Addition through Depletion: The Brain Drain as a Catalyst of Human Capital Formation and Economic Betterment

C. Simon Fan, Lingnan University
Oded Stark, University of Vienna; University of Bonn; and ESCE Economic and Social Research Center, Cologne and Eisenstadt

November 2002

Abstract

Enabling educated individuals to work abroad entails a brain drain and results in educated unemployment at home. Because the prospect of migration raises the expected returns to higher education it also facilitates a "brain gain": a developing economy ends up with a higher fraction of educated individuals. Due to the positive externality effect of the prevailing, economy-wide endowment of human capital on the formation of human capital, a relaxation of migration policy pursued in both the current period and the preceding period can greatly facilitate the "take-off" of a developing economy in the current period. Thus we identify a new policy tool that could yield an improvement in the well-being of the population of a developing economy: a controlled migration of educated workers.

Keywords: Brain drain; Human capital formation; Externalities; Economic growth; Social welfare

JEL classification: F22; H23; I30; J61; O40

1. Introduction

When the feasibility of migration entails a probability of migration, the brain drain script may have to be rewritten: compared to a closed economy, an economy open to migration differs not only in the opportunities that workers face but also in the incentives that they confront; higher prospective returns to human capital in a foreign country impinge favourably on human capital formation decisions at home. A related work (Stark and Wang, 2002) identified conditions under which the induced acquisition of human capital resulted in per-capita output in the home country that was higher than the per-capita output that would have been achieved in the absence of migration. This outcome arises (partly) because workers who do not end up as migrants work at home. But as they are equipped with the human capital acquired in response to their probable migration, they are more productive.

But suppose that workers who were not offered employment in a foreign country attempted to obtain such employment subsequently, and that this effort was incompatible with work at home. The prospect of migration to a foreign country by educated workers induces unemployment of such workers at home. The picture that emerges then looks quite bleak: educated workers leave, workers who otherwise would have worked are lured to form human capital only to end up unemployed, and output shrinks. The main and surprising result reported in this paper is that a closer scrutiny of the sequence of repercussions triggered by the prospect of migration invites portrayal of a starkly different panorama: the brain drain is accompanied by a "brain gain;" the ensuing "brain gain" can result in a higher average level of human capital in the home country; the higher average level of human capital can prompt a "take-off" of the economy; and the "take-off" can bite into the unemployment rate. Thus we depict a setting in which rather than being the culprit of human capital drain and output contraction, the migration of educated workers is the harbinger of human capital gain and output growth.[1] An analysis of the entire dynamics associated with the response of educated workers to the prospect of migration therefore raises the intriguing possibility that what, on first impression, appears to constitute a curse is, in fact, a blessing in disguise.

Our analysis builds on recent work by Stark, Helmenstein, and Prskawetz (1997, 1998) who point out that the prospect of migration increases the individual's incentive to accumulative human capital, on an inquiry that elucidates the role of migration of human capital from a country in reducing income inequality in the country (Mountford, 1997), and on a study that considers the migration of human capital from a country as a policy tool of enhancing welfare in the country (Stark and Wang, 2002). We also draw on the studies by Azariadis and Drazen (1990) and Galor and Stark (1994) that link the long-run growth in an economy's output with the average level of the economy's human capital. Our results are more dramatic than those reported early on because in our present framework the prospect of migration is taken to entail both depletion of human capital and unemployment of human capital, which stacks the cards more firmly against viewing migration as a catalyst of growth. And the possibility considered by Galor and Stark of highly educated migrants entering a developed economy, raising the average level of human capital in that economy, and pulling the economy toward a high per-capita locally stable steady-state equilibrium is unlikely to apply in the

[1] Thus we differ sharply from a view expressed in a recent World Bank paper: "There is no doubt that "brain drain" is, indeed, a serious problem ... because of its adverse growth effects." (Solimano, 2001).

case of a developing economy. Yet, in spite of the harsh setting, we show that the migration prospect (cum some actual migration) can yield a favourable outcome that would not have been achievable in the absence of the migration prospect.

The problem of the brain drain from developing countries has troubled development and trade economists for more than three decades now (Grubel and Scott (1966), Bhagwati and Wilson (1989)). The problem of unemployment of the educated in developing countries has bewildered development and labor economists at least since the early 1970s (Blaug (1970), ILO (1971)). The main reason why both the migration of educated workers and the unemployment of educated workers have caused considerable trepidation is quite simple: migration entails a contraction of the production possibilities frontier, unemployment entails location below the frontier. Output is less than what it could otherwise be. While the flight of human capital and the unemployment of human capital occupied the center stage of development economics at about the same time (the 1970s), analysts and policy makers did not make a causal connection between the two phenomena, except for noting that unemployment induced a desire to migrate. We start our analysis by considering a link: we incorporate the possibility that work in a foreign country for a wage higher than the wage for educated workers at home prompts workers to prefer unemployment to work. We show that such an unemployment would not have arisen in the absence of the migration possibility. We examine the human capital formation calculus of workers who are aware of the possibility that even after a repeated attempt to gain employment in the foreign country they will not end up working in that country, in which case they will accept employment in the home country. We derive conditions under which the home country's endowment of human capital and of human capital per worker is nonetheless higher.

This result prompts us to study the relationship between the growth of output in the home country and the average level of human capital in the home country. We show how, conditional on a careful choice of the probability of migration, an increase in the latter induces the former. Finally, we go the full length of the loop, demonstrating that consequent on the economy taking off, the rate of unemployment of the educated workers, to which we allude at the outset, declines. In conclusion, we cannot then reject the possibility that in the wake of and in spite of the migration of educated workers, the home country will end up locating at a point outside its initial production possibilities frontier.

The first part of the analysis demonstrates that in the short run, a policy of migration relaxation leads to a brain drain, educated unemployment, and possibly to a consequent reduction of per-capita output. The second part of the analysis reveals that in the longer run (one generation down the road), the legacy of the migration relaxation policy prompts a "take-off" of the economy. The results are derived in a framework of rational expectations equilibrium.

