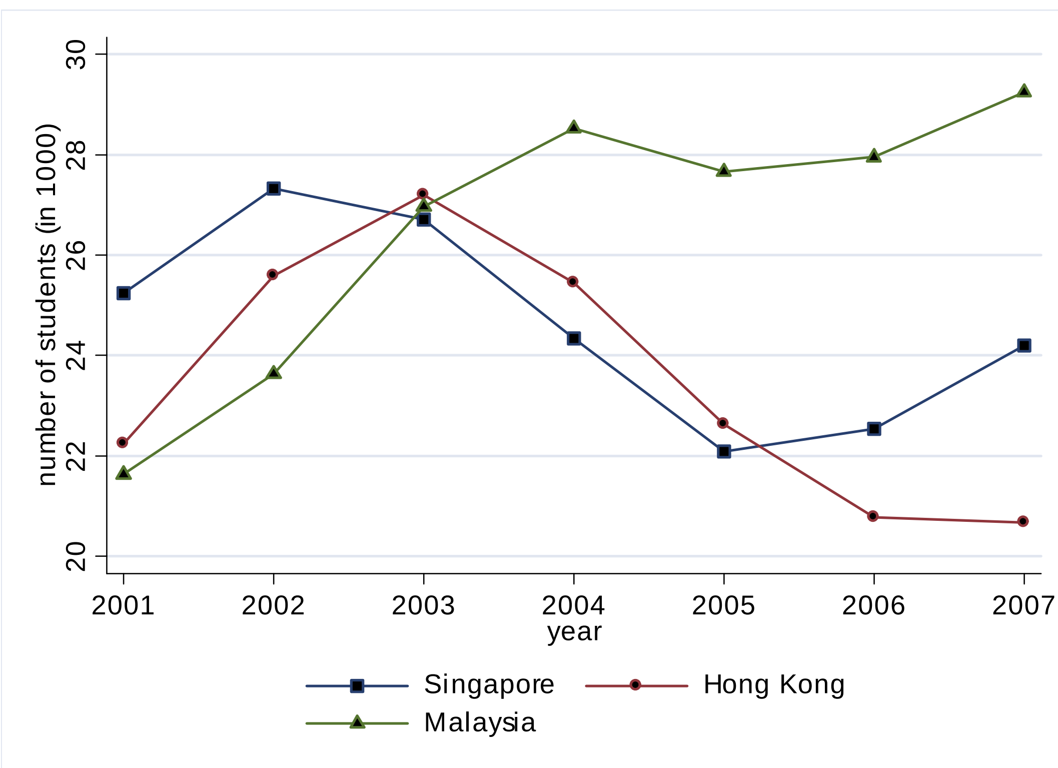


Table 1: Historical share distribution for the top sending countries

	CHN	IND	INDNS	HK	MLS	SNGP	TWN	THLD	US	JPN	KR
Monash U.	5.2	2.4	4.7	10.8	5.5	8.5	5.1	3.2	1.0	5.6	3.5
Australian National U.	1.8	0.6	1.1	1.0	0.6	0.8	0.5	1.8	2.6	3.2	1.4
U. of Adelaide	0.9	0.9	1.0	0.4	1.6	0.3	0.1	0.9	1.6	0.9	1.2
U. of Melbourne	2.3	1.2	1.2	2.0	2.5	1.3	1.8	1.8	6.1	2.8	1.5
U. of New South Wales	5.9	4.0	6.4	5.3	3.1	1.8	5.1	4.7	10.8	2.2	8.7
U. of Queensland	1.6	0.9	1.4	0.8	0.8	0.7	1.7	3.9	4.0	3.3	1.0
U. of Sydney	3.1	1.6	1.0	2.1	0.9	1.3	3.2	1.8	4.9	5.1	3.9
U. of Western Australia	1.0	1.2	1.1	0.6	2.2	3.8	0.7	2.4	0.6	0.8	0.5
Total group 8	21.9	12.7	17.7	23	17.3	18.7	18.1	20.3	31.4	24.1	21.8

Note: Percents of students from top sending countries (listed in columns) at the Group of Eight universities (in rows), averaged over the period 1989 to 1994. The top student-sending countries and regions are China, Hong Kong, India, Indonesia, Japan, Korea, Malaysia, Singapore, Taiwan, Thailand, and the US.

