International Trade in Education, Skilled Migration and Economic Growth

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Abstract

International trade in education is a large and growing phenomenon. We investigate the consequences of such trade for economic growth in developing countries using a model with a role for trade costs and endogenous emigration of students educated abroad. We assume a technological disadvantage in the developing country's education sector, so trade in educational services allows the country to acquire human capital at a lower opportunity cost. This raises the education importing country's steady-state growth rate. If a sufficiently large share of students remain abroad, however, the net effect of international trade and skilled migration reduces steady-state growth rates below their autarky levels. Migration is endogenous to the skilled wage gap in our model, and the wage gap depends, in part, on technological disadvantage in the education sector. Countries with sufficiently poor education technologies can experience slower-than-autarky growth rates when they import education.

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1 Introduction

Recent years have seen a rapid expansion of trade in educational services. By 1998, international educational services trade had reached US$30 billion – 3 per cent of global trade in services.[1] In 2002 there were around 1.8 million students undertaking higher education in foreign countries. This number is projected to rise to 8 million by 2025.[2] The Doha Round of multilateral trade negotiations has seen several proposals to further liberalize trade in education services.

At the moment, educational services trade usually involves developing country students traveling abroad to study in developed countries; English speaking countries are the most common destinations. Foreign students' experience in these countries can leave them favorably disposed toward permanent migration to their host countries. Education abroad may also improve their chances of successful migration.[3] The emigration of students who have studied abroad is an inescapable feature of trade in educational services. Zhang and Li (2002) calculate, for example, that roughly 75 percent of Chinese students studying abroad between 1978 and 1999 had not returned to live in China.[4]

We build an analytical model that captures key features of trade in educational services, focusing on the implications of such trade for economic growth in a developing country. In section 2 we describe a closed economy, two-sector endogenous growth model similar to that of Uzawa (1965) and Lucas (1988). An education sector uses human capital to produce human capital. In the goods sector, firms combine human capital with physical capital to produce a good that can be consumed, exported, or installed as new physical capital.

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[1] See Larsen and Morris (2002). In some cases, education exports are even more significant. According to Reserve Bank of Australia (2008), education accounts for fully one quarter of Australia's services exports.

[2] Australian Department of Foreign Affairs and Trade (2005).

[3] Some host countries (e.g. Australia) have immigration policies that favor skilled migrants, and degrees earned at host country institutions can help students qualify for host country citizenship.

[4] The denominator in this ratio includes some students who were currently studying, so the return rate upon graduation in this case was likely somewhat higher than one in four.

We assume that the developing country's education sector has a permanent technological disadvantage, relative to the rest-of-world education sector. We derive the implications for the trade pattern and for developing country growth in section 3. Trade in education allows human capital to be acquired at lower opportunity cost than in autarky. This remains true when we incorporate trade costs, which are quite plausibly large for trade of this sort. The developing country imports education and exports the physical capital/consumption good.

In section 4 we consider the possibility that students educated abroad may choose permanent emigration. Emigration represents a reduction in the education importer's terms of trade in our framework, and it may lead to lower-than-autarky growth rates. We model emigration as an endogenous outcome that depends upon returns to human capital in the developing country and the rest of the world. Low returns to education lead to greater emigration, *ceteris paribus*. Because the education sector employs human capital exclusively, countries with highly inefficient education technologies will tend to have low skilled wages, fostering greater emigration. This suggests a paradox: while the value of imported education is largest in those countries with the least-productive education technologies, countries with such technologies will tend to suffer more from endogenous emigration. Countries with education technologies that are reasonably close to the frontier have less outward migration, so access to better technology via trade in education raises economic growth rates.

2 Autarky model

Our closed economy growth model follows Uzawa (1965) and Lucas (1988).[5] We consider a simple economy with two production sectors: a commodity production sector and an education (human capital production) sector. There are two factors of production, physical

[5] We follow the notation and discussion in Barro and Sala-i Martin (1995).

capital (K) and human capital (H). Human capital is spread evenly among the population, L, so H can be characterized as product of L and h, the human capital of the typical person ($H = Lh$). New human capital is produced with existing human capital as the only factor of production.

A representative household undertakes a range of activities. It provides labor services (with human capital incorporated) in exchange for wages; it earns interest income on assets (i.e. physical capital); it purchases consumable goods and education services; and it saves by accumulating physical capital. We model these phenomenon in a continuous-time setting. A representative worker chooses the level of physical capital investment, human capital investment (including the education-importing decision) and consumption at time t.[6]

The commodity production sector employs K and H in a Cobb-Douglas production technology:

$$Y_t = AK_t^{\alpha}(x_t H_t)^{(1-\alpha)}, \tag{1}$$

where x_t is the fraction of total human capital employed in sector Y at time t, A is a shift parameter defining the total factor productivity (TFP), $A > 0$, and $\alpha \in (0,1)$. The closed economy's resource constraint is

$$C_t + \dot{K}_t + \delta K_t = AK^{\alpha}(x_t H_t)^{(1-\alpha)}, \tag{2}$$

where δ is the physical capital's depreciation rate, C is total consumption.

