BRUSSELS ECONOMIC REVIEW - CAHIERS ECONOMIQUES DE BRUXELLES
VOL. 47 - N°1 SPRING 2004

BRAIN DRAIN AND REMITTANCES: IMPLICATIONS FOR THE SOURCE COUNTRY*

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ABSTRACT:

In this paper, we model a developing economy in which individual decisions about education and migration are constrained by capital market imperfections (liquidity constraints). We examine the joint impact of brain drain and international remittances on human capital accumulation in the emigration country. We derive the condition under which the emigration of the most talented workers stimulates the economy-wide average stock of human capital in the sending country (compared to the closed economy benchmark). Such a BBD outcome (beneficial brain drain) is obtained (i) when the return to education is high compared to the costs of education and migration and (ii) when remittances received by each young are important. Unlike recent papers in that literature, the BBD cannot be obtained if emigration rates are small.

JEL CLASSIFICATION: F22, J24, J61, J68.

KEYWORDS: skilled migration, immigration policy, human capital, growth.

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* We thank Michele Cincera, Hillel Rapoport, Abdeslam Marfouk and Mouna Aguir for useful comments. The usual disclaimer applies.

Introduction

This paper mixes two strands of the literature on international migration, i.e. the economics of international remittances and the economics of the brain drain. Our purpose is to analyze the effects of increasingly "quality-selective" immigration policies on human capital in the source countries when talented emigrants remit a part of their earnings. Clearly, the joint impact of brain drain and international remittances is ambiguous. On the one hand, international remittances increase *ceteris paribus* the welfare of remaining residents. On the other hand, the brain drain resulting from the quality selection is usually seen as a detrimental phenomenon for the sending country. We combine these two interrelated facts and examine their global impact on human capital formation.

Regarding international transfers, it is well documented that workers' remittances often make a significant contribution to GNP and are a major source of income in many developing countries. For labor-exporting countries such as Egypt, Pakistan, Turkey, Caribbean or Pacific countries, it is not uncommon to observe flows of remittances that equal about half the value of their exports or 10% of their GDP. These remittances may have a short-run macroeconomic impact through their effects on price or exchange rate levels (see Djajic, 1986). The long run implications of remittances are also likely to be significant. They impinge on households' decisions in terms of labor supply, investment, education, migration, occupational choice, fertility with potentially important aggregated effects[1]. This is especially the case in poor countries where capital market imperfections (liquidity constraints) reduce investment possibilities in low-income classes. Since dollars are fungible and education has a relatively high income-elasticity, one would expect remittances to have significant positive effects on the educational attainments of children from households with emigrants. Few studies have looked for - and found - clear evidence on this potential link between remittances and education. Hanson and Woodruff (2002) use the 2000 Mexican Census and show that children in households with a migrant member complete significantly more years of schooling, with an estimated increase that ranges from 0.7 to 1.6 years of schooling. Interestingly, the gain is the highest for the categories of children traditionally at risk of being dropped from school, i.e. girls and older children (13 to 15 year-olds). In their study on El Salvador, Cox Edwards and Ureta (2003) show that remittances significantly contribute to lower the hazard of leaving school.

Regarding brain drain, there is a fair amount of evidence suggesting that the brain drain is now much more extensive than, say, 25 years ago. Since 1984, Australia's immigration policy has officially privileged skilled workers, with the candidates selected according to their prospective "contribution to the Australian economy". The Canadian immigration policy follows along similar lines, resulting in an increasing share of highly educated people among the immigrants selected. In the US, the Immigration Act of

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[1] See Rapoport and Docquier (2003) for a survey.

1990 established the selection of highly skilled workers through a system favoring candidates with academic degrees and/or specific professional skills. Immigration policies in EU countries are less clear and still oriented towards traditional targets such as asylum seeking and family reunion. However, there is some evidence suggesting that European countries (such as Germany) are also leaning towards becoming quality-selective[2].

The classical literature on the economic impact of brain drain emphasizes that the welfare of those left behind would fall if migrants' contribution to the economy is greater than their marginal product (this is obviously the case when the social return to education exceeds its private return)[3]. However, recent studies suggest that migration prospects can boost human capital accumulation[4], or that some gain can be associated with imperfect information and return migration[5].

This paper belongs to the literature on the economic impact of brain drain for the source countries. We show that brain drain can boost the stock of human capital per capita when the resulting remittances are sufficiently high. To demonstrate this result, we build a simple theoretical supply-side model examining the enhancing effect of remittances on human capital formation.

Along the lines suggested by Perotti (1993), we consider that liquidity constraints impede educational investment and migration within the low and medium income classes. Since education is a prerequisite for migration, emigrants belongs to the most talented class (those who can afford paying for both education and migration costs). This assumption seems particularly realistic for developing countries. Such a brain drain has a negative direct impact on the stock of human capital per capita. Skilled emigrants then remit a part of the migration gains. There are evidence reveal that remittances increase with remitters' income. In the UK, Kangasmieni et al (2004) show that 45 percent of doctors send remittances to their home country (on average, these transfers amount to 16 percent of their income in the UK). In our framework, remittances enable some liquidity constrained agents to pay for education costs.

Our results reveal that the global effect of brain drain can be positive under some specific conditions. The return to education must be high, compared to the costs of education and migration, remittances received by each young must be high. Hence, unlike most recent papers on the beneficial effect of brain drain, a positive impact can be obtained if the number of skilled emigrants is sufficiently large.

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[2] See the contribution of Bauer and Kunze in this special issue.

[3] See Haque and Kim (1995) or Grubel and Scott (1996).

[4] See Mountford (1997), Vidal (1998), Beine et al (2001).

[5] See Stark et al. (1997).