Our analytical predictions appear to be in line with evidence. For example, from 1960 to 1980, countries characterized by high rates of migration of skilled labor (such as India and Ireland) were among those countries that experienced the lowest rates of economic growth (Summers and Heston, 1991). However, since the late 1980s (that is, after approximately one generation), both India and Ireland have experienced fast economic growth, which to a large extent has been due to an expansion of their skill-intensive information technology sector.

2. Migration and unemployment of the educated

Consider a world that consists of two countries: Home, H, and Foreign, F. Country H is developing and is poorer than the developed country F. Due to a policy of selective migration by F, only educated individuals (say university graduates) of H have a chance of working in, hence migrating to, F.

We first analyze the behavior of the Home country's educated individuals. We subsequently analyze the decision to acquire education.

2.1. The choices of educated individuals

In this subsection we assume that everyone in H is educated. The decision-making process of an educated individual is illustrated by the following decision tree:

Figure 1 is here

Thus, an educated individual makes decisions in (at most) 3 stages:[2]

(1) The first stage. When an individual graduates from a university, the individual participates in a draw that results in probable work in F. If the individual obtains a winning ticket, his income will be

$$w^f \ .$$

The probability of being selected into work in F is

$$p \ .$$

[2] We assume that relative to the duration of the individual's working life, the duration of the 3 stages is short.

(2) The second stage. (Note that there is no second stage for individuals who win the draw.) A person who graduates and fails to secure work in F faces the following choices: to work or to wait for another draw. Waiting for another draw frees time to fill in applications for work in F. Alternatively, if the individual were to work, little time (and energy) would be available for preparing applications and, in addition, the individual's academic qualifications could depreciate, thereby lowering the probability of being picked up for work in F.[3]

For simplicity, we assume that if the individual works, he cannot participate in any additional draw so that his probability of ending up working in F is zero. If the individual does not work and awaits another draw, his chances of going abroad are

$$p' \ .$$

(3) The third stage. (Note that the third stage only applies to those who waited for another draw in the second stage.) If an individual wins this draw, he will go abroad. Otherwise, he will work at home, receiving the home country's mean wage rate.

The job offers in the second and the third stage follow an independently identical distribution. The cumulative distribution function of the wage offer, $\widetilde{w}$, is

[3]The assumption that the chances of finding a (new) job when the individual does not take a job but instead concentrates on searching are much higher than when the person conducts a search while already working is fundamental to the literature on job search and the natural rate of unemployment (see, for example, Mortensen (1986)). Schaafsma and Sweetman (2001) demonstrate that "working experience in the source country yields virtually no return in the host country."

$F(\bullet)$. We assume that $F(\bullet)$ is differentiable. We also assume that

$$\widetilde{w} \in [w^l, w^h]$$

and that the density function, $dF(w) \equiv F'(w)$, is strictly positive in its domain, that is

$$F'(w) > 0 \quad \forall w \in [w^l, w^h] \ .$$

The expected income of the (risk-neutral) individuals in the third stage is

$$(1-p')\overline{w} + p'w^f \tag{2.1}$$

where $\overline{w}$ is the mean wage of H, namely,

$$\overline{w} = \int_{w^l}^{w^h} w dF(w) \ .$$

In the second stage, if the individual receives a wage offer at H, w, he will accept it if and only if

$$w > \frac{1}{1+r}[(1-p')\overline{w} + p'w^f] \ , \tag{2.2}$$

where r is the individual's discount rate.

We define

$$w^c \equiv \frac{1}{1+r}[(1-p')\overline{w} + p'w^f] \ . \tag{2.3}$$

Then, the individual will accept the wage offer if and only if

$$w > w^c \ .$$

Further simplifying, we assume that[4]

$$w^l \geq \frac{1}{1+r}\overline{w} \ ; \tag{2.4}$$

[4]Although this assumption is not necessary, resorting to it highlights the notion that "educated unemployment" is caused by the prospect of migration.

educated unemployment will not exist in the absence of an additional possibility of migration (that is, when $p' = 0$).

Then, the fraction of the educated who are unemployed is

$$u \equiv P(\tilde{w} \leq w^c) = F(w^c) \ . \tag{2.5}$$

Clearly,

$$\begin{aligned} \frac{du}{dp'} &= \frac{du}{dw^c}\frac{dw^c}{dp'} \\ &= F'\frac{(w^f - \overline{w})}{1+r} \ . \end{aligned} \tag{2.6}$$

Since $F' > 0$,

$$\frac{du}{dp'} > 0 \ . \tag{2.7}$$

In addition, noting that $w^c \equiv \frac{1}{1+r}[\overline{w} + p'(w^f - \overline{w})]$,

$$\frac{du}{d(w^f - \overline{w})} = F'\frac{p'}{1+r} > 0 \ . \tag{2.8}$$

In summary, we have the following proposition.

Proposition 1: *(1) The unemployment rate of university graduates in a developing country will increase as the probability of migration rises. (2) The unemployment rate of university graduates in a developing country will increase as the wage gap between the developed country and the developing country increases.*

2.2. The choice of acquiring higher education

The benefit that education without migration confers is simply H's mean wage rate of educated workers

$$\overline{w} \ .$$

When migration is a possibility, the expected payoff from the three stages described in the preceding subsection is

$$\begin{aligned} V &\equiv pw^f + (1-p)\{\int_{w^c}^{w^h} wdF(w) + F(w^c)[p'w^f + (1-p')\overline{w}/(1+r)]\} \\ &= pw^f + (1-p)[\int_{w^c}^{w^h} wdF(w) + F(w^c)w^c] \\ &= pw^f + (1-p)[\int_{w^c}^{w^h} wF'(w)dw + F(w^c)w^c] \ . \end{aligned} \tag{2.9}$$

Clearly,

$$\begin{aligned} \frac{dV}{dw^f} &= p + (1-p)[-F'(w^c)w^c + F'(w^c)w^c + F(w^c)]\frac{dw^c}{dw^f} \\ &= p + (1-p)F(w^c)\frac{p'}{1+r} > 0 \ . \end{aligned} \tag{2.10}$$

Let us assume that

$$p' = p(1+\alpha) \tag{2.11}$$

where α is a fixed parameter. To ensure that $0 < p' < 1$, we assume that $-1 < \alpha < \frac{1}{p} - 1$.