The education sector employs H to produce H using the technology:

$$\dot{H}_t + \delta H_t = B(1 - x_t)H_t, \tag{3}$$

[6] Our assumption that human capital acquisition is instantaneous is an abstraction that helps us focus on the terms of trade and the human capital formation function of education. Were we to focus on the time-based opportunity costs of education we might have usefully employed an overlapping generations model. We abstract from these issues here.

where $B > 0$ denotes the productivity parameter in the education sector. For notational simplicity, we assume that the depreciation rate for human capital is equivalent to that of physical capital, δ.

We normalize the size of the work force at time 0 to unity, and assume a constant population growth rate of n. The population's size at time t is given by $L_t = e^{nt}$. We work largely in terms of ratios that will be constant in the steady state, including per capita consumption $c_t \equiv \frac{C_t}{L_t}$, the per capita stock of physical capital $k_t \equiv \frac{K_t}{L_t}$, the per capita stock of human capital $h_t \equiv \frac{H_t}{L_t}$, the ratio of physical to human capital $\hat{k}_t \equiv \frac{K_t}{H_t} = \frac{k_t}{h_t}$, and the ratio of consumption to physical capital $c_{kt} \equiv \frac{C_t}{K_t} = \frac{c_t}{k_t}$. We derive growth rates for the per capita stocks of physical and human capital and for the ratio of the two types of capital (γ_k, γ_h, and $\gamma_{\hat{k}}$, respectively).

$$\gamma_{kt} = Ak_t^{\alpha-1}(x_t h_t)^{(1-\alpha)} - (\delta + n) - c_{kt} = Ax_t^{1-\alpha}\hat{k}_t^{-(1-\alpha)} - (\delta + n) - c_{kt}, \tag{4}$$

$$\gamma_{ht} = B(1 - x_t) - (\delta + n), \tag{5}$$

and

$$\gamma_{\hat{k}t} = \gamma_{kt} - \gamma_{ht} = Ax_t^{1-\alpha}\hat{k}_t^{-(1-\alpha)} - c_{kt} - B(1 - x_t). \tag{6}$$

The representative household's utility function takes the form of a constant intertemporal elasticity of substitution utility function:

$$u(c_t) = \frac{c_t^{1-\theta} - 1}{1 - \theta}, \tag{7}$$

where $\theta > 0$ represents the intertemporal elasticity of substitution. The agent maximizes lifetime discounted utility, subject to the motion equations for human and physical capital, non-negativity constraints on consumption, human and physical capital, and transversality conditions imposed on physical and human capital. Following Ortigueira and Santos (1997), we impose the condition $\rho - n > (B-\delta)(1-\theta)$ (where ρ is the discount rate), which guarantees that the optimization problem yields a unique solution of $\{c_t, h_t, k_t, x_t\}$. If investment in K and H is strictly positive in each period, then the problem can be characterized by the Hamiltonian:

$$\mathscr{H} = u(c_t)e^{-(\rho-n)t} + v_t[y_t - c_t - (\delta+n)k_t] + \mu_t[B(1-x_t)h_t - (\delta+n)h_t], \tag{8}$$

where v_t and μ_t are the shadow prices at time t of physical capital and human capital, respectively. The representative household makes an optimal decision in period t regarding its asset stream (in terms of physical capital), as well as its stock of human capital (which it accumulates by purchasing the output of the education sector).

We choose a consumption stream to optimize (8), and solve for a number of variables in the system. Of particular interest are the growth rates of per capita consumption:

$$\gamma_{ct} = \frac{1}{\theta}[A\alpha x_t^{1-\alpha}\hat{k}_t^{-(1-\alpha)} - \delta - \rho], \tag{9}$$

and the price of human capital, relative to that of goods, as:

$$\frac{p_t^E}{p_t^Y} = \frac{\mu_t}{v_t} = \frac{A}{B}(1-\alpha)x_t^{-\alpha}\hat{k}_t^{\alpha}, \tag{10}$$

where $\frac{p_t^E}{p_t^Y}$ represents the relative price of installed human capital in units of contemporaneous output. Equation (10) indicates that the relative price of human capital is increasing in $\hat{k}_t$ (the ratio of physical capital to human capital employed in sector Y) and decreasing in x_t (the share of human capital employed in the commodity sector). Both these relationships link human capital scarcity to a high relative price of human capital.