The remainder of this paper is organized as follows. Section 1 presents our assumptions. The closed economy solution is briefly described in Section 2. The open economy equilibrium is characterized in Section 3. Then, Section 4 provides the conditions under which a beneficial brain drain is obtained. Finally, the last Section concludes.

1. Assumptions

Our model depicts a small developing economy with overlapping generations of households. Individuals live for two periods, youth and adulthood. At the beginning of their life, they decide whether to invest in education or not, by maximizing their life-cycle income. Education is modeled as a "take it or leave it" decision.

We introduce heterogeneity by considering that the inherited level of human capital of the young (denoted by y_i) is exogenously distributed on the domain $[0,\bar{y}]$. Low skill and high skill workers are perfect substitutes on the local labor market[6]. The wage rate per efficiency unit of human capital is constant and normalized to unity. Hence, y_i also measures individual's income.

For the sake of simplicity, we consider a stationary uniform density function:

$$y_{i,t} \rightarrow U(y) \equiv \frac{1}{\bar{y}} \qquad (1)$$

If he opts for education, each young agent faces a fixed cost y^e and expects to get a rate of return to education, R. The cost of educational service is fully borne privately. This hypothesis clearly holds in most developing countries. As in Perotti (1993), the return to education is higher than its cost for all individuals: $R>y^e$ (see assumption A1 below). However, liquidity constraints impede human capital investment within low-income classes. Individuals whose income is lower than the education cost cannot borrow to pay for human capital formation.

At the end of the first period of life, educated agents have the possibility to emigrate to a richer country at an exogenous migration cost y^m. As in Mountford (1999), Vidal (1999) and Beine et al. (2001), a central assumption of our model is that education is a necessary prerequisite for migration (emigrants are partly out-selected). However, we assume that education is also a sufficient condition. By migrating, educated agents sell their human capital at a higher price: they get a higher rate of return than in the domestic country ($R^*>R$). The return gap exceeds migration cost: migration always increases lifetime income (see assumption A2 below). However, liquidity constraints are impeding migration within middle income classes: agents cannot borrow to pay for migration costs (emigrants are partly self-selected).

Consequently, the effective migrants belong to the upper-income class of the population (those who can afford paying for education and migration costs). Our model thus reproduces the brain drain phenomenon.

Our purpose is to examine the effect of brain drain on the average level of human capital of remaining members. We do not formalize the externalities associated to human capital but consider them as a crucial by-product of our analysis. At this stage, brain drain is unambiguously detrimental for human capital accumulation. However, if we consider that migrants remit a constant fraction of their foreign wage, these remittances enable some liquidity-constrained agents to pay for the education cost in the source country: a higher share of the population has an access to human capital formation. This beneficial effect must then be compared to the detrimental effect sketched above.

For altruistic reasons that we do not explicitly formalize here, we consider that migrants remit a fraction θ of the return gap on human capital (R^*-R) to their origin country. This assumption is made for analytical convenience. Similar results would be obtained by assuming that migrants remit a constant fraction of their income. The source country is small and cannot influence the size of the return gap.

Young agents from generation t (young at time t) receive an amount of altruistic transfers τ_t from the previous generation of emigrants. We do not deal with intergenerational mobility in the ability scale and with endogenous differences in the amount transferred. For simplicity, we assume that each young receives an identical amount of remittances [7].

The decision to educate for agent i is denoted by a discrete variable e_{it} (e_{it}=1 denotes investing in education and e_{it}=0 denotes no access to education). Similarly, the decision to migrate is denoted by a discrete variable m_{it} (m_{it}=1 denotes opting for migration and m_{it}=0 denotes not to migrate). Individuals choose e_{it} and m_{it} so as to maximize lifetime income W(e_{it},m_{it}) subject to a non-negativity constraint on saving, i.e.

$$\begin{aligned} \underset{e_{it},m_{it}}{Max}\ W_{it}(e_{it},m_{it}) &\equiv \left[y_i+\tau_t-e_{it}y^e-m_{it}y^m\right] \\ &+\left[(1-m_{it})(y_i+e_{it}R)+m_{it}(y_i+e_{it}R^*)-e_{it}m_{it}\theta\left(R^*-R\right)\right] \end{aligned} \qquad (2)$$

subject to: $y^i+\tau_t-e_{it}y^e-m_{it}y^m\geq 0$

Our set of assumptions can be written as follows:

A1: For each agent i, the rate of return on education exceeds the education cost: $W_{it}(1,0)>W_{it}(0,0)$. Formally, this requires $R>y^e$.

A2: For each educated agent i, migration always induces a gain in lifetime income: $W_{it}(1,1)>W_{it}(1,0)$. Formally, this requires $(R^*-R)(1-\theta)>y^m$.

[6] Introducing imperfect substitution would not change the nature of our effects.

[7] Galor and Zeira (1993) examine the inequality effects of the transmission of wealth within families.

A3: Even without remittances, a strictly positive share of the population would have an access to education and migration : $y^e < y^e + y^m < \bar{y}$.

A4: The product $\theta(R^*-R)$ is lower than $\bar{y}$. Given (2), this conditions ensures that the second-period income is non negative for the highest ability emigrants. As it will appear below, this condition also implies that the long run level of per capita amount of remittances is finite.

Given the amount of altruistic transfers per member τ_t at time t, we have at most three groups in our economy. Agents with income $y_i < y_e - \tau_t$ cannot afford paying for education cost. Agents with income $y^e - \tau_t \leq y_i \leq y^e + y^m - \tau_t$ can afford paying for education but cannot pay for migration costs. Finally, agents with income $y_i \geq y^e + y^m - \tau_t$ get educated and emigrate. Of course, the amount of remittances can be such that one group totally disappears. For example, each young has an access to education when $y^e - \tau_t < 0$.