Table 2: Relationship between native students and foreign students in HEPs

	(1)	(2)	(3)	(4)
$S_{f,it}$	1.04***	1.15***	0.73**	0.75**
	(0.24)	(0.18)	(0.35)	(0.29)
HEP-fixed effects	yes	yes	yes	yes
HEP-fixed trends	no	yes	no	yes
Year-fixed effects	no	no	yes	yes
First-stage F-statistics	59	72	19	25
n	273	273	273	273
	Ordinary least squares estimates			
$S_{f,it}$	0.46***	0.56***	0.23***	0.29**
	(0.10)	(0.17)	(0.08)	(0.13)

Notes: The specifications are based on instrumental variables estimation where the actual number of foreign students in an HEP is treated as endogenous. The dependent variable is the native enrollment in a HEP. The sample has 273 observations based on the 39 HEPs for the years 2001 to 2007. The standard errors are clustered by institution to adjust for potential serial correlation. *** indicates $p-value < 0.01$, ** indicates $p-value < 0.05$, and * indicates $p-value < 0.1$.

Table 3: A check for the validity using an IV using outbound mobility of students

	(1)	(2)	(3)	(4)
$S_{f,it}$	0.96***	1.08***	0.73**	0.85**
	(0.21)	(0.16)	(0.35)	(0.28)
HEP-fixed effects	yes	yes	yes	yes
HEP-fixed trends	no	yes	no	yes
Year-fixed effects	no	no	yes	yes
First-stage F-statistics	29	27	11	10
n	273	273	273	273

Notes: The specifications are based on instrumental variables estimation where the actual number of foreign students in an HEP is treated as endogenous. The dependent variable is the native enrollment in an HEP. The sample has 273 observations based on the 39 HEPs for the years 2001 to 2007. The standard errors are clustered by institution to adjust for potential serial correlation. *** indicates $p - value < 0.01$, ** indicates $p - value < 0.05$, and * indicates $p - value < 0.1$.

Table 4: The relationship between native enrollment and tuition revenue from foreign students

	(1)	(2)	(3)
REV_{it}^{f}	0.13***	0.06*	0.09***
	(0.04)	(0.04)	(0.03)
HEP-fixed effects	yes	yes	yes
HEP-fixed trends	no	no	yes
year-fixed effects	no	yes	yes
First-stage F-statistics	14.2	9	12.6
n	238	238	238

Notes: The specifications are based on instrumental variables estimation where the revenue collected from foreign students (in 1,000 constant (2000) Australian dollars) is treated as endogenous. The dependent variable is the native enrollment. The sample has 238 observations based on the 34 HEPs for the years 2001 to 2007. The standard errors are clustered by institution to adjust for potential serial correlation. *** indicates $p-value < 0.01$, ** indicates $p-value < 0.05$, and * indicates $p-value < 0.1$.

Table 5: The relationship between revenue and demand-driven variation in foreign enrollment

	(1)	(2)	(3)	(4)	(5)	(6)
	REV_{it}^{f}			REV_{it}^{g}		
$\widehat{S}_{f,it}$	11.02***	11.18**	13.51***	0.62	6.07*	-14.40
	(2.93)	(3.73)	(3.81)	(2.34)	(3.20)	(9.94)
$\widehat{S}'_{f,it}$	1.16***	1.51***	1.22**	-0.54	0.61	-1.38
	(0.21)	(0.38)	(0.48)	(0.47)	(0.42)	(1.02)
HEP-fixed effects	yes	yes	yes	yes	yes	yes
HEP-fixed trends	no	no	yes	no	no	yes
Year-fixed effects	no	yes	yes	no	yes	yes
n	238	238	238	238	238	238

Notes: The dependent variable in columns (1) to (3) is tuition revenue collected from foreign students in 1,000 constant (2000) Australian dollar. The dependent variable in columns (4) to (6) is revenue from Commonwealth Government Financial Assistance in 1,000 constant (2000) Australian dollars. The independent variable is the instrumental variable. The sample has 238 observations based on the 34 HEPs for the years 2001 - 2007. The standard errors are clustered by institution to adjust for potential serial correlation. *** indicates $p - value < 0.01$, ** indicates $p - value < 0.05$, and * indicates $p - value < 0.1$.