The steady state of the system can be defined when x is constant and c, k, h grow at constant and equal rates $\gamma_k = \gamma_h = \gamma_c$. $\dot{\gamma}_{\hat{k}}$, $\dot{\gamma}_{c_k}$, and $\dot{\gamma}_x$ will equal zero in the steady state, and we use these restrictions to solve for the steady states of $\hat{k}$, c_k, and x in autarky. Let $\varphi \equiv \frac{1}{\theta B}[\delta(1-\theta)+\rho] - \frac{n}{B}$. Then

$$\hat{k}^A = \left[\alpha \frac{A}{B}\right]^{1/(1-\alpha)} \left[\varphi + \frac{(\theta-1)}{\theta}\right], \tag{11}$$

$$c_k^A = B\left[\varphi + \frac{1}{\alpha} - \frac{1}{\theta}\right], \tag{12}$$

and

$$x^A = \varphi + \frac{(\theta-1)}{\theta}. \tag{13}$$

The corresponding steady state growth rate of y_t, c_t, k_t and h_t is:

$$\gamma_c = \gamma_y = \gamma_k = \gamma_h = \bar{\gamma} = \frac{1}{\theta}\left[B - \delta - \rho\right]. \tag{14}$$

In the steady state the relative price of education, $\frac{p_t^E}{p_t^Y}$, will stay fixed (it is evaluated at fixed $\hat{k}$ and x), while k, h, c grow at a constant rate, $\bar{\gamma}$. Note that these latter rates are increasing in B, the technology parameter in the education sector. This is relevant because trade in education will allow this economy to access the output of a more productive foreign education sector.

As is common in the trade literature, we are interested in the relationship between output prices and factor prices. We derive the relationships among goods and factor prices in autarky using the value marginal products of capital and human capital in the goods sector along with equation (10). These expressions contain variables x_t and $\hat{k}_t$, which can be eliminated via substitution of (11) and (13). Doing so allows us to solve for factor prices in terms of output prices (and technology parameters). The skilled wage, w_t, can be expressed as

$$w_t = p_t^Y \frac{\partial F(K_t, H_t)}{\partial x_t H_t} = p_t^Y A(1-\alpha)\left(\frac{\hat{k}_t}{x_t}\right)^{\alpha} = p_t^E B, \tag{15}$$

and, the return to capital, r, as

$$r_t = p_t^Y \frac{\partial F(K_t, H_t)}{\partial K_t} = p_t^Y A(1-\alpha)\left(\frac{x_t}{\hat{k}_t}\right)^{1-\alpha} = \alpha(1-\alpha)^{2(1-\alpha)}(Ap_t^Y)^{(1-\alpha)}. \tag{16}$$

Both factor prices are increasing in the output price of the sector that employs it most intensively, and increasing in the TFP parameter that applies to that industry.

3 Trade in educational services

We now consider the opening up of the economy to trade in educational services. We assume the country in question is small in comparison to the rest of the world, so its accumulation of physical and human capital has a negligible impact on the world interest rate and return to education. Neither do its trade policies affect output prices in the rest of the world. To highlight the impact of the transfer of human capital across countries on economic growth, we also assume that the developing country cannot borrow on the international market, so that the value of imports must be covered by exports in each period of the model. Furthermore, we assume costless trade in the capital-intensive good, and normalize both the world and domestic prices of the capital-intensive good to 1.

Assume that the rest of the world (hereafter *ROW*) is more efficient than the home country (hereafter *HOME*) in producing education such that $B^* > B$.[7] Under this assumption, *ROW* retains an absolute advantage in producing education. Both *HOME*'s technological disadvantage and its (endogenous) relative scarcity in human capital give it a comparative disadvantage in education. *HOME* will import human capital and export Y when it opens

[7]We use $*$ to denote *ROW* variables. We remove t subscripts from *ROW* variables because our small country assumption leaves these variables fixed in the steady state.

up to trade with the developed *ROW*. Equations (10), (11) and (13) can be combined to show that the steady state relative price of education in autarky is lower in *ROW* than in *HOME*:

$$p_t^E = \alpha^{\frac{1}{1-\alpha}}(1-\alpha)\left[\frac{A}{B}\right]^{\frac{2-\alpha}{1-\alpha}} > \alpha^{\frac{1}{1-\alpha}}(1-\alpha)\left[\frac{A}{B^*}\right]^{\frac{2-\alpha}{1-\alpha}} = p^{E*} \tag{17}$$

This is a formal statement of *HOME's* comparative disadvantage in the education sector.

