Unknown Talents and the Brain Drain:
The Informational Role of Migration

by

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Abstract

This paper shows that the migration of educated workers abroad can convey a positive signal about the ability of native talents. When there is uncertainty about the distribution of talents in the donor country and/or about the effectiveness of its education system, migrants may reveal information about their talents. This may enhance the reputation of the workforce both in the host country and in the donor country. The brain drain can thus act as an information device. The main possible consequences of the brain drain are: (i) higher investment in human capital by the younger generations; and (ii) higher investment in the domestic economy. The out-migration of talented people could be an essential condition for long-run growth in the donor economy.

Acknowledgments

1.   Introduction

The conventional wisdom on the brain drain typically argues that while donor countries incur the cost of educating people, it is the host country that reaps the rewards further exacerbating the inequality between rich and poor nations (see Bhagwati and Wilson, 1989, for a review). The loss of a significant mass of educated people from any given economy implies the reduction in average levels of productivity precisely because it is the most talented that are likely to migrate. Moreover, given that educated workers are likely to be on higher incomes, the erosion of a significant component to the tax base following migration has important welfare implications (Desai *et al,* 2001).

Grubel and Scott (1966) argued that the sectors from which educated people leave is crucial in assessing the impact of a brain drain. Losses in production depend on the degree of substitutability of skills and the length of time it takes to retrain someone to fill in the vacant post. In the UK it has been estimated that there are approximately 60,000 Indian doctors representing 12% of the total stock of doctors in India (Chanda, 2001). Such an outflow generates negative externalities as nurses and other related healthcare professionals also suffer declining levels of productivity. These losses are compounded by the lengthy training period for new doctors. Similar arguments have been made in other fields such as science, engineering and information technology. There is real concern in Russia, for example, that the next generation of graduates will not have access to the best teachers so that the quality of future research and innovation is likely to decline.

Both traditional models and the new growth models (see Barro and Sala-i-Martin, 1995) present a strong case for the net loss to the donor country which is particularly severe if the donor country is poor. The evidence suggests that whilst the brain drain is not a new phenomenon by any means, the number of educated people leaving developing countries is now much greater than in the 1960s and 1970s (see Carrington and Detragiache, 1999, for a comprehensive survey on migration rates). Although the emphasis in the immigration literature tends to focus on low-skilled and often illegal immigration, Lowell and Findlay (2001) suggest a greater degree of migration for skilled workers.

A key question is whether the migration of the most talented brings any benefits to the donor country. Mountford (1997) and Stark and Wong (2001) both argue that a brain drain in itself may not have adverse effects if it encourages more people to pursue an education. That is, as long as the number of people acquiring an education exceeds the number leaving there is no long-term loss to the donor economy. Indeed, there may be some optimal outflow of migrants that is necessary precisely for the development of human capital in the donor country (see Beine *et al*, 1999, for an empirical analysis of an optimal brain drain).

Moreover, some migrants may return and bring back crucial skills and experience acquired abroad. Johnson and Regets (1998) refer to this as a "brain circulation", which may result in increased average productivity in the donor country. Remittances

could also provide the means by which people can invest in technology thereby creating the potential for increased economic growth. However, the extent to which remittances can result in significant growth crucially hinges on whether they are used mostly for consumption or investment purposes. The evidence for developing countries is not promising in terms of investment levels (see Oberoi and Singh, 1980, and Taylor *et al*, 1996). Significantly, there has been no effective study of the remittance behaviour of the highly skilled. Moreover, remittance multipliers tend to be higher in rural areas, which are unlikely to be the main suppliers of a highly skilled labour force in most developing countries. Educated migrants tend to leave with their families, thereby reducing the likelihood to remit. However, when these people do remit, it tends to involve large amounts.

An important explanation for the brain drain lies in the very large wage differentials that exist between rich and poor countries, particularly for the highly skilled. However, in the absence of a well-defined modern sector in the donor economy, educated workers who remain may find that the only place of employment may effectively be the traditional sector, thus rendering redundant the costs of education they have borne. Migration, therefore, may represent an optimal choice for educated workers to exercise their skills in a modern sector. In the long run, this individually optimal decision may not necessarily have an adverse effect on the home economy.