Then,

$$\begin{aligned} \frac{dV}{dp} &= w^f - [\int_{w^c}^{w^h} wdF(w) + F(w^c)w^c] \\ &\quad +(1-p)[-F'(w^c)w^c + F'(w^c)w^c + F(w^c)]\frac{(w^f - \overline{w})(1+\alpha)}{1+r} \qquad (2.12) \\ &= w^f - [\int_{w^c}^{w^h} wdF(w) + F(w^c)w^c] + (1-p)F(w^c)\frac{(w^f - \overline{w})(1+\alpha)}{1+r} \ . \end{aligned}$$

We further assume that

$$w^f > w^h \ . \tag{2.13}$$

To rule out the unreasonable possibility that all the educated are unemployed, we assume that

$$w^c < w^h \ . \tag{2.14}$$

Then, we have that

$$\begin{aligned}
& \int_{w^c}^{w^h} wdF(w) + F(w^c)w^c \\
\leq & \int_{w^c}^{w^h} w^h dF(w) + F(w^c)w^h \\
= & \; w^h \int_{w^c}^{w^h} dF(w) + F(w^c)w^h \\
= & \; w^h(F(w^h) - F(w^c)) + F(w^c)w^h \\
= & \; w^h \; .
\end{aligned}$$

Therefore,

$$w^f > [\int_{w^c}^{w^h} wdF(w) + F(w^c)w^c] \; , \tag{2.15}$$

and it then follows from (2.12) that

$$\frac{dV}{dp} > 0 \; , \tag{2.16}$$

the benefit of acquiring a university education in H increases as the probability of migration rises.

We next incorporate the cost of acquiring education. Our idea is that individuals differ in their abilities and familial background, hence in their cost of acquiring education. We normalize the size of (pre-migration) population of H to be Lebesgue measure 1. Suppose that the individuals' cost of obtaining education, c, follows the following uniform distribution

$$\tilde{c} \in [0, \Omega] \; .$$

Recalling the assumption that only individuals with university degrees have any chance of migrating, an individual will choose to acquire a university education if and only if

$$V - c > \Phi \tag{2.17}$$

where Φ is the (lifetime) income of an uneducated individual, which is assumed to be a fixed parameter.

Let us define

$$c^* \equiv V - \Phi \ . \tag{2.18}$$

It follows that an individual will obtain a university education if and only if his cost of education maintains

$$c \leq c^* \ .$$

Since c follows a uniform distribution and the population size of the economy is of Lebesgue measure 1, both the proportion and the number of educated individuals are given by

$$\frac{c^*}{\Omega} \ . \tag{2.19}$$

Totally differentiating (2.19) with respect to c^* and p yields

$$\frac{d(c^*/\Omega)}{dp} = \frac{1}{\Omega}\frac{dV}{dp} > 0 \ , \tag{2.20}$$

where the inequality sign in (2.20) follows from (2.16). We thus have the following proposition.

Proposition 2: *The number of individuals undertaking university education will increase as the probability of migration rises.*

This proposition implies that while the prospect of migration causes the unemployment rate of educated individuals in the home country to increase (2.7), it also induces *more* individuals to acquire education (2.20). The end result may be an increase in the *number* of unemployed university graduates. Thus, Propositions 1 and 2 provide an explanation for the phenomenon of educated unemployment by linking it to migration.

3. Macroeconomic implications

3.1. A brain drain versus a "brain gain"

The following proposition shows that the "brain gain" caused by the prospect of migration may be larger than the loss from the brain drain.

Proposition 3: *There exists a positive level of* p *at which the number of university graduates in the developing country is higher than the number of university graduates in the developing country when* $p = 0$*, for any given* α*, if* $w^f > (3+\alpha)\overline{w}$.

Proof. We first note that c^* is a function of V and hence of p, so we define

$$c^* \equiv c(p) \; . \tag{3.1}$$

Then, under the migration prospect, the number of university graduates *remaining* in the developing country is

$$\begin{aligned} & \frac{c(p)}{\Omega} - [p\frac{c(p)}{\Omega} + (1-p)p'\frac{c(p)}{\Omega}] \\ = \; & c(p)[(1-p)(1-p(1+\alpha))]/\Omega \; . \end{aligned} \tag{3.2}$$

Let us define

$$\frac{K(p)}{\Omega} \equiv \frac{c(p)(1-p)[1-p(1+\alpha)]}{\Omega} - \frac{c(0)}{\Omega} \; ,$$

that is, $\frac{K(p)}{\Omega}$ is the difference between the number of educated individuals in the home country when $p > 0$, and the number of educated individuals in the home country when $p = 0$.

Since

$$K(p) \equiv c(p)(1-p)[1-p(1+\alpha)] - c(0) \ ,$$

we know that

$$K(0) = 0$$

and that

$$K'(p) = c'(p)(1-p)[1-p(1+\alpha)] - (2+\alpha-2(1+\alpha)p)c(p) \ .$$

We seek to show that $K'(0) > 0$, which, by the continuity of $K(p)$, will imply that $K(p) > K(0)$ in the small (positive) neighborhood of $p = 0$. Note that

$$K'(0) = c'(0) - (2+\alpha)c(0) > 0 \ .$$

When $p = 0$, we know from assumption (2.4) that $w^c = w^l$. Then, from the last line of (2.12) and upon noting that $F(w^l) = 0$, we get

$$\begin{aligned} \frac{dV}{dp}|_{p=0} &= w^f - [\int_{w^c}^{w^h} wdF(w) + F(w^c)w^c] + (1-p)F(w^c)\frac{(w^f-\overline{w})(1+\alpha)}{1+r} \\ &= w^f - [\int_{w^l}^{w^h} wdF(w) + F(w^l)w^l] + (1-p)F(w^l)\frac{(w^f-\overline{w})(1+\alpha)}{1+r} \\ &= w^f - \overline{w} \ . \end{aligned} \tag{3.3}$$