The most common form of trade in education involves the temporary migration of students from a source country to a host country to obtain education services. This temporary migration can involve high relocation costs, as well as costs associated with learning the host country's language, identifying quality educational institutions, and more. We characterize these frictions as adjustment costs that occur as the human capital is 'installed.' The adjustment cost also helps us justify the developing country's retention of a domestic education sector. Absent trade costs, constant returns to scale in the education sector would insure that costless trade would lead *HOME* to specialize completely in the consumable good, and to import all its human capital.

Our adjustment cost is an increasing function of the share of imported education services, I_H^*, in the total stock of human capital. We denote the adjustment cost associated with imported education as:

$$\Phi\left(\frac{I_{H,t}^*}{H_t}\right) = \Phi(\chi_t), \tag{18}$$

where $\chi_t \equiv \frac{I_{H,t}^*}{H_t} = \frac{I_{h,t}^*}{h_t}$. We assume $\frac{\partial \Phi}{\partial I_h^*} > 0$, which implies that the adjustment cost is increasing in the volume of educational services imports. To facilitate the analysis further, we adopt a particular functional form for trade costs:

$$\Phi(\chi_t) = \eta\chi_t, \tag{19}$$

where $\eta > 0$ the proportional increase in trade costs associated with an increase in χ. The developing country's average terms of trade are such that it must give up $p^{E*} + \eta\chi_t$ units of the exportable for each unit of imported education.[8]

The assumption of convex adjustment costs is common in the growth literature. In this context, the form also implies trade costs that are increasing in the volume of trade. Deardorff (2006) argues that increasing marginal trade costs offer useful advantages in simple trade models: they lead to incomplete specialization, and they can help explain the 'missing trade' that constant returns models imply. We view increasing marginal trade costs in education as highly plausible.[9] What is more, they facilitate the incomplete specialization that we observe in practice.[10]

Trade in our model involves an exchange of the consumable good for imported human capital. Under balanced (and costly) trade, the developing country must give up $p_t^{E*} + \eta\chi$ units of the consumable in exchange for one unit of imported human capital investment I^*. Our new Hamiltonian appears as

$$\mathscr{H} = u(c_t)e^{-(\rho-n)t} + \nu_t[y_t - c_t - (p^{E*} + \eta\chi_t)I^*_{ht} - (\delta+n)k_t] + \mu_t[B(1-x_t)h_t + I^*_{ht} - (\delta+n)h_t]. \quad (20)$$

Relative to (8), the terms $(p^{E*} + \eta\chi_t)I^*_{ht}$ and I^*_{ht} have been added to the motion equations for physical and human capital, respectively.

[8] Because of convex adjustment/trade costs, we will need to distinguish between the price of imported education (a marginal condition) and the average terms of trade.

[9] Developing countries may, for example, have limited capacity to prepare students for study abroad. Language training would seem to be a particular hurdle. Furthermore, if students vary in their abilities, and better students are the first to begin study abroad, then marginal trade costs will increase with the trade volume. Small groups of foreign students may be able to attend the 'best' foreign institutions, while larger volumes might require the use of foreign institutions that are less suited to the education of foreign students. Larger volumes of imported education may also require the developing country to purchase education from more host countries (and possibly train students in more host country languages) and that may further raise costs of trade.

[10] Few developing countries appear to have outsourced their entire tertiary education program. While this may primarily be attributed to developing countries' government policies (which aim at retaining a tertiary education sector for cultural and political reasons), it may also be partially attributed to trade costs.

The first derivative of this Hamiltonian with respect to x_t^T is

$$\frac{\partial \mathscr{H}}{\partial x_t^T} = \nu_t A(1-\alpha)(\hat{k}_t{}^T)^{\alpha}(x_t^T)^{-\alpha} h_t - \mu_t B h_t^T = 0. \tag{21}$$

The first derivative with respect to $I_{h,t}^*$ is

$$\frac{\partial \mathscr{H}}{\partial I_{h,t}^*} = \nu_t \{A(1-\alpha)(\hat{k}^T)_t^{\alpha}(x_t^T)^{-\alpha} h_t^T x_t^{T\prime}(I_{h,t}^*) - (p^{E*} + 2\eta\chi_t)\} + \mu_t[-Bx_t'^T(I_{h,t}^*)h_t^T + 1] = 0. \tag{22}$$

We can use (21) to simplify (22), and link the relative shadow price of human and physical capital to the domestic and imported relative prices of education:

$$\frac{\mu_t}{\nu_t} = p^E = p^{E*} + 2\eta\chi_t. \tag{23}$$

Note that the appearance of χ_t in (23) means that the relative price that governs the representative household's investment decision is increasing in the trade volume. Note also that the 'wedge' between the domestic relative shadow price and the *ROW* relative price is double that observed in (19). The optimizing condition relies on the marginal trade cost, $2\eta\chi_t$, even as the average trade cost, $\eta\chi_t$, applies in the balance-of-trade condition.