Assumption A3 ensures that a positive share of the population can pay for education and migration costs even without remittances. However, the size of remittances determines the skill structure of the population as well as the number of emigrants. Three types of equilibrium can be obtained:

- in an open economy such that $\tau_t < y^e$, a positive share of the population has no access to education. Such an equilibrium is labeled as a **type-A equilibrium**;
- if $y^e < \tau_t < y^e + y^m$, all agents opt for education but a positive share of the population has no access to migration. Such an equilibrium is labeled as a **type-B equilibrium**;
- finally, if $\tau_t > y^e + y^m$, all agents opt for education and migration. Such a trivial equilibrium is labeled as a **type-C equilibrium**.

Hence, the structure of the population is fully determined by the distribution of human capital at birth relatively to two critical levels ($y^e - \tau_t$ and $y^e + y^m - \tau_t$). Obviously, an increase in the level of remittances displaces both critical levels to the left.

2. The Closed Economy Benchmark Equilibrium

Assume that the domestic government is able to prevent any form of emigration. It follows that $m_{it}=0$ for all i and t. Hence, there is no altruistic remittances ($\tau_t=0$). At each period of time, the share of educated agents is given by $(\bar{y}-y^e)/(\bar{y})$.

The average stock of human capital of adults is given by

$$Y_{cl} = \int_0^{y^e} yU(y)dy + \int_{y^e}^{\bar{y}} (y+R)U(y)dy = \frac{\bar{y}^2 + 2R(\bar{y} - y^e)}{2\bar{y}} \quad (3)$$

It obviously comes out that the average stock of human capital decreases with the cost of education and increases with R, the domestic rate of return to education. This closed economy result will be used as a benchmark for examining the effect of brain drain on human capital formation.

3. The Small Open Economy Equilibrium

In an economy opened to migration, the high skilled agents export their human capital abroad. In return, they send altruistic remittances that displace the critical levels of ability to the left. This improves the access to education and migration for the next cohort. The total impact of brain drain balances these effects.

Basically, the average human capital stock in an open economy is given by

$$Y_{op,t+1} = \frac{\bar{y}}{y^e + y^m - \tau_t}\left[\int_0^{\max(0,y^e-\tau_t)} yU(y)dy + \int_{\max(0,y^e-\tau_t)}^{y^e+y^m-\tau_t} (y+R)U(y)dy\right] \tag{4}$$

The average stock at time t+1 clearly depends on the decision of migration taken by the members of the previous generation (the number of adult emigrants at time t determines the amount of remittances, τ_t).

In (4), the first term under brackets is the stock of human capital of the uneducated; the second term is the stock of human capital of the educated remaining in the source country. These two terms are multiplied by a fraction capturing the total proportion of agents remaining in the domestic country. Hence, (4) measures the average stock of human capital among remaining residents.

A type-A equilibrium emerges when $\tau_t < y^e$. In that case, a positive share of the population has no access to education and the first term between brackets is positive (max $[0, y^e-\tau_t]=y^e-\tau_t>0$). When $y^e<\tau_t<y^e+y^m$, a type-B equilibrium emerges and the first term between brackets disappears (max $[0, y^e-\tau_t]=0$).

Developing the integral in (4), we express the stock of human capital per head as a function of remittances:

$$Y_{op,t+1} = \begin{cases} \dfrac{(y^e + y^m - \tau_t)^2 + 2Ry^m}{2(y^e + y^m - \tau_t)} \equiv Y^{(1)}_{op,t+1} \ \ if\ \tau_t \leq y^e \\[2ex] \dfrac{(y^e + y^m - \tau_t)^2 + 2R(y^e + y^m - \tau_t)}{2(y^e + y^m - \tau_t)} \equiv Y^{(2)}_{op,t+1} \ \ if\ \tau_t > y^e \end{cases} \tag{5}$$

The general function $Y_{op,t+1}$ is determined by $Y^{(1)}_{op,t+1}$ or by $Y^{(2)}_{op,t+1}$ according to the sign of τ_t-y^e. Obviously, when τ_t-y^e=0,$Y^{(1)}_{op,t+1}$ and $Y^{(2)}_{op,t+1}$ coincide. Hence, the analysis of the small open economy solution requires a complete description of the dynamics of altruistic remittances.

Clearly, the current level of altruistic remittances is related to the number of emigrants within the previous generation. Since liquidity constraints are restricting migration opportunities, the past flow of emigration is itself related to the past amount of remittances. The small open economy problem is intertemporal: the amount remitted at time t depends on the amount remitted at time t-1.

Remember that each young receives an identical amount of transfers (there is no specific wealth transmission rule). It follows that the aggregate amount of remittances is equally shared among the young:

$$\tau_t = \int_{y^e+y^m-\tau_{t-1}}^{\bar{y}} \theta\left(R^* - R\right)U(y)dy = \theta\left(R^* - R\right)\frac{\bar{y} - y^e - y^m + \tau_{t-1}}{\bar{y}} \equiv \phi\left(\tau_{t-1}\right) \qquad (6)$$

This dynamic equation τ_t=$\phi(\tau_{t-1})$ fully describes the time path of altruistic transfers and, given (5), the time path of the average human capital stock per adult. Let us now focus on the steady state equilibrium of our small open economy. The following result is obtained:

Proposition 1. *The steady state level of altruistic transfers is given by*

$$\tau^{ss} = \frac{\theta\left(R^* - R\right)\left(\bar{y} - y^e - y^m\right)}{\bar{y} - \theta\left(R^* - R\right)}.$$

Using assumption A4, this long run solution is strictly positive and globally stable.