Then, from the equality in (2.20), we know that $\frac{dc^*}{dp} = \frac{dc(p)}{dp} = \frac{dV}{dp}$. Therefore,

$$\frac{dc(p)}{dp}|_{p=0} = c'(0) = \frac{dV}{dp}|_{p=0} = w^f - \overline{w} \ . \tag{3.4}$$

When $p = 0$, $V = \overline{w}$. Hence, from (2.18) and the definition $c^* = c(p)$

$$\begin{aligned} c(0) &= V - \Phi \\ &= \overline{w} - \Phi \ . \end{aligned} \tag{3.5}$$

Therefore, $K'(0) > 0$ if and only if

$$w^f - \overline{w} - (2+\alpha)(\overline{w} - \Phi) > 0 \ ,$$

that is, if and only if

$$w^f > (3+\alpha)\overline{w} - (2+\alpha)\Phi \ . \tag{3.6}$$

Since $\Phi > 0$, it follows that when $w^f > (3+\alpha)\overline{w}$, (3.6) will be satisfied, in which case we will have that $K'(0) > 0$. Hence, by the continuity of $K(p)$, we must have that $K(p) > K(0)$ in the small (positive) neighborhood of $p = 0$. ■

Proposition 3 shows that a developing country may end up with more university graduates despite the brain drain of university graduates.

Combining Propositions 1 and 3 yields the following corollary.

Corollary 1: *A positive level of educated unemployment in a developing country co-exists with a larger number of university graduates in the country than the number of university graduates in the country under no educated unemployment if* $w^f > (3+\alpha)\overline{w}$.

Since there are fewer individuals in the country under feasible migration, and since there are more educated individuals in the country under feasible migration, it must follow that the average level of human capital in the country is higher under migration than in the absence of migration. This higher level can play a critical role in determining long-run output growth, an issue to which we turn next.

3.2. The prospect of economic growth and welfare gain

In this section we will show that in the short run, relaxation of migration, which leads to a brain drain and to educated unemployment, could result in a reduction of per-capita output. Yet in the longer run (in the next generation), the legacy of a relaxed migration policy will prompt a "take-off" of the economy. The latter result will be derived in a framework of rational expectations equilibrium.

Our analysis draws on the work of Azariadis and Drazen (1990), who emphasize the role of a "threshold externality" in economic development.[5] They argue forcefully that the average level of human capital is a key factor for an economy's "take-off".[6] Specifically, we assume that

$$\text{wage of the educated in the home country} = \begin{cases} \beta\widetilde{w} & \text{if } e \geq e^c \\ \widetilde{w} & \text{if } e < e^c \end{cases}$$

where $\beta > 1$,[7] and e denotes the proportion of the educated in the home country. With labor being the only factor of production in the economy, an increase in the wage rate is tantamount to a "take-off" of the economy.

Since the number of individuals undertaking education is a function not only of the probability of migration, p, but also of the wage rate that awaits educated workers, we define

$$\xi = \begin{cases} \beta & \text{if } e \geq e^c \\ 1 & \text{if } e < e^c \end{cases}$$

[5] The assumption has been used widely in the literature (see, for example, Galor and Stark (1994) and Galor and Tsiddon (1996)). These usages follow, and are in congruence with, the pioneering study of Rosenstein-Rodan (1943).

[6] The concept and phenomenon of a "take-off" have been emphasized frequently in the development literature and are at the heart of many analyses by economic historians of the stages of economic growth (Rostow (1960)).

[7] The "big push" theory (for example, Murphy, Shleifer and Vishny (1989)) and the argument of a skill-induced technological change (for example, Acemoglu (1998)) both explain the endogenous determination of β.

and modify the notation $c(p)$, replacing it by $c(p,\xi)$. Note that the size of the population remaining in the home country, which we denote by $n(p,\xi)$, decreases when $p > 0$. Also, recall that to begin with, the size of the population of the economy is of Lebesgue measure 1. Then,

$$\begin{aligned} n(p,\xi) &= 1 - [p\frac{c(p,\xi)}{\Omega} + (1-p)p'\frac{c(p,\xi)}{\Omega}] \\ &= 1 - \frac{c(p,\xi)}{\Omega} + \frac{c(p,\xi)}{\Omega}(1-p)[1-p(1+\alpha)] \ . \end{aligned} \tag{3.7}$$

Recalling (3.2), the fraction of the educated individuals out of the population remaining in the home country is

$$e(p,\xi) \equiv \frac{c(p,\xi)(1-p)[1-p(1+\alpha)]}{n(p,\xi)\Omega} \ . \tag{3.8}$$

Then, a "take-off" of H can be sustained (or achieved) by a rational expectations equilibrium if and only if

$$e(p,\beta) > e^c \ . \tag{3.9}$$

If (3.9) can be satisfied by a careful choice of p, then a "take-off" can occur in the current period. Yet even if (3.9) cannot be satisfied in the current period, it may be satisfied in the next period upon a careful choice of p in the current period, which increases the number of educated parents of the individuals in the next period.[8]

In the following discussion we will use the subscript t to denote the current period, and the subscript $t+1$ to denote the next period.

[8]Since a larger β implies higher returns to education, we would expect $e(p,\beta)$ to be an increasing function of β. In addition, if $e(0,\beta) < e^c$, a careful choice of p (> 0) can reverse this inequality.

Resorting to an assumption which appears to have gained wide adherence - that the cost of acquiring education decreases with parental human capital (that is, the number of parents who have acquired a university education), we write

$$\frac{d\Omega_{t+1}}{de_t} < 0 \ . \tag{3.10}$$

The importance of parental human capital for an individual's educational attainment has been consistently confirmed in the empirical literature ever since the well-known Coleman report (Coleman et al (1966)).[9]

We are now in a position to state and prove the following proposition.

Proposition 4: *(1) If (3.9) cannot be satisfied so that a "take-off" does not occur in the current period, the prospect of migration entails a decline in the economy's per-capita output in the short run. (2) However, a careful choice of p in both the current period and the next period facilitates a "take-off" of the economy in the next period.*

Proof. (1) If a "take-off" does not occur in the current period, the prospect of migration will result in a loss of average (per-capita) output.