This paper presents a departure from the traditional analysis of the brain drain by considering the *informational role* of migration. The emigration of educated workers can convey a positive signal about the ability of native talents and thus stimulate domestic investment. If there is uncertainty over the distribution of talents in the donor country and/or there is imperfect information on the effectiveness of the educational system, then workers who migrate may reveal information about their talents through their productivity in the host country. Not only is the reputation of the workforce in the host country enhanced if migrants do well but, importantly, the donor country also has information on the quality of its own talent.

In this paper we develop a two-period signalling model where talents are heterogeneous and where there is uncertainty over the distribution of talents and worker productivity. There are two possible technologies: traditional and modern. The donor country has a traditional sector in period one, but could have a modern sector in period two. The host country presents a modern sector in both periods. Workers in the donor country can invest in human capital, which increases their productivity in the modern sector. Individuals have private information about their talent, but face uncertainty about the effectiveness of their investment in education. Migration to the modern sector of the host economy reduces this uncertainty. The brain drain thus acts as an important *information device*.

This informational role of the brain drain has two main possible consequences:

(i)   Higher investment in human capital by the younger generations. If the second-generation workforce observes that the older migrants have done well in the host country, this may increase the incentives of the talented young to invest in education;

(ii)   Higher investment in the domestic economy. The success of the older generation abroad may provide the necessary impetus in the donor country to invest in the creation of its own modern sector once the distribution of talents has been revealed.

Our analysis proceeds by considering the conditions under which a brain drain may result in the creation of a modern sector in the donor country. Initially, we assume that a necessary condition for this is the return of some of the successful migrants. This can be justified on the grounds that these people have managerial and technological skills that can promote the more effective development of the modern sector. In effect, the first-period brain drain is necessary precisely because it allows for crucial *technology transfers* from the advanced host economy to take place (see also Saxenian, 2000).

The creation of a modern sector requires a significant proportion of those that stay to invest in education and effectively provide the necessary rewards that make it possible for some proportion of the first wave of migrants to return. However, given the existence of the large wage differentials between developed and developing countries, the assumption of return migration is relaxed. In section 5 we develop an autarkic model where the success of the first-generation educated migrants is a powerful enough signal on its own to promote the development of a modern sector in the donor economy.

Migration can relay important information about the *quality of talents* in the donor country and a brain drain, under certain conditions, could be necessary for the long-run development of the donor economy.

2.   Migration as an information device

Our model considers a two-period, one-good world with two sectors. The sectors differ in the technology they use: a modern sector ("IT"), that requires managerial input and has higher productivity, and a traditional sector. Agents differ according to their individual level of ability, or talent. Individual talent is exogenous and private information. Agents can decide whether to invest in education. Education increases individual productivity in the modern sector but not in the traditional sector. Productivity in the modern sector is a stochastic function of education. When workers migrate, their productivity may reveal information about the distribution of ability in their country of origin. Migration thus acts as a *signalling device* for the ability of educated workers.

In the first period there is no modern sector in the home, or source, economy. Workers must decide whether or not to invest in their human capital, and whether to remain in their home country or to migrate in the destination economy and search for a job in the modern sector. The potential productivity of migrant workers in the modern sector of the destination economy is not known *ex ante*. However, if they find employment in the modern sector, a more precise measure of their actual productivity will be

observed, and they will be paid their estimated marginal product. If migrants are unable to find a job in the modern sector of the economy, they will receive an income from being employed in the informal labour market. The informal income will be an increasing function of individual talent.

In the second period it becomes possible to set up a modern sector in the home economy, if first-period migration has revealed a high level of productivity amongst educated migrants. The set-up costs for a modern sector must cover the reward for the necessary managerial skills that only first-generation educated migrants possess. Second-generation workers can still decide to migrate from the home to the destination economy, but now successful first-generation migrants can return migrate and find employment, in a managerial capacity, in the modern sector of the domestic economy.

Workers in the home economy are characterised by an individual ability parameter $\theta \in [0,1]$ (their "talent"). Workers decide whether to invest in their human capital, h. For simplicity, we assume that human capital can only take the values $\{0, 1\}$, where $h = 1$ means that the worker has invested in his/her human capital and has thereby attained a given level of education. Investing in human capital incurs a cost $c(\theta) > 0$, where $c'(\theta) < 0$, $c''(\theta) > 0$. More talented workers find it cheaper to acquire human capital, but at a decreasing rate.