The new steady state with trade in education is specified by solving the following non-linear system of equations:[11]

$$\gamma_{\hat{k},t}^T = A(x_t^T)^{(1-\alpha)}(\hat{k}_t^T)^{-(1-\alpha)} - (p^{E*} + \eta\chi_t)\frac{\chi_t}{\hat{k}_t^T} - c_{k,t}^T - B(1 - x_t^T) - \chi_t = 0, \tag{24}$$

$$\gamma_{c,t}^T = \frac{1}{\theta}[A\alpha(x_t^T)^{(1-\alpha)}(\hat{k}_t^T)^{-(1-\alpha)} - \delta - \rho] \tag{25}$$

$$\gamma_{x,t}^T = B(\frac{1-\alpha}{\alpha}) + \frac{1}{\alpha}\frac{\eta\chi_t^2}{p_t^{E*} + 2\eta\chi_t} + Bx_t^T - c_{k,t}^T - \chi_t - (p^{E*} + \eta\chi_t)\frac{\chi_t}{\hat{k}_t^T} = 0, \tag{26}$$

[11] We use superscript T to denote variables in the trade equilibrium.

and

$$\frac{A(1-\alpha)(\hat{k}_t^T)^{\alpha}(x_t^T)^{-\alpha}}{B} = p^E = p^{E*} + 2\eta\chi_t. \tag{27}$$

Let $c^T, x^T, \hat{k}^T$ and χ be the solutions of the system of non-linear equations given in (24) - (27). Although we cannot solve this system of equations analytically, we can show by subtracting (26) from (24) that we have:

$$A\alpha(\hat{k}^T)^{-(1-\alpha)}(x^T)^{(1-\alpha)} = B + \frac{\eta\chi^2}{p^{E*} + 2\eta\chi}. \tag{28}$$

(28) can be substituted into (25), and the steady state growth rate with international trade in education revealed as:

$$\bar{\gamma}^T = \frac{1}{\theta}[B + \frac{\eta\chi^2}{p^{E*} + 2\eta\chi} - \delta - \rho]. \tag{29}$$

Comparing (29) with (14) shows that the difference between the trade and autarky steady state growth rates is given by:

$$\bar{\gamma}^T - \bar{\gamma}^A = \frac{\eta\chi^2}{p^{E*} + 2\eta\chi}, \tag{30}$$

which is positive for positive trade flows ($\chi > 0$). Because education trade allows *HOME* access to human capital at a lower opportunity cost, *HOME*'s growth rate increases with trade.

4 Skilled migration

One of the issues encountered by a source country when participating in international trade in education services is that their students might not return home upon finishing their study abroad. We will call this loss of foreign-educated students "skilled migration." It seems likely that trade in education services via overseas consumption facilitates migration, as it allows students to develop familiarity with the host country's language and institutions, to establish connections with potential employers, and to better exploit host country immigrant networks that often facilitate permanent migration. In the context of our model, migration of this sort can be interpreted as a deterioration in the developing country's terms of trade. Our formalization of this effect within a dynamic model allows an evaluation of the effects of skilled migration on the accumulation of both human and physical capital, and on economic growth.

To isolate the role that trade in education plays in migration, we will assume that direct migration is limited, and that only foreign-educated students migrate. We "semi-endogenize" the rate of students' returning home upon graduation, linking it to the wage gap between *HOME* and *ROW*, and to an additional cost of settling in *ROW*. The return rate is semi-endogenous in the sense that the representative agent in *HOME* (who makes the consumption, saving and human capital investment decisions) is not choosing the level of migration; she treats this rate as a given. The migration rate is, however, endogenous to the wage gap; this is a reduced form 'decision' by foreign educated students. For simplicity, we assume that the developing country decisionmaker gets no utility from the emigrant's higher wages.[12]

We define the migration rate as a ratio of migrants to the population at time t:

$$\xi_{Lt} \equiv \frac{M(t)}{L(t)}, \tag{31}$$

where $M(t)$ represents the migration flow or population change in the source country in every period t (following Braun (1993), cited in Barro and Sala-i Martin (1995)) and $\xi_{Lt} \in [0,1]$. The net growth rate of L over time is adjusted by the migration of graduated students,

[12]One might expect that parents get utility from their children's revealed preference for life in *ROW*, or that they might receive remittances from descendants. Since these effects are unlikely to persist into the infinite future, we abstract away from them, assuming that the agent only cares to maximize utility of those descendants who return to the developing country.