To facilitate a comparison between the case in which $p > 0$ and the case in which $p = 0$, we divide the individuals into three distinct categories (for the case in which $p > 0$):

(i) Individuals who do not acquire education;

(ii) Individuals who acquire education and fail to secure work abroad;

[9] For a helpful survey see Hanushek (1996).

(iii) Individuals who acquire education and migrate.

(i) Individuals of the first type do not acquire education when $p > 0$. From the analysis in the previous section we know that they would not have acquired education when $p = 0$. Thus, the prospect of migration has no impact on their (net) earnings which, in either case, are equal to the wage of the uneducated, Φ.

(ii) As to individuals of the second type, the prospect of migration results in some of them receiving lower net earnings than the earnings that they would have received when $p = 0$. This comes about through two channels: (a) The migration prospect prompts "too many" individuals to acquire education; (b) the migration prospect causes educated unemployment.

(a) Absent a migration prospect, the number of educated individuals is

$$\frac{c(0)}{\Omega} .$$

When $p > 0$, the number of educated individuals is

$$\frac{c(p)}{\Omega} .$$

In the presence of a migration prospect, the number of educated individuals remaining in the home country who have acquired a higher education "wrongly" is

$$[\frac{c(p)}{\Omega} - \frac{c(0)}{\Omega}](1 - p)[1 - p(1 + \alpha)] . \tag{3.11}$$

For these individuals, the cost of their education is in the domain

$$[c(0), c(p)] ,$$

and the distribution of that cost in this domain is uniform. Thus, the average cost of education for these individuals is

$$\frac{c(0)+c(p)}{2} \ . \tag{3.12}$$

The (expected) benefit of education (in comparison with no education) for any individual who remains in the home country is less than[10] or equal to

$$\overline{w} - \Phi \ .$$

(Since the number of individuals is a continuum, the expected value is equal to the average value.)

Thus, the average net loss per individual is not less than

$$\frac{c(0)+c(p)}{2} - (\overline{w} - \Phi) > 0 \ , \tag{3.13}$$

where the inequality in (3.13) arises from (3.5).

(b) From Assumption (2.4), no educated individual will choose to be unemployed in the absence of a migration prospect. Therefore, the (discounted) income of some of the educated individuals remaining in the home country would have been higher had they not chosen to be unemployed (in the sense of an *ex post* consideration). The number of these individuals is the fraction of the educated who are unemployed multiplied by the number of the educated who remain in the home country:

$$F(w^c)\frac{c(p)}{\Omega}(1-p)[1-p(1+\alpha)] \ . \tag{3.14}$$

[10]It can be less because some individuals may choose to become unemployed, yet the unemployment is *ex post* inefficient if they fail to go abroad.

If these individuals had worked rather than been unemployed, their average income would have been

$$\frac{w^l + w^c}{2} \ . \tag{3.15}$$

However, because they chose to wait, their expected earnings are

$$\frac{\overline{w}}{1+r} \ . \tag{3.16}$$

(Again, note that the number of individuals is a continuum, hence the expected value is equal to the average value.)

Thus, the average loss per individual is

$$\frac{w^l + w^c}{2} - \frac{\overline{w}}{1+r} > 0 \ , \tag{3.17}$$

where the inequality sign in (3.17) arises from (2.4).

The preceding discussion shows that for the set of individuals who remain in the home country when $p > 0$, that is, individuals of types (i) and (ii), some receive lower net earnings than when $p = 0$, while others receive the same net earnings. Thus, the average earnings of type (i) and type (ii) individuals when $p > 0$ are lower than when $p = 0$. We next show that the departure of educated individuals further reduces the average income.

(iii) Had $p = 0$, the type (iii) individuals who would have acquired an education as a fraction of the individuals who would have acquired education had $p > 0$ is

$$\frac{c(0)/\Omega}{c(p)/\Omega} = \frac{c(0)}{c(p)}$$

When $p = 0$, the average income of type (iii) individuals who would have acquired education, net of the education cost, would have been

$$\overline{w} - \frac{c(0)}{2} \ .$$

Recall that the earnings of the uneducated are Φ. Thus, when $p = 0$, the average income of individuals of type (iii) is

$$\frac{c(0)}{c(p)}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{c(p)}]\Phi \ . \tag{3.18}$$

When $p = 0$, the average income of all individuals is

$$\frac{c(0)}{\Omega}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{\Omega}]\Phi \ . \tag{3.19}$$

Because $\Omega > c(p)$, and $\overline{w} - \frac{c(0)}{2} > \overline{w} - c(0) = \Phi$ (recall (3.5)), we have that[11]

$$\begin{aligned} & \frac{c(0)}{c(p)}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{c(p)}]\Phi \\ > \ & \frac{c(0)}{\Omega}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{\Omega}]\Phi \ . \end{aligned}$$

Thus, the average income of the individuals whom the home country loses through migration would have been higher than the national average when $p = 0$. Thus, when $p = 0$, the average income of individuals of type (i) and type (ii) is lower than the average income of individuals of type (i), type (ii), and type (iii). Therefore, the loss of educated individuals through migration further reduces the average income in the economy.

(2) Note that from (3.8),

$$\frac{de_{t+1}(p_{t+1}, \xi)}{d\Omega_{t+1}} < 0 \tag{3.20}$$

for any given p_{t+1} and ξ. Since, recalling (3.10),

$$\frac{d\Omega_{t+1}}{de_t} < 0 \ ,$$

[11] Consider the function $\frac{c(0)}{x}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{x}]\Phi$. It can be shown easily that this function declines in x.