Effectively, education h captures the *observable* characteristics of workers, whereas talent θ captures their *unobservable* characteristics. In principle, the model could be generalized to consider a hierarchy of educational attainments, where h can take more than two values. Our main results would still be robust to such an extension.

If workers invest in their education (that is, if $h = 1$), their productivity in the destination and in the home economy is a realization from a jointly normally distributed random variable:

$$(1) \qquad \begin{bmatrix} \pi^D \\ \pi^H \end{bmatrix} \sim N\left(\begin{bmatrix} \mu^D \\ \mu^H \end{bmatrix}, \begin{bmatrix} \sigma^2 & \sigma_{DH} \\ \sigma_{DH} & \sigma^2 \end{bmatrix} \right)$$

where $\mu^D > \mu^H$ (the expected productivity of skilled workers in the destination economy is higher than in the home economy) and where $\sigma_{DH} > 0$ (the realizations of productivity in the destination and in the home economy are positively correlated). The expected values μ^D and μ^H are also the best prior (unconditional) predictions for the true productivity values π^D and π^H respectively, before migration is undertaken.

We assume the variances of π^D and π^H to be identical. In principle, there is no obvious reason for assuming that either variance is greater. It is possible to argue that the variance of π^D is likely to be greater that the variance of π^H since $\mu^D > \mu^H$ is also likely to be associated to a larger variability of π^D. On the other hand, the realization of productivity in the modern sector in the home economy can be regarded as involving greater uncertainty than in the destination economy, since the modern sector

in the donor country has to be created *ex novo*. The analysis can however be generalized without difficulty to the case of unequal variances.

If workers do not migrate, they are employed in the traditional sector of the home economy. In this case their productivity is given by $\phi > 0$, irrespective of their ability θ. However, if workers migrate and find employment in the modern sector, both workers and firms would observe a noisy measure of productivity, x^D:

(2) $$x^D = \pi^D + z^D$$

where z^D is a stochastic disturbance, distributed independently of π^D and of π^H: $z^D \sim N(0, \sigma_z^2)$.

Workers and firms in the modern sector of the host economy face a signal extraction problem that can intuitively be explained as follows. *Ex ante*, workers have some perceptions about their productivity in the modern sector abroad. *Ex post*, the value of the realised measure of productivity may not exactly match the *ex ante* perceptions of productivity. In other words, at the end of the first period a worker in the modern sector will have revealed a measure of her productivity. The gap between this measure and the *ex ante* perception constitutes the noise. The variability of the noise can be seen as a measure of the uncertainty associated with their employability overseas. Once employed, more information is revealed about the potential productivity of workers and the estimate of productivity is revised. The signal may be more accurate in successive periods as more of the uncertainty is resolved *vis à vis* worker productivity in the modern sector.

The advantage of this framework is that any potential anomalies in any one signal are corrected over time. Suppose that a worker goes abroad, does well and is paid the value of his realised productivity. This may reveal some information about the quality of workers that come from the home country but the success of the first generation of workers may not in itself be sufficient to signal the true quality of the educational system. Over time, the signal improves and more precise inferences can be made on the quality of workers. Simply, an erratic signal of productivity, which is significantly different from the true underlying productivity, in any one period will be offset by other signals that are more accurate indicators of productivity. In subsequent periods, realised productivity may be significantly higher or lower than in the first period and so the quality of the signal becomes more reliable over time. This allows us to extract information about the true nature of productivity as the sequence of signals becomes less subject to noise.

Moreover, productivity in the modern sector at home is positively correlated with productivity in the modern sector abroad. The justification for this is that if workers fare well abroad then they are equally likely to do well at home if a modern sector was present.

The solutions to the signal extraction problems for firms and workers are:

(3) $$E(\pi^D \mid x^D) = \mu^D + \frac{1}{1+v_z}(x^D - \mu^D) = \frac{v_z}{1+v_z}\mu^D + \frac{1}{1+v_z}x^D$$

(4) $$E(\pi^H \mid x^D) = \mu^H + \frac{\rho}{1+v_z}(x^D - \mu^D)$$

where $v_z \equiv \sigma_z^2 / \sigma^2$ is a measure of the relative imprecision of observed productivity x^D as a signal of true productivity, π^D, and where $\rho \equiv \sigma_{DH}/\sigma^2$ is the correlation coefficient between π^D and π^H. Equations (3) and (4) can be regarded as updating rules, whereby the prior expectations on π^D and π^H are revised in the light of the observed signal x^D by a fraction of the difference between the signal and the prior expectations.