and is now specified as:

$$\gamma_{Lt} = n - \xi_{Lt} \tag{32}$$

We also find it useful to relate the number of migrants to the subset of the population that is acquiring foreign education. Let us denote the share of foreign educated students returning home as $\lambda_t \in [0,1]$. We will refer to λ as the returning rate. If $\lambda < 1$, the source country will suffer a terms of trade loss associated with migration. The country will pay a gross amount of $(p^{E*} + \eta\chi_t)I^*_{H,t}$ for $I^*_{H,t}$ units of imported education but will only receive $\lambda_t I^*_{H,t}$ units of human capital. We can also express γ_{Lt} in terms of λ_t and χ_t:

$$\gamma_{Lt} = \frac{\dot{L}_t}{L_t} = n - \xi_{L,t} = n - (1-\lambda_t)\chi_t. \tag{33}$$

One of the main reasons students stay in the host country upon graduation is that they can receive a higher wage rate when entering the work force in the host country than in the source country. We consider the case in which the skilled migration of graduates is of a permanent nature, as we want to see how this consequence of trade in education will affect the source country's long-run growth rate. A student might consider a permanent residence in the host country if $w^* > w_t$ with $\forall t,\ t \in [\tau, ...\infty)$.[13] Assume that the above wage condition holds, then we can define the benefit from permanent migration as:

$$\beta_t = w^* - w_t > 0 \tag{34}$$

We follow the discussion in Barro and Sala-i Martin (1995) (attributed to Braun (1993)) by

[13]It would be more accurate to consider the present value of the future wage stream over the period $[\tau, \infty)$. However, this would not give us a closed form solution in the steady state. Our installation cost insures that the recent graduates will be more likely to return home than to pay the cost to replace a past graduate who is returning home. In that sense, we might view the current period decision as permanent in the steady state.

specifying the migration cost with the form:

$$C(\xi_{Lt}) = \varsigma \xi_{Lt} w_t \quad \varsigma > 0 \tag{35}$$

This specification is chosen largely for convenience, it implies that the cost incurred by each staying graduate is assumed to be an increasing function of the student migration rate $\xi_{L,t}$. The key property here is that the cost of moving for the marginal emigrant is rising with the number of emigrants. This might reflect increasing resistance to migration in *ROW*.[14] It may also reflect that selection effects lead those who can migrate at lowest cost to remain while others return home.[15] The migration cost is assumed to show up as a quantity of work time foregone, so that, for a given rate of student migration, $\xi_{L,t}$, the cost measured in units of output is proportional to the source country's human capital wage rate, w_t, which the graduates would have earned in their original locations in the period of migration.

Graduates would be indifferent between staying in the host country and returning home if and only if

$$\beta_t = C(\xi_{L,t}) \Rightarrow \lambda_t = 1 - \frac{w^* - w_t}{\varsigma \chi_t w_t} \tag{36}$$

The returning rate is decreasing in the wage gap at time t, and increasing in the migration cost, the trade volume, and in the home country wage rate.

Equation (36) highlights a problem for the developing country. Low wages (w), migration costs (ς), or trade volumes (χ) imply low values of λ. $\lambda = 0$ implies that all *HOME*'s foreign educated students choose to stay abroad. Opening to trade in education will lead *HOME* to increase its exports of the consumption good, but it will receive no human capital imports in return. With human and physical capital stocks growing more slowly than in autarky, growth

[14] Notice, however, that our small-country assumption means that the migration of *HOME*'s students should not affect the welfare of the workers in *ROW*.

[15] On the other hand, there might also be returns to scale in migration, because critical mass in a single immigrant community can lower the costs to each member. We wish to be clear that convex migration costs are a choice of convenience in this setting.

rates in the economy will be lower than they would have been in autarky. This occurs if the domestic return to human capital is too low, relative to the migration-cost-adjusted return in *ROW*. Formally this is true if $w_t < \frac{w^*}{\varsigma\chi_t + 1}$.

The returning rate of foreign students need not be zero for trade to reduce *HOME*'s rate of growth below its autarky level. In order to generalize this condition we return to the representative agent's Hamiltonian problem, adjusting the constraints to include migration:[16]

$$\begin{aligned}\mathscr{H} = \frac{c_t^{1-\theta}-1}{1-\theta} e^{-(\rho-n)t-\int_0^t \xi_{L(j)}dj} \\ &+\nu_t\{A(k_t^M)^{\alpha}(x_t^M h_t^M)^{(1-\alpha)} - (p^{E*}+\eta\chi_t)I_{h,t}^* - c_t - [(\delta+n)-\xi_{Lt}]k_t^M\} \\ &+\mu_t\{B(1-x_t^M)h_t^T + \lambda_t I_{h,t}^* - (\delta+n)h_t^M\} \qquad (37)\end{aligned}$$