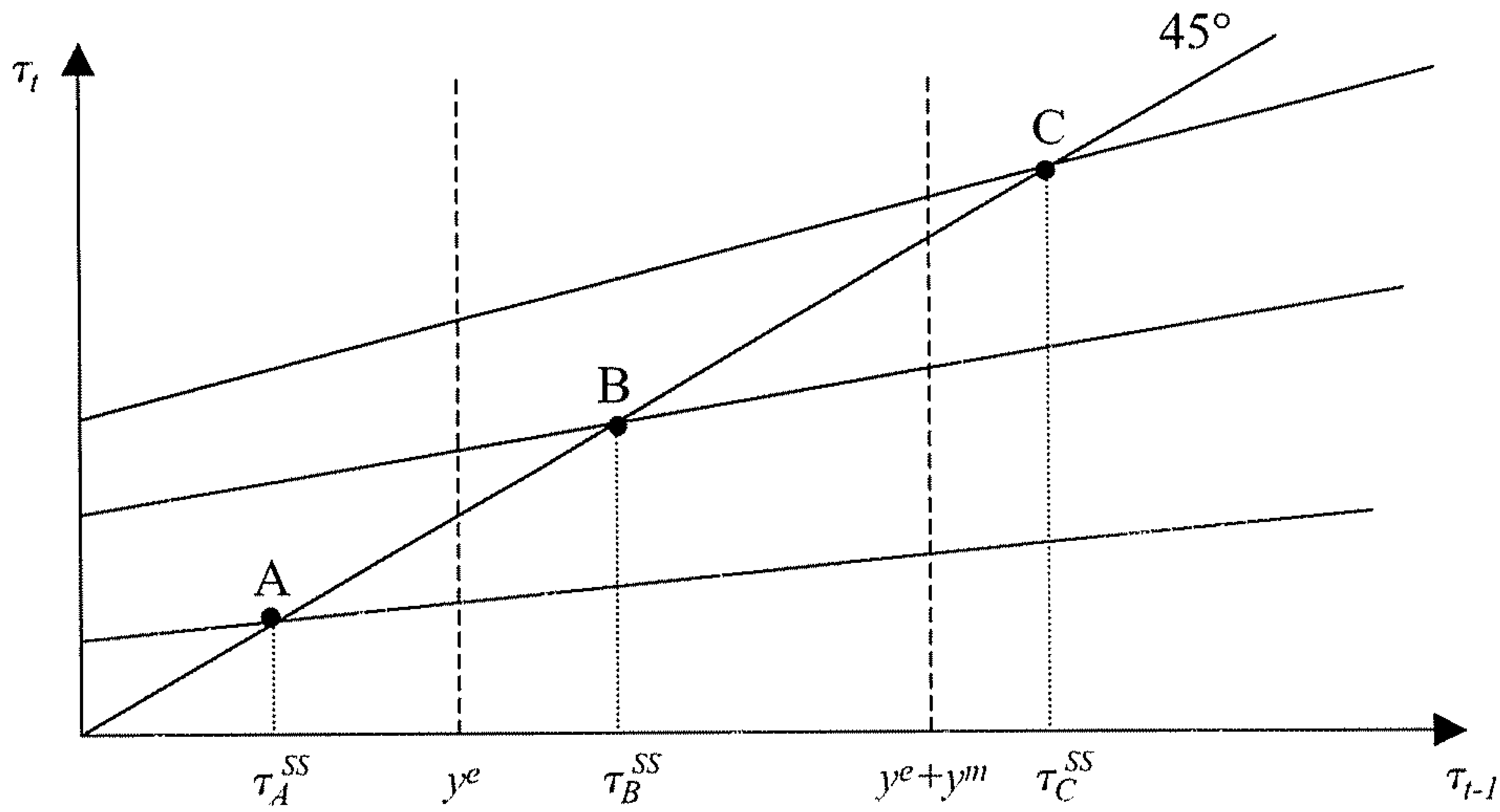
Proof: Using τ_t=τ_{t-1}=τ in (6) clearly gives τ^{SS}. The stability property of this steady state can be studied by examining the derivative ϕ'.

One obtains $0 < \phi' = \frac{\partial \tau_t}{\partial \tau_{t-1}} = \frac{\theta(R^* - R)}{\bar{y}} < 1$.

Given A4, the steady state is globally stable.

Figure 1 illustrates how changes in $\theta(R^*\text{-}R)$, determining both $\phi(0)=\frac{\theta\left(R^*-R\right)}{\bar{y}}\bar{y}\text{-}\left(y^e-y^m\right)$ and the slope of the dynamic locus, affect the type of equilibrium. In each case, the unique intersection wit the 45° line corresponds to a steady state.

FIGURE 1. ALTRUISM AND THE STEADY STATE AMOUNT OF TRANSFERS – DYNAMIC REPRESENTATION



- For small values of $\theta(R^*-R)$, the steady state is depicted by point A. The long-run amount of remittances (τ_A^{SS}) is lower than : a positive share of the population has no access to education (type-*A* equilibrium).

- For intermediate values of $\theta(R^*-R)$, the steady state is depicted by point B. The long-run amount of remittances (τ_B^{SS}) lies between y^e and y^e+y^m: all agents have an access to education and a positive fraction of the population is staying put (type-*B* equilibrium).

- For high values of $\theta(R^*-R)$, the steady state is depicted by point C. The long-run amount of remittances (τ_C^{SS}) is above y^e+y^m: all agents educate and emigrate so that the population size tends to zero (type-*C* equilibrium).

Let us now determine the type of equilibrium as a function of the parameters of our model:

Corollary 1. *A type-A solution emerges when* $\theta(R^*-R) < \dfrac{\bar{y}y^e}{y - y^m}$.