Migrant workers unable to find employment in the modern sector will earn an income $\beta = \beta(\theta)$ in the informal sector, where $\beta : [0,1] \rightarrow [\underline{\beta}, \overline{\beta}]$ is an increasing function of individual talent: $\beta'(\theta) > 0$, $\beta''(\theta) < 0$, and where $0 < \underline{\beta} < \overline{\beta} < \phi$. The unemployment rate in the destination economy is $u \in [0,1]$. The costs of outward migration and of return migration are $I > 0$ and $E > 0$ respectively.

The set-up costs of a modern sector in the home economy consist of two components. First, a cost S per worker. This amount includes the variable costs associated with the creation of a domestic modern sector. Second, a cost $K^* = nK$, where n is the number of workers in the modern sector (excluding educated workers who return from the destination economy). The amount K^* goes to remunerate those return migrants, m, who have been successful and are able to supply the necessary managerial skills. The remuneration per returning migrant is therefore $K^*/m=nK/m$.

Workers are risk neutral and maximize the undiscounted expected income from the alternative choices available to them.

3. The education and migration decisions

In order to establish the condition for first- and second-generation workers to invest in education, we compute their value of acquiring education. The payoffs corresponding to the final outcomes are shown in the Appendix. The value to first-generation workers of investing in their education is given by:

(5) $$V_{h=1}^0 = \max\left\{(1-u)\cdot\max\left[2\mu^D - I, \mu^D - I + \mu^H + \frac{nK}{m} - S - E\right] + \right.$$

$$\left. + u\cdot[2\beta(\theta) - I]\phi + \mu^H - K - S, 2\phi\right\} - c(\theta)$$

This value is an increasing function of talent θ, since $c'(\theta)<0$ and $\beta'(\theta)>0$.

The value of not investing in education is:

(6) $$V_{h=0}^0 = \max\{2\beta(\theta) - I, 2\phi\}$$

This is a non-decreasing function of θ, since $\beta'(\theta) > 0$. We have that $\partial V_{h=1}^0 / \partial \theta > \partial V_{h=0}^0 / \partial \theta$ provided $|c'(\theta)| > \beta'(\theta)$, $\forall \theta \in [0,1]$, that is, the advantage of more talented workers in terms of a marginal reduction in their education costs exceeds the marginal increase in their informal sector income. There could therefore exist a critical value of talent, $\hat{\theta}$, such that $V_{h=1}^0 \geq V_{h=0}^0$ if and only if $\hat{\theta} \leq \theta \leq 1$: only the most talented first-generation workers will find it optimal to acquire education.

Educated first-generation workers will migrate if the following condition holds:

(7) $$\left\{(1-u) \cdot \max\left[2\mu^D, \mu^D + \mu^H + \frac{nK}{m} - S - E\right] + u \cdot 2\beta(\theta)\right\} - I \geq$$

$$\geq \max\{\phi + \mu^H - K - S, 2\phi\}$$

The left-hand side of condition (7) is an increasing function of talent θ. Hence, only the most talented amongst the educated workers will choose to migrate.

Second-generation workers will acquire an education if the value of doing so exceeds the value of not investing in education. The value to young workers of investing in education is given by:

(8) $$V_{h=1}^1 = \max\left\{(1-u) \cdot \left[\mu^D + \frac{1}{1+v_z}(x^D - \mu^D) - I\right] + u \cdot [\beta(\theta) - I],\right.$$

$$\left.\mu^H + \frac{\rho}{1+v_z}(x^D - \mu^D) - K - S, \phi\right\} - c(\theta)$$

Young workers who have acquired an education may choose to migrate or remain in the home economy. Among those that migrate, some will find employment in the modern sector, with probability $1 - u$, and others will end up in the informal sector, with probability u. Those educated second-generation workers who remain can either help set up a modern sector or they can choose to work in the traditional sector. Equation (8) thus captures the choices faced by second-generation workers who decide to invest in education.

For second-generation workers the estimated productivity incorporates the signal revealed by first-generation migrants, x^D. It can be seen from equation (8) that the respective weights attached to the estimated productivities for both those who migrate and those who stay depend on the precision of the signal. However, for those that stay the informational content of the signal is discounted by the correlation coefficient ρ.