it follows that

$$\frac{de_{t+1}(p_{t+1}, \xi)}{de_t} > 0 \ . \tag{3.21}$$

Thus, when p_t is chosen in such a way that $p_t = p^o > 0$ and $e(p^o, 1) > e(0, 1)$, we have

$$e_{t+1}(p^*_{t+1}, \beta)|_{p_t = p^o} \geq e_{t+1}(p^{**}_{t+1}, \beta)|_{p_t = p^o} > e_{t+1}(p^{**}_{t+1}, \beta)|_{p_t = 0} \tag{3.22}$$

where the notation "$e_{t+1}(p^*_{t+1}, \beta)|_{p_t = p^o}$" means the fraction of the population remaining in the home country who are educated when $p_t = p^o$ and $p_{t+1} = p^*_{t+1}$, and where

$$p^*_{t+1} = \arg\max e_{t+1}(p_{t+1}, \beta)|_{p_t = p^o}$$

and

$$p^{**}_{t+1} = \arg\max e_{t+1}(p_{t+1}, \beta)|_{p_t = 0} \ .$$

Hence, when e^c is in the region

$$e_{t+1}(p^*_{t+1}, \beta)|_{p_t = p^o} > e^c > e_{t+1}(p^{**}_{t+1}, \beta)|_{p_t = 0} \tag{3.23}$$

a "take-off" is possible in period $t + 1$ in a framework of rational expectations equilibrium only if migration was allowed in the preceding period so that more parents chose to become educated. ■

Proposition 4 implies that a policy of migration relaxation in both periods is important for achieving the benefit of long-run growth.

Let us now examine the welfare implications of a "take-off" in the next period. From the proof of Proposition 4, recalling (3.19), we know that when $p = 0$, the average income of all the individuals is

$$\frac{c(0)}{\Omega}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{\Omega}]\Phi \ .$$

When $p > 0$, the number of educated individuals remaining in the home country is, recalling (3.2),

$$(1-p)[1-p(1+\alpha)]\frac{c(p)}{\Omega} ,$$

and the number of uneducated individuals is

$$1 - \frac{c(p)}{\Omega} .$$

Therefore, for all the individuals remaining in the home country, *if* no one had chosen to be unemployed, the total (net) income would have been

$$(1-p)(1-p(1+\alpha))\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi . \tag{3.24}$$

Furthermore, from (3.14), we know that the number of the individuals who become unemployed is

$$F(w^c)c(p)(1-p)[1-p(1+\alpha)]/\Omega .$$

The average income of these individuals, had they chosen to work rather than become unemployed, would have been

$$\frac{w^l + w^c}{2}$$

whereas their average income when choosing unemployment is, recalling (3.16),

$$\frac{\overline{w}}{1+r} .$$

Since the average net cost is, recalling (3.17),

$$\frac{w^l + w^c}{2} - \frac{\overline{w}}{1+r} ,$$

the total cost is

$$[\frac{w^l + w^c}{2} - \frac{\overline{w}}{1+r}]F(w^c)c(p)(1-p)(1-p(1+\alpha))/\Omega \ . \tag{3.25}$$

Thus, when $p > 0$, for all the individuals remaining in the home country, their total income (income if all were employed less the income lost due to unemployment) is equal to

$$\begin{aligned} &(1-p)(1-p(1+\alpha))\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi \\ &-[\frac{w^l + w^c}{2} - \frac{\overline{w}}{1+r}]F(w^c)c(p)(1-p)[1-p(1+\alpha)]/\Omega \ . \end{aligned} \tag{3.26}$$

For expositional simplicity, we define

$$\Gamma \equiv (1-p)(1-p(1+\alpha))$$

Note that since the entire population is normalized to be one, we must have that $\Gamma < 1$. Then, total income is

$$\begin{aligned} & \Gamma\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi - [\frac{w^l + w^c}{2} - \frac{\overline{w}}{1+r}]F(w^c)c(p)\Gamma/\Omega \\ \geq \ & \Gamma\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi - [\frac{w^l + w^h}{2} - \frac{\overline{w}}{1+r}]F(w^h)c(p)\Gamma/\Omega \\ = \ & \Gamma\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi - [\frac{w^l + w^h}{2} - \frac{\overline{w}}{1+r}]c(p)\Gamma/\Omega \\ = \ & \Gamma\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi - [\overline{w} - \frac{\overline{w}}{1+r}]c(p)\Gamma/\Omega \\ = \ & \Gamma\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi - \frac{r\overline{w}}{1+r}c(p)\Gamma/\Omega \ . \end{aligned} \tag{3.27}$$

Since the total number of the individuals remaining in the home country is Γ, their average net income is

$$\{\Gamma\frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi - \frac{r\overline{w}}{1+r}c(p)\Gamma/\Omega\}/\Gamma$$

$$
\begin{aligned}
&= \frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi/\Gamma - \frac{r\overline{w}}{1+r}c(p)/\Omega \\
&> \frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] + [1 - \frac{c(p)}{\Omega}]\Phi - \frac{r\overline{w}}{1+r}\frac{c(p)}{\Omega} \ . \qquad (3.28)
\end{aligned}
$$

When $p = 0$, the average income of all individuals is, recalling (3.19),

$$
\frac{c(0)}{\Omega}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{\Omega}]\Phi \ .
$$

Thus, the short-run loss in terms of average income arising from the migration prospect is less than

$$
\begin{aligned}
L &\equiv \frac{c(0)}{\Omega}[\overline{w} - \frac{c(0)}{2}] + [1 - \frac{c(0)}{\Omega}]\Phi - \frac{c(p)}{\Omega}[\overline{w} - \frac{c(p)}{2}] - [1 - \frac{c(p)}{\Omega}]\Phi + \frac{r\overline{w}}{1+r}\frac{c(p)}{\Omega} \\
&= \frac{(1+r)c(0) - c(p)}{(1+r)\Omega}\overline{w} + \frac{(c(p))^2 - (c(0))^2}{2\Omega} + \frac{\Phi}{\Omega}(c(p) - c(0)) \ . \qquad (3.29)
\end{aligned}
$$