The new terms (relative to 22) are $\int_0^t \xi_{L(j)}dj$ in the objective function, and ξ_{Lt} and λ in the motion equations for capital and human capital, respectively. The first derivative of $\mathscr{H}$ with respect to $I_{h,t}^*$ is[17]

$$\frac{\partial\mathscr{H}}{\partial I_{h,t}^*} = \nu_t\{A(1-\alpha)(\hat{k}^M)_t^{\alpha}(x_t^M)^{-\alpha}h_t^M x_t^{M\prime}(I_{h,t}^*) - (p^{E*}+2\eta\chi_t)\} + \mu_t[-Bx_t^{\prime M}(I_{h,t}^*)h_t^M + \lambda_t] = 0. \quad (38)$$

As we did above, we can substitute the counterpart of (21) and rearrange (38) to get:

$$\frac{\mu_t}{\nu_t} = \frac{p^{E*}+2\eta\chi_t}{\lambda_t}. \quad (39)$$

Employing the remaining first order conditions associated with differentiating (37), we solve for the growth rates of selected variables in the model. The growth rate of optimal

[16]The superscript *M* indicates the trade and migration setting.

[17]The representative household views the entire labor force, $e^{nt-\int_0^t \xi_{L(j)}dj}$ and the migration rate $\xi_{L,t}$ as given at the time where the optimizing decision is made.

consumption has the same form as derived under autarky:

$$\gamma_{ct}^{M} = \frac{1}{\theta}[A\alpha(x_t^M)^{(1-\alpha)}(\hat{k}_t^M)^{-(1-\alpha)} - \delta - \rho]. \tag{40}$$

The growth rate of $\hat{k}_t$ is:

$$\begin{aligned} \gamma_{\hat{k}t}^{M} &= \gamma_{kt} - \gamma_{ht} = A(x_t)^{(1-\alpha)}(\hat{k}_t)^{-(1-\alpha)} - (p^{E*} + \eta\chi_t)\frac{\chi_t}{\hat{k}_t} - c_{kt} \\ & \quad -B(1-x_t) - \lambda_t\chi_t + \xi_{Lt} \end{aligned} \tag{41}$$

The growth rate of x_t^M is:

$$\begin{aligned} \gamma_{xt}^{M} &= B(\frac{1-\alpha}{\alpha}) + \frac{1}{\alpha}\frac{\eta\lambda_t\chi_t^2}{p^{E*} + 2\eta\chi_t} + Bx_t - c_{k,t} - \lambda_t\chi_t \\ & \quad -(p^{E*} + \eta\chi_t)\frac{\chi_t}{\hat{k}_t} - (\frac{1-\alpha}{\alpha})\xi_{Lt} \end{aligned} \tag{42}$$

The steady state is defined when k_t, c_t and h_t grow at the same rate such that $\gamma_{kt} = \gamma_{ht} = \gamma_{ct}$, and when the wage differential, the human capital allocation ratio, x_t, the trade volume, χ_t, the physical-human capital ratio, k_t, the physical capital-consumption ratio, $c_{k,t}$ and the student returning rate, λ_t, are constant. Hence, we have:

$$\gamma_{\hat{k}t}^{M} = A(x)^{(1-\alpha)}(\hat{k})^{-(1-\alpha)} - (p^{E*} + \eta\chi)\frac{\chi}{\hat{k}} - c_k - B(1-x) + 1 - 2\lambda\chi = 0, \tag{43}$$

$$\begin{aligned} \gamma_{xt}^{M} = B\left(\frac{1-\alpha}{\alpha}\right) + \frac{1}{\alpha}\frac{\eta\lambda\chi^2}{\sigma + 2\eta\chi} + Bx - c_k - \lambda\chi - (p^{E*} + \eta\chi)\frac{\chi}{\hat{k}} \\ -\left(\frac{1-\alpha}{\alpha}\right)(1-\lambda)\chi = 0, \end{aligned} \tag{44}$$

and

$$\frac{A(1-\alpha)(\hat{k})^{\alpha}(x^M)^{-\alpha}}{B} = p^E = \frac{p^{E*}+2\eta\chi}{\lambda} \tag{45}$$

Recall from above that the student returning rate, λ, is regarded as a "semi-endogenous" variable in our model. It is endogenous to the wage gap, but the household has no direct control over it.[18] From the relationship specified in (45) we observe that skilled migration ($\lambda < 1$) implies a greater domestic price of education in *HOME*. A related implication is that the marginal product of human capital in the goods sector must rise. This is accomplished via the movement of human capital from the goods sector to the education sector. Emigration of foreign-educated students represents a deterioration in the terms of trade, and leads to the reallocation of *Home*'s resources towards the sector in which it has a comparative disadvantage, the education sector.