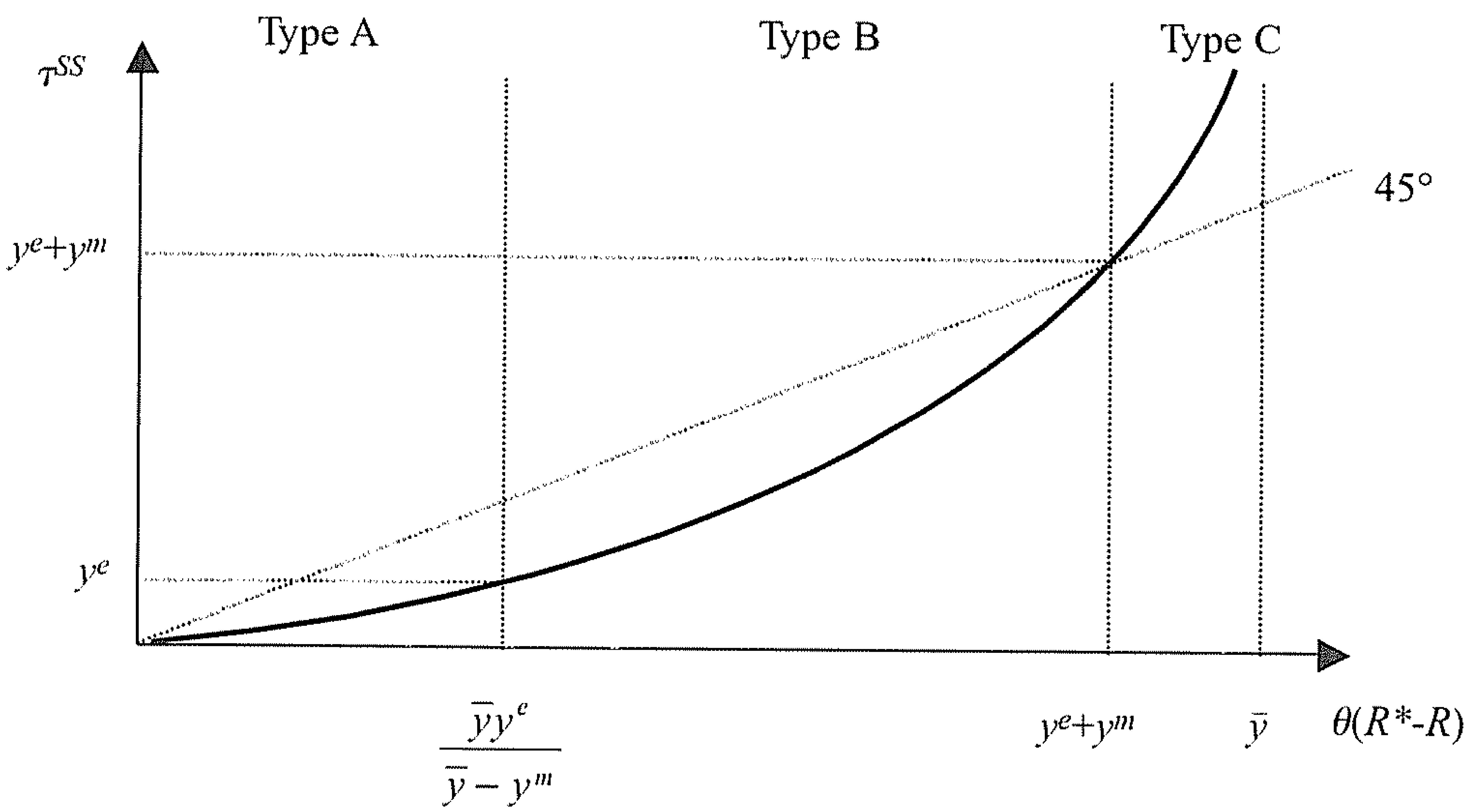
A type-B solution emerges when $\dfrac{\bar{y}y^e}{\bar{y} - y^m} < \theta(R^*-R) < y^e+y^m$.

A type-C solution emerges when $\theta(R^*-R) > y^e+y^m$.

Proof. The condition for a type-*A* equilibrium is $\tau^{SS}<y^e$. Conditions for a type-*B* equilibrium are $\tau^{SS}>y^e$ together with $\tau^{SS}<y^e+y^m$. A condition for a type-*C* equilibrium is $y^e+y^m<\tau^{SS}<\bar{y}$.

As illustrated on figure 2, the steady state level of altruistic transfers is a convex function of the product $\theta(R^*\text{-}R)$. The type-C critical value $\tau^{SS}<y^e+y^m$ is reached when $\theta(R^*\text{-}R)=y^e+y^m$: the function intersects with the 45° line at this point.

FIGURE 2. ALTRUISM AND THE STEADY STATE AMOUNT OF TRANSFERS – THE LONG RUN SOLUTION



Finally, given assumption A3, the migration process takes off at period 1. Starting from a closed economy at time 0 ($\tau_0=0$), we have $\tau_1=\phi(0)>0$.

4. BRAIN DRAIN AND HUMAN CAPITAL FORMATION

To examine the global impact of brain drain on human capital accumulation in the source country, we compare the closed economy level of human capital per capita (Y_{cl}) to the open economy level ($Y_{op,t}$). We focus on the long-run impact of brain drain by considering the small open economy solution expressed at the steady state (time indexes are dropped).

Note that the small open economy result exclusively depends on the steady state value of altruistic transfers. If the amount remitted is too high, all agents emigrate in the long run. We do not consider such trivial type-C solutions and focus on type-A and type-B equilibria.

Our analysis is made in two steps. First we investigate the existence of an interval of altruistic transfers on which a beneficial brain drain can be observed (at least in the long run). Then, we examine if some altruistic rate can generate such a long run equilibrium.