More precisely, as we would expect, the signal for migrants who work in the modern sector abroad is stronger than for workers who remain and work in the domestic modern sector. This is because the signal imparts information directly on π^D, but only indirectly on π^H through ρ.

The value of not investing in education is:

(9) $\qquad V_{h=0}^1 = \max\{\beta(\theta) - I, \phi\}$

The value of investing in education is an increasing function of talent θ, whereas the value of not-investing in education is a non-decreasing function of θ. As for first-generation workers, $\partial V_{h=1}^1 / \partial \theta > \partial V_{h=0}^1 / \partial \theta$ provided $|c'(\theta)| > \beta'(\theta)$, $\forall \theta \in [0,1]$. Hence, only the most talented second-generation workers will acquire education.

Educated second-generation workers will migrate to the destination country if the following condition is met:

(10) $\qquad (1-u) \cdot \left[\mu^D + \dfrac{1}{1+v_z}(x^D - \mu^D) \right] + u \cdot \beta(\theta) - I \geq$

$$\geq \max\left[\mu^H + \dfrac{\rho}{1+v_z}(x^D - \mu^D) - K - S, \phi \right]$$

Note that the left-hand side of condition (10) is an increasing function of talent θ. Hence, one possible outcome is that second-generation workers with the highest level of talent will acquire an education and migrate, those with an intermediate level of talent will acquire an education but seek to work in the modern sector of the home economy, and the least talented ones will not invest in their education. In the discussion that follows, we elect to focus on this outcome. Other possible outcomes might involve no investment in education, or that all educated workers find it optimal to migrate.

4.   The domestic modern sector: Nash Equilibrium

The creation of a modern sector in the domestic economy requires: (i) the existence of educated return migrants with experience in a modern sector abroad; and (ii) a critical number of educated workers from the domestic economy who are first-generation educated workers who did not migrate and/or second generation educated whose θ is not sufficiently high to warrant migration. The strategy of each group of workers must be the optimal response to the strategy chosen by the other groups. Thus, a Nash equilibrium is required for the presence of a modern sector in the domestic economy. This requires that $m > 0$, that is, the number of return migrants is strictly positive, and $n > 0$, that is, the number of non-managerial workers in the modern sector in the home economy is strictly positive.

For *m* > 0 it is required that:

$$(11) \qquad \mu^H + \frac{nK}{m} - S - E \geq \mu^D + \frac{1-\rho}{1+v_z}(x^D - \mu^D)$$

Condition (11) is independent of θ. This means that the number of returning migrants is independent of individual talent: thus, either all successful first-generation migrants will return or nobody returns. This result rests on our initial assumption that productivity is only a function of education, and not of individual talent. Whilst the cost of acquiring an education does depend on talent, the eventual outcome in terms of productivity does not. However, the model could be generalised to consider various levels of educational attainment, in which case some successful first-generation migrants will return and some will remain in the destination country.

From condition (11), if $x^D > \mu^D$ this implies a high realization of measured productivity compared to the *ex ante* expectation. Return migration is then *ceteris paribus* more likely when ρ is high, that is when the signal on π^D is highly correlated with π^H. Intuitively, this indicates that a skilled migrant who is highly productive abroad is likely to be highly productive at home as well. In addition, if the signal has poor informational content on π^D, that is when v_z is large, return migration is also more likely. That is, the revision of estimated productivity will be larger, in absolute value, for the productivity in the destination economy than in the home economy.

The condition for $n_1 > 0$ is:

$$(12) \qquad \mu^H + \frac{\rho}{1+v_z}(x^D - \mu^D) - K - S \geq \phi$$

that is, educated first-generation workers must prefer to work in the modern sector in the domestic economy in the second period rather than remaining in the traditional sector.

The joint conditions for $n_2 > 0$ are (12) and:

$$(13) \qquad \mu^H + \frac{\rho}{1+v_z}(x^D - \mu^D) - K - S \geq$$

$$\geq (1-u)\left[\mu^D + \frac{1}{1+v_z}(x^D - \mu^D)\right] + u \cdot \beta(\theta) - I$$

Condition (13) requires that educated second-generation workers prefer to be employed in the modern sector of the home economy as opposed to migrating.