Consider now the gain to the home country if a "take-off" occurs in the next period. We denote the choice of p in the next period, as described in part (2) of the proof of Proposition 4, by

$$
p^n
$$

Then, by a reasoning similar to that which yields (3.28), the average income of the economy is greater than

$$
\frac{c(p^n)}{\Omega'}[\beta\overline{w} - \frac{c(p^n)}{2}] + [1 - \frac{c(p^n)}{\Omega'}]\Phi - \frac{r\beta\overline{w}}{1+r}\frac{c(p^n)}{\Omega'} \ ,
$$

where Ω' is the maximal cost of education in the next period when $p > 0$ in the current period, and

$$
\Omega' < \Omega \ .
$$

The benefit, measured in terms of the average income in the next period arising from the prospect of migration less the average income that would have obtained in the absence of such a prospect, is greater than

$$\begin{aligned} G &\equiv \frac{c(p^n)}{\Omega'}[\beta\overline{w} - \frac{c(p^n)}{2}] + [1 - \frac{c(p^n)}{\Omega'}]\Phi - \frac{r\beta\overline{w}}{1+r}c(p^n)/\Omega' - \frac{c(0)}{\Omega}[\overline{w} - \frac{c(0)}{2}] - [1 - \frac{c(0)}{\Omega}]\Phi \\ &= [\frac{\beta c(p^n)}{(1+r)\Omega'} - \frac{c(0)}{\Omega}]\overline{w} - \frac{(c(p^n))^2}{2\Omega'} + \frac{(c(0))^2}{2\Omega} - \Phi(\frac{c(p^n)}{\Omega'} - \frac{c(0)}{\Omega}) \ . \qquad (3.30) \end{aligned}$$

Thus, the long-run gain is greater than the short-run loss if and only if

$$L + \rho G > 0 \qquad (3.31)$$

where ρ is the social discount rate across generations. Clearly, when β is large enough, for any given ρ, (3.31) will be satisfied. Thus, we have the following corollary.

Corollary 2: *If β is sufficiently large, migration of educated individuals will confer a welfare gain to the individuals remaining in the home country despite the phenomenon of educated unemployment.*

In addition, when a "take-off" occurs, we have the following proposition.

Proposition 5: *After a "take-off" occurs, the unemployment rate of the educated is lower than that prior to the "take-off".*

Proof. Prior to the "take-off", we know, following (2.3) and (2.5), that the unemployment rate of the educated is

$$u^b \equiv F(w^c) = F[\frac{(1-p')\overline{w}}{1+r} + \frac{p'w^f}{1+r}] \ . \qquad (3.32)$$

After the "take-off" occurs, the fraction of the educated who are unemployed is

$$u^a \equiv P(\beta\widetilde{w} \leq w^{cc}) = F(\frac{w^{cc}}{\beta}) \tag{3.33}$$

where w^{cc} is the equivalent of w^c in (2.3), that is,

$$w^{cc} \equiv \frac{1}{1+r}[(1-p')\beta\overline{w} + p'w^f] \ . \tag{3.34}$$

Thus,

$$\begin{aligned} u^a &= F(\frac{w^{cc}}{\beta}) \\ &= F(\frac{[(1-p')\beta\overline{w} + p'w^f]}{(1+r)\beta}) \\ &= F[\frac{(1-p')\overline{w}}{1+r} + \frac{p'w^f}{(1+r)\beta}] \ . \end{aligned} \tag{3.35}$$

Comparing (3.32) and (3.35) and noting that $\beta > 1$ and $F' > 0$, we have

$$u^b > u^a \ . \tag{3.36}$$

■

4. Conclusions

Since the late 1960s (Todaro, 1969), the literature of development economics has pointed to a stark connection between migration and unemployment: workers change their location, but not their productive attributes, in response to an expected wage at destination that is higher than their wage at origin only to end up unemployed and, at equilibrium, with no change in total wage earnings. Only the composition of the wage bill is altered. Unless added leisure is counted as an improvement, welfare, when measured by earnings per worker, remains unchanged.

While we too propose a connection between migration and unemployment, ours arises from a very different tale: workers are moving into unemployment *at origin* (that is, without changing location) in response to an expected wage at destination, workers *improve* their productive attributes and the earnings of both those who migrate and those who stay behind rise, albeit not necessarily in the short run. Welfare is higher.

At the heart of our analysis is the idea that allowing some individuals to work abroad implies not only a brain drain and educated unemployment at home, but also, because the migration prospect raises the expected returns to higher education, a "brain gain": the developing country ends up with a higher fraction of educated individuals. Indeed, the brain drain is a catalyst of the "brain gain". More importantly, due to the positive externality effect of the prevailing, economy-wide endowment of human capital on the formation of human capital, a relaxation of migration policy in both the current period and the preceding period can greatly facilitate the "take-off" of a developing economy in the current period. Thus, our analysis points to a new policy tool that could yield an improvement in the well-being of the population of a developing economy: a controlled migration of *educated* workers. Somewhat counterintuitively, it is the exit of human capital that sets in motion a process of acquisition of human capital which, in turn, may well lead to economic betterment for all.