The type-A case

The type-A case emerges when the steady state level of altruistic transfers is such that some agents have no access to education ($\tau^{SS}<y^e$). Brain drain is then beneficial for human capital accumulation when $Y_{op}^{(1)}$ is higher than Y_{cl}, that is when

$$\frac{\left(y^e + y^m - \tau^{ss}\right)^2 + 2Ry^m}{2\left(y^e + y^m - \tau^{ss}\right)} > \frac{\bar{y}^2 + 2R(\bar{y} - y^e)}{2\bar{y}} \tag{7}$$

This condition can be rewritten as

$$\varphi_{op}^{(1)}\left(\tau^{ss}\right) \equiv \bar{y}\left[y^e + \left(y^m - \tau^{ss}\right)^2 + 2Ry^m\right] > \left(y^e + y^m - \tau^{ss}\right)\left[\bar{y}^2 + 2R\left(\bar{y} - y^e\right)\right] \equiv \varphi_{cl}\left(\tau^{ss}\right) \tag{7'}$$

These two functions can be represented in terms of τ^{SS}.

The $\varphi_{op}^{(1)}$-locus is a linear decreasing function such that $\varphi_{op}^{(1)}(0) = \bar{y}\left[\left(y^e + y^m - \tau^{ss}\right)^2 + 2Ry^m\right]$, $\varphi_{op}^{(1)}\left(y^e\right) = \bar{y}\left[\left(y^m\right)^2 + 2Ry^m\right]$ and $\varphi_{op}^{(1)}\left(y^e + y^m\right) = 2\bar{y}Ry^m$

The $\varphi_{op}^{(1)}$ -locus is a decreasing and convex function such that

$\varphi_{op}^{(1)}(0) = \bar{y}\left[\left(y^e + y^m - \tau^{ss}\right)^2 + 2Ry^m\right], \varphi_{op}^{(1)}\left(y^e\right) = \bar{y}\left[\left(y^m\right)^2 + 2Ry^m\right]$ and $\varphi_{op}^{(1)}\left(y^e + y^m\right) = 2\bar{y}Ry^m$.

The following result emerges:

Lemma 1. *Given assumption A3, a beneficial brain drain cannot be observed when the amount of altruistic transfers is too low.*

Proof. Under A3 ($y^e<y^e+y^m<\bar{y}$), we have $\varphi_{op}^{(1)}.(0)<\varphi_{cl}^{(1)}<(0)$.

The $\varphi_{op}^{(1)}$ -locus thus starts below $\varphi_{cl}^{(1)}$-locus.

This result stands in contrast with the theoretical model of Beine et al. (2001). They argue that, by increasing the expected return on education, migration prospects have a positive impact on human capital formation. In this framework, a beneficial brain drain can be obtained in countries where the migration rate of the highly educated is rather low. In our model, a beneficial brain drain can only be obtained when the amount received by each remaining resident is sufficiently high, i.e. when the proportion of emigrants is not too small.

It should be noted that, as the level of remittances approaches the education cost, the $\varphi_{op}^{(1)}$-locus can become lower or higher than the $\varphi_{cl}^{(1)}$ -locus. One can easily shows that $\varphi_{op}^{(1)}(y^e)>\varphi_{cl}(y^e)$ when $2Ry^e>\bar{y}(\bar{y}-y^m)$, labeled as condition **C1**. This condition will be used below.

The type-*B* case

The type-B case emerges when the steady state level of remittances is such that all agents become educated ($\tau^{SS}>y^e$). Brain drain is then beneficial for human capital formation when $Y_{op}^{(1)}$ is higher than Y_{cl}, that is

$$\frac{\left(y^e+y^m-\tau^{ss}\right)^2+2R\left(y^e+y^m-\tau^{ss}\right)}{2\left(y^e+y^m-\tau^{ss}\right)}>\frac{\bar{y}^2+2R\left(\bar{y}-y^e\right)}{2\bar{y}} \tag{8}$$

This may be rewritten as

$$\varphi_{op}^{(2)}\left(\tau^{ss}\right)\equiv\bar{y}\left[y^e+\left(y^m-\tau^{ss}\right)^2+2R\left(y^e+y^m-\tau^{ss}\right)\right]>\varphi_{cl}\left(\tau^{ss}\right) \tag{8'}$$

These two functions can be represented in terms of τ^{SS}. The φ_{cl}-locus is identical to that obtained in the type-*A* case. The $\varphi_{op}^{(2)}$-locus is also a decreasing and convex function such

that $\varphi_{op}^{(2)}(0)=\bar{y}\left(y^e+y^m+2R\right)\left(y^e+y^m\right)>\varphi_{op}^{(1)}(0)$, $\varphi_{op}^{(2)}\left(y^e\right)=\varphi_{op}^{(1)}\left(y^e\right)$ and

$\varphi_{op}^{(2)}\left(y^e+y^m\right)=0$.

Graphically, the $\varphi_{op}^{(2)}$ -locus intersects with the $\varphi_{op}^{(1)}$-locus when the amount remitted is equal to the education cost. Then it decreases and intersects with the φ_{cl}-locus when $\tau^{SS}=y^e+y^m$. Does the $\varphi_{op}^{(2)}$-locus approach the φ_{cl}-locus from above of from below? To answer this question, one has to compare the derivatives at $\tau^{SS}=y^e+y^m$. Given $\varphi_{op}^{(2)}$ is a convex and decreasing function, it approaches φ_{cl} from above when its derivative is smaller, i.e. when $2Ry^e>\bar{y}$, labeled as condition **C2**. This condition will be used below.

Global result

Let us now combine type-*A* and type-*B* equilibria. Three possible cases can be distinguished according to inequality C1 and inequality C2.