The wage gap between the two countries can be so large that $\lambda = 0$ and the price of imported education becomes infinite. We focus on the interior solution where $\lambda > 0$. In this case, the condition

$$w_t = A(1-\alpha)(x^M)^{-\alpha}(\hat{k}^M)^{\alpha} = \frac{B(p^{E*}+2\eta\chi)}{\lambda} \tag{46}$$

holds in equilibrium. Subtracting (44) from (43) produces:

$$A(\hat{k}^T)^{-(1-\alpha)}(x^M)^{(1-\alpha)} = \frac{B}{\alpha} + \frac{\lambda}{\alpha}\frac{\eta\chi^2}{p^{E*}+2\eta\chi} - \frac{1}{\alpha}(1-\lambda)\chi \tag{47}$$

Substituting (47) into (40) returns the steady state growth rate in the presence of trade in education and skilled migration:

$$\bar{\gamma}^M = \frac{1}{\theta}[B + \lambda\frac{\eta\chi^2}{p^{E*}+2\eta\chi} - (1-\lambda)\chi - \delta - \rho]. \tag{48}$$

[18]The household can forecast it perfectly, but must treat its response to conditions as exogenous in the optimising decision.

Equation (48) indicates that in the presence of skilled migration, the steady growth rate of the source country is clearly smaller than the steady state growth rate without skilled migration. In order to compare $\bar{\gamma}^M$ with the autarky growth rate, we subtract (14) from (48):

$$\bar{\gamma}^M - \bar{\gamma}^A = \lambda \frac{\eta\chi^2}{p^{E*} + 2\eta\chi} - (1-\lambda)\chi. \tag{49}$$

If (49) is negative, then the autarky growth rate is higher than the growth rate with trade and migration. Inspection of (49) reveals that it can become negative for sufficiently small values of λ, provided χ remains positive. Rather than rely on this observation with two endogenous variables, we would like to determine how the sign of $\bar{\gamma}^M - \bar{\gamma}^A$ depends upon the model's structural parameters.

Equation (45) links the domestic price and the international price of education via trade costs and the return rate. (46) translates these into the domestic wage. The foreign wage can be expressed as $w^* = B^* p^{E*}$. Substituting for w and w^* in (36), and substituting this expression for λ in (49) gives us a revised condition for slower-than-autarky growth:

$$\frac{\chi(B\eta\chi(\varsigma\chi+1) - B^* p^{E*} + B(p^{E*} + 2\eta\chi))}{B^* p^{E*} + B\varsigma\chi(p^{E*} + 2\eta\chi)} < 0. \tag{50}$$

Positive trade implies $\chi > 0$, and the denominator is positive. Thus, the condition in (50) will hold if the parenthetical expression in the numerator is negative. We can rearrange this term, and write the expression for slower-than-autarkic growth as:

$$\frac{B^*}{B} > \frac{\eta\chi(\varsigma\chi+1) + p^{E*} + 2\eta\chi}{p^{E*}}. \tag{51}$$

While the χ term is endogenous, it is bounded above by 1. All of the other values on the right hand side are exogenous (from the point of view of the developing country) and finite. Thus, (51) tells us that if B is sufficiently small, the country will experience slower growth with trade and migration than it would in autarky. This is notable because, in the absence of emigration, countries with low values of B would have the most to gain from trade in education.

5 Conclusion

Trade in education represents a sizable share of world services trade. Viewed in isolation, it seems likely that such trade facilitates human capital accumulation in education-importing countries, and is likely to increase the growth prospects of many developing nations. Much educational services trade is accomplished through temporary migration of students to host countries. It is quite likely that studying abroad facilitates emigration of developing country students to the host nation, and we explore this additional complication of education services trade.

We adapt a standard two-sector growth model and investigate the possible consequences of trade in education for developing country growth experiences. Our model assumes a technological disadvantage in the developing country's education sector. Importing educational services allows the country to acquire human capital more cheaply, and therefore grow at a faster rate. We take the existence of the developing country educational institutions, even when they have a technological disadvantage, as an important feature of the environment. In order to generate this feature in our model, we introduce increasing marginal trade costs, which we believe are plausible in this setting. The positive impact of trade on growth remains in this setting, though it is reduced by trade costs.

We next turn our attention to the possible link between trade and the emigration of students educated abroad. We adapt a standard treatment of emigration, and link it to the wage gap and the volume of imported education. Emigration acts as a terms of trade loss in our model; the developing country is unable to install all the human capital it purchases in this setting. Countries with sufficiently poor education technologies suffer most from skilled migration. If their education technology is sufficiently poor, these countries may rationally choose not to trade.

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