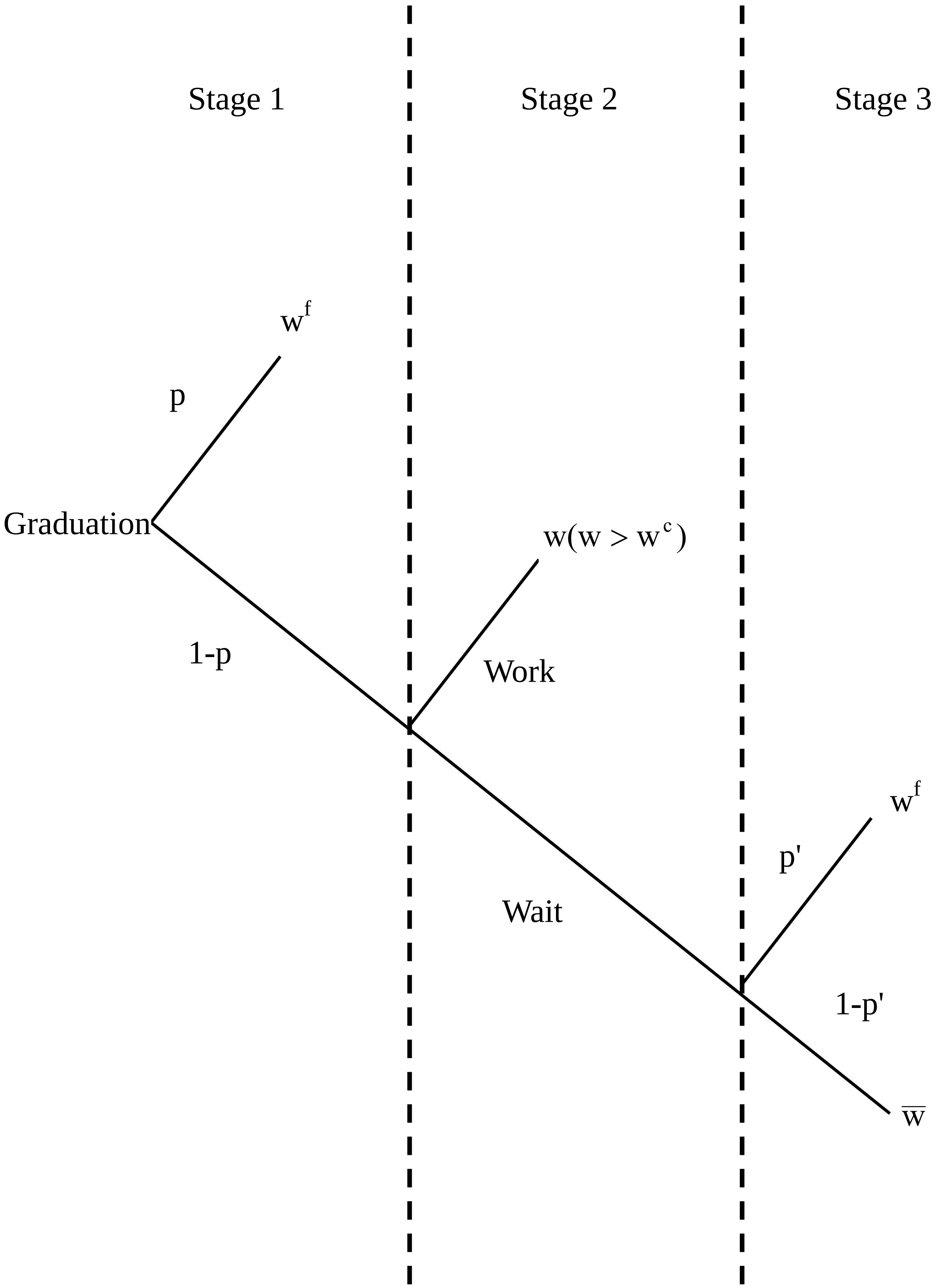

Figure 1: Stages in the decision-making process of an educated individual

References

[1] Acemoglu, Daron (1998) "Why Do New Technologies Complement Skills? Directed Technical Change and Wage Inequality," *Quarterly Journal of Economics*; 113(4): 1055-89.

[2] Azariadis, Costas and Drazen, Allan (1990) "Threshold Externalities in Economic Development," *Quarterly Journal of Economics*; 105(2): 501-526.

[3] Bhagwati, Jagdish and Wilson, John D. (1989) *Income Taxation and International Mobility*. Cambridge, MA: MIT Press.

[4] Blaug, Mark (1970) "The Unemployment of the Educated in India," in Blaug, Mark ed. *The Economics of Education*. London: Allen Lane.

[5] Coleman, James S. et al (1966) "Equality of Educational Opportunity," U.S., G P. O., Washington, D. C..

[6] Galor, Oded and Stark, Oded (1994), "Migration, Human Capital Formation, and Long-Run Output," in Siebert, Horst ed. *Migration: A Challenge for Europe*. Tübingen: Mohr.

[7] Galor, Oded and Tsiddon, Daniel (1996) "Income Distribution and Growth: The Kuznets Hypothesis Revisited," *Economica*, 63(250): S103-S117.

[8] Grubel, Herbert B. and Scott, Anthony D. (1966) "The International Flow of Human Capital," *American Economic Review*, 56: 268-274.

[9] Hanushek, Eric (1996) "Measuring Investment in Education," *Journal of Economic Perspectives*, 10(4): 9-30.

[10] International Labor Office (ILO) (1971) *Matching Employment Opportunities and Expectations: A Programme of Action for Ceylon*. Geneva: International Labor Office.

[11] Mountford, Andrew (1997) "Can a Brain Drain Be Good for Growth in the Source Economy?" *Journal of Development Economics*, 53(2): 287-303.

[12] Mortensen, Dale T. (1986) "Job Search and Labor Market Analysis," in Ashenfelter, Orley and Layard, Richard, eds. *Handbook of Labor Economics*, Amsterdam: North-Holland: 849-919.

[13] Murphy, Kevin, Shleifer, Andrei, and Vishny, Robert (1989) "Industrialization and the Big Push," *Journal of Political Economy*, 97(5): 1003-1026.

[14] Rosenstein-Rodan, Paul (1943), "Problems of Industrialisation of Eastern and Southern-Eastern Europe," *Economic Journal*, 53: 202-211.

[15] Rostow, Walt W. (1960) *The Stages of Economic Growth*, Cambridge: Cambridge University Press.

[16] Schaafsma, Joseph and Sweetman, Arthur (2001) "Immigrant Earnings: Age at Immigration Matters," *Canadian Journal of Economics*, 34(4): 1066-1099.

[17] Solimano, Andrés (2001) "International Migration and the Global Economic Order: An Overview," Washington, D. C.: The World Bank, mimeo.

[18] Stark, Oded, Helmenstein, Christian and Prskawetz, Alexia (1997) "A Brain Gain with a Brain Drain," *Economics Letters*, 55(2): 227-34.

[19] Stark, Oded, Helmenstein, Christian and Prskawetz, Alexia (1998) "Human Capital Depletion, Human Capital Formation, and Migration: A Blessing or a "Curse"?" *Economics Letters*, 60(3): 363-67.

[20] Stark, Oded and Wang, Yong (2002) "Inducing Human Capital Formation: Migration as a Substitute for Subsidies," *Journal of Public Economics*, 86(1): 29-46.

[21] Summers, Robert and Heston, Alan (1991) "The Penn World Table (Mark 5): An Expanded Set of International Comparisons, 1950-1988," *Quarterly Journal of Economics*, 106(2): 327-68.

[22] Todaro, Michael P. (1969) "A Model for Labor Migration and Urban Unemployment in Less Developed Countries," *American Economic Review*, 59(1): 138-148.