- In case (a), we consider that C1 does not hold. This implies $\varphi_{op}^{(1)}(y^e)<\varphi_{cl}(y^e)$, i.e. $2Ry^e<\bar{y}(\bar{y}-y^m)$. It follows that C2 does not hold too, i.e. $2Ry^e<\bar{y}$. The φ_{op}-locus is always below the φ_{cl}-locus and brain drain is always detrimental for human capital accumulation.

- In case (b), we consider that C1 holds ($2Ry^e>\bar{y}(\bar{y}-y^m)$) but C2 does not hold ($2Ry^e<\bar{y}$). The φ_{op}-locus is above the φ_{cl}-locus for intermediate values of remittances, i.e. for intermediate migration rates. The possibility of beneficial brain drain exists if the emigration rate is not too small and not too large.

- In case (c), we consider that both C1 and C2 hold ($2Ry^e>\bar{y}(\bar{y}-y^m)$ and $2Ry^e>\bar{y}$), the φ_{op}-locus is above the φ_{cl}-locus for sufficiently high values of remittances. The possibility of beneficial brain drain exists if the emigration rate is sufficiently high.

These three cases are depicted on figure 3 where the beneficial brain drain corresponds to the bold segment on the X-axis.

It is worth noticing that these conditions do not depend on the altruistic rate (θ) and on the gap in the rate of return on education (R^*-R). Nevertheless, remember that the product $\theta(R^*-R)$ determines the steady state level of remittances. If a beneficial brain drain segment exists, it will then generally be possible to find a product $\theta(R^*-R)$ such that the long-run level of remittances belongs to that interval.

Proposition 2. *A necessary condition to obtain a segment of beneficial brain drain is that* $2\times\frac{R}{\bar{y}}\times\frac{y^e}{\bar{y}}>1-\frac{y^m}{\bar{y}}$.

If this condition holds, two configurations are distinguished:

if $1-\frac{y^m}{\bar{y}}<2\times\frac{R}{\bar{y}}\times\frac{y^e}{\bar{y}}<1$ *brain drain is beneficial for intermediate levels of remittances. The altruistic factor* $\theta(R^*-R)$ *must be close from* $\frac{\bar{y}y^e}{\bar{y}-y}$ *;*

if $1-\frac{y^m}{\bar{y}}<1<2\times\frac{R}{\bar{y}}\times\frac{y^e}{\bar{y}}$ *brain drain is beneficial for high levels of remittances. The altruistic factor* $\theta(R^*-R)$ *must be close from or higher than* $\frac{\bar{y}y^e}{\bar{y}-y^m}$.

Proof. The first condition is obtained by developing $\varphi_{op}(y^e)>\varphi_{cl}(y^e)$ (C1). The second condition combines C1 and C2. According to corollary 1, we have $\tau^{SS}=y^e$ when

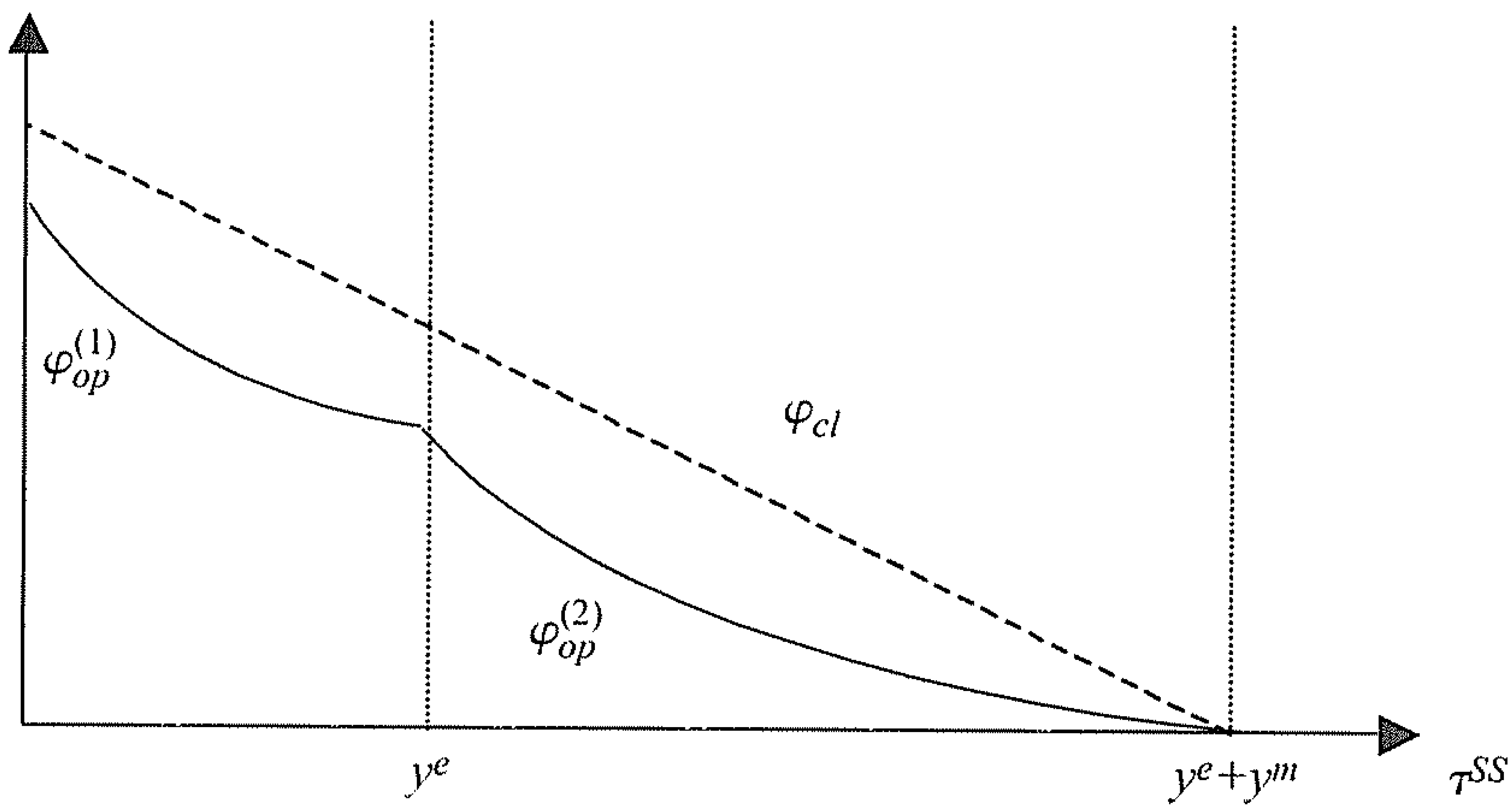
$$\theta(R^*-R)=\frac{\bar{y}y^e}{\bar{y}-y^m}.$$