Note that, from the above conditions, $n_2 > 0$ implies $n_1 > 0$. No educated second-generation worker will choose to work in the domestic sector of the home economy,

unless educated first-generation workers who had not migrated also choose to work in the modern sector rather than in the traditional sector of the domestic economy. However, $n_1 > 0$ does not imply $n_2 > 0$. The joint conditions on n_1 and on n_2 determine the size of the modern sector in the home economy, if indeed a modern sector is established.

Under the Nash equilibrium we define the conditions for a modern sector to be created in the home economy. A necessary condition is the return of first-generation successful migrants, alongside a sufficient number of educated second-generation workers and of first-generation educated non-migrants. The accuracy of the signal,` together with the actual value of the signal, matters in the decision of whether first-generation migrants return.

5.   The autarkic economy

The analysis in the previous sections maintains that return migration is a necessary condition for the establishment of a modern sector in the source economy. The justification for this approach is the consideration that successful migrants can play a crucial role in the diffusion of technological knowledge and of production methods in their country of origin. As a result, they receive a premium relative to the workers who have not been exposed to the migration experience.

However, the assumption that some workers return to their home economy is not in general necessary in order to obtain an informational role for migration. The present section explores the conditions under which a modern sector can be established, in a purely autarkic fashion, without the requirement that older workers who have been successful abroad migrate back to their country of origin. Even though return migration is not a necessary condition here, the quality of the signal on realized productivity of the first-generation modern sector migrants is important in relaying information on expected productivity in the modern sector in the home economy. The correlation coefficient ρ plays an important role in that a high productivity abroad will be highly correlated with high productivity at home. This could be seen as a critical measure of the likelihood of success of a domestic modern sector.

The main assumptions for this section are:

(i)   no return migration;

(ii)   first-period migrants obtain a signal x^D on their productivity, which conveys information on π^H;

(iii)   the set-up costs for a domestic modern sector are given by S: they consist of the variable costs borne by all workers in the modern sector in the domestic economy.

A modern sector in the home economy is viable if and only if $n \equiv n_1 + n_2 > 0$. Similarly to the analysis in the previous section, we examine the conditions under which the creation of the home modern sector is a Nash Equilibrium for an autarkic economy. For $n_1 > 0$ we have:

$$(14) \qquad \mu^H + \frac{\rho}{1+v_z}(x^D - \mu^D) - S \geq \phi$$

Condition (14) can be compared to (12). The two conditions are identical, apart for the absence of the managerial remuneration K in the left-hand side of (14).

For $n_2 > 0$ condition (14) must be satisfied, and in addition it must be:

$$(15) \qquad \mu^H + \frac{\rho}{1+v_z}(x^D - \mu^D) - S \geq$$

$$\geq (1-u)\left[\mu^D + \frac{1}{1+v_z}(x^D - \mu^D)\right] + u \cdot \beta(\theta) - I$$

Finally, for $n_2 > 0$ we need second-generation workers to invest in their education, which requires:

$$(16) \qquad V_{h=1}^1 = \mu^H + \frac{\rho}{1+v_z}(x^D - \mu^D) - S - c(\theta) \geq$$

$$\geq \max\left[\beta(\theta) - I, \phi\right] \equiv V_{h=0}^1$$

Note that, as in section 5, $n_2 > 0$ implies $n_1 > 0$.

In the autarkic case the actual value of the signal need not be as high as in the economy with return migration, for the creation of a modern sector to be viable. This rests on the assumption that set-up costs and productivity in the home economy are the same with or without return migration. In principle, however, it is conceivable that, in the absence of return migration, there will be only limited technological transfers from the modern sector in the destination economy to the modern sector in the home economy. This could result in higher set-up costs and lower productivity in the autarkic case that in the case of return migration. The conditions under which the creation of a modern sector in the donor economy becomes viable may therefore be more stringent under autarky.

The role of migration is now purely one-dimensional – migration conveys information on the quality of talent in the home country that can make it possible to set up a domestic modern sector given the conditions defined above. In the case of return migration, the role of migration is significantly two-dimensional. As in the autarkic case, it conveys important information on domestic talent but in the event of a

domestic modern sector being created there are crucial technology transfers that take place. However, in both cases it is the informational role of migration and the quality of this signal that is critical to the development of a modern sector. Technology transfers whilst desirable are not a necessary condition for a modern sector to be created. However, we acknowledge that the skills and expertise brought back by migrants will impact on the competitive nature of the modern sector and its ultimate success.

6.   Conclusions

This paper shows how migration can act as the mechanism that reveals information on the quality of talent and of the educational system in a poor donor economy. Migration can thus play an important signalling role in the creation of a modern sector where no such sector was present. The informational effects from migration are two-fold. First, younger generations may have an increased incentive to invest in education following the success of first-generation migrants overseas. Second, the success of the first generation migrants may result in higher investment in the donor economy with the creation of a modern sector. Migration allows for the potential of the home talents to be revealed and it is this that may under some conditions allow for the set-up of a modern competitive sector.

Initially, we have assumed that a necessary condition for the creation of a modern sector is the return of successful first generation migrants. This assumption allows us to acknowledge the role of the managerial and technological skills which return migrants bring back after their experience abroad. These skills would not be available in the donor country. However, successful migrants may choose not to return in order to continue enjoying the typically higher wages abroad. Nonetheless, the success of these migrants still sends a strong enough signal on their own, without the need for return migrants, on the quality of talents in the source economy. Thus a modern sector can still be created, as the realised value of productivity in the destination economy in the first period is the condition that determines whether a modern sector is set up at all and indeed the size of this sector.

Our results show that a brain drain could be a necessary condition for the long-term development of an economy. In fact, without migration and the employment of some of these migrants in the host economy, information on the quality of talent in the donor economy would simply not be available. Migration acts as the very device that permits information on the educational system to be revealed. In the absence of migration, there would be no signal generated externally or internally to the donor economy.

Once the donor country has information on the distribution of talents then investment in education and in the development of non-traditional sectors may become an optimal strategy for long-term development. Our model gives rise to some important policy implications. First, for a developing country to "close" its borders to prevent a

brain drain may not be desirable for long-term growth. This is because migration imparts information on quality and if this information is missing or lacking then forcibly retaining the educated elite may prohibit the development of a competitive modern sector. Second, the success of migrants overseas encourages private investment in education. Younger generations are more willing to incur the costs of education. Third, the sectors in which first generation educated migrants are successful provides important information on where the donor country should divert investment. If, for example, first generation migrants are successful in the IT sector abroad, this could be seen as the signal whereby donor governments provide investment benefits for this or related sectors. We would then expect a trickle down effect whereby education tends to be geared to the provision of skilled labour to these sectors.

Not only does migration send a signal of quality to the donor country, but it also reveals information to the host economy. The modern sector here will be more inclined to hire future migrants but also may over time consider funding the set-up costs for the development and/or the expansion of a modern sector in the donor economy. Thus, migration can be of benefit to both host and donor economies.

Appendix

Expected payoffs for workers.

First-generation workers.

Workers who invest in education, migrate, are employed in the modern sector, and remain in the destination country:

(A1) $\qquad 2 \cdot \mu^D - c(\theta) - I$

Workers who invest in education, migrate, are employed in the modern sector, and return to the country of origin:

(A2) $\qquad \mu^D + \mu^H + \dfrac{nK}{m} - S - c(\theta) - I - E$

Workers who invest in education, migrate, and are employed in the informal sector:

(A3) $\qquad 2\beta(\theta) - c(\theta) - I$

Workers who invest in education, do not migrate, and work in the domestic modern sector in the second period:

(A4) $\qquad \phi - c(\theta) + \mu^H - K - S$

Workers who invest in education, do not migrate, and work in the traditional sector:

(A5) $\qquad 2\phi - c(\theta)$

Workers who do not invest in education and migrate:

(A6) $\qquad 2\beta(\theta) - I$

Workers who do not invest in education and do not migrate:

(A7) $\qquad 2\phi$

Second-generation workers.

Workers who invest in education, migrate, and are employed in the modern sector:

(A8) $\qquad \mu^D + \dfrac{\rho}{1+v}(x^D - \mu^D) - c(\theta) - I$

Workers who invest in education, migrate, and are employed in the informal sector:

(A9) $\qquad \beta(\theta) - c(\theta) - I$

Workers who invest in education, do not migrate, and work in the domestic modern sector:

(A10) $\qquad \mu^H + \dfrac{\rho}{1+v}(x^D - \mu^D) - c(\theta) - K - S$

Workers who invest in education, do not migrate, and work in the traditional sector:

(A11) $\qquad \phi - c(\theta)$

Workers who do not invest in education and migrate:

(A12) $\qquad \beta(\theta) - I$

Workers who do not invest in education and do not migrate:

(A13) $\qquad \phi$

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