For illustrative purpose, consider an economy where the cost of education represents 25% of income and where the cost of migration (including transport, visa, search costs, housing and the monetary value of psychic costs) amounts to 50% of income for the highest ability individual ($y^e/\bar{y}$=2.5 and $y^m/\bar{y}$=.5). According to proposition 2, if the rate of return to education ($R/\bar{y}$) is lower than 1, there is no possibility of beneficial brain drain. If the return to education is between 1 and 2, a beneficial brain drain is obtained when the amount remittances is not too small and not too high. For higher rates of return, a beneficial brain drain is obtained when the amount of remittances is not too small. For the two latter cases, the maximal impact on human capital is obtained when the amount of remittances is just equal to the cost of education.

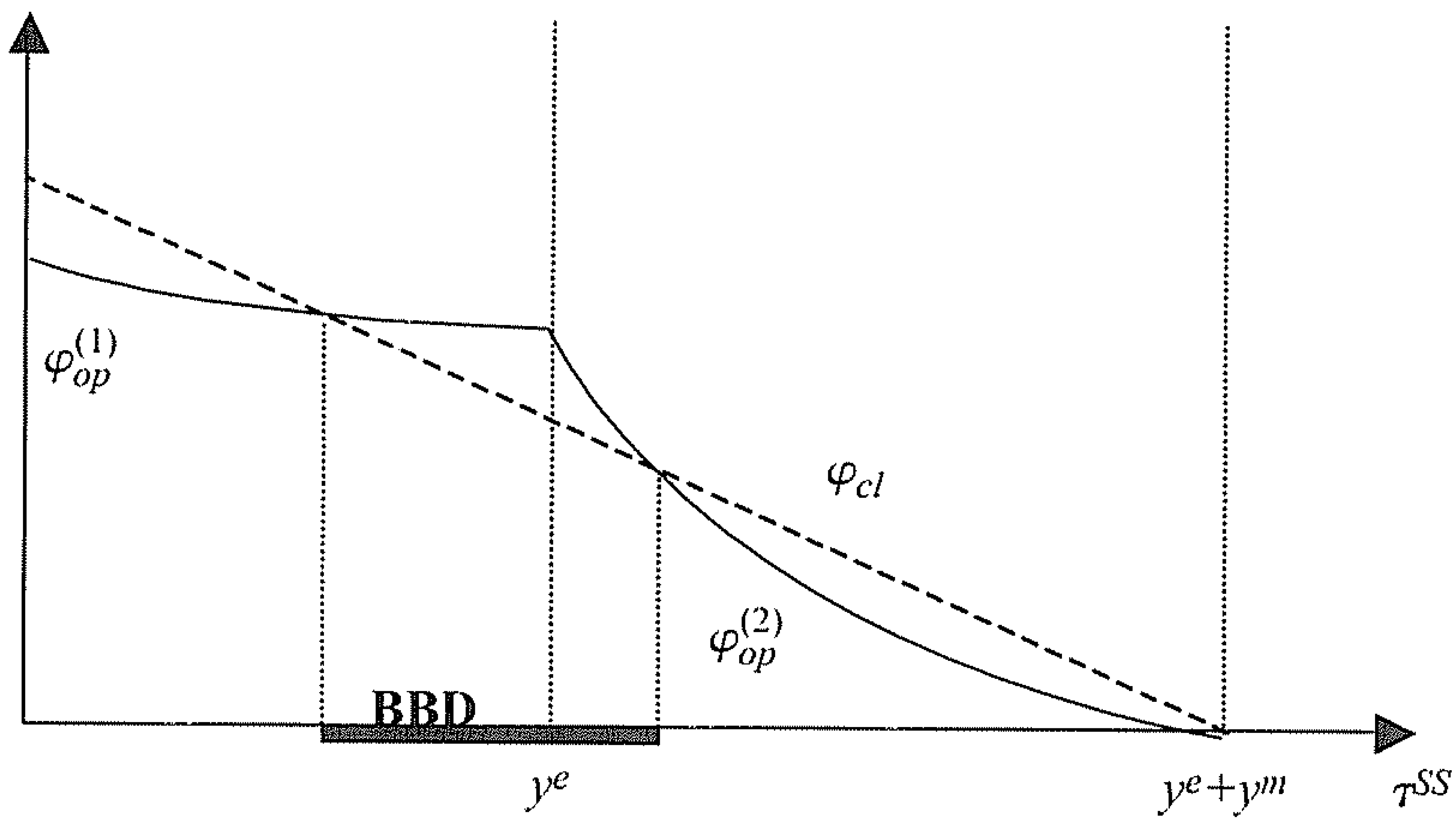
More generally, a beneficial brain drain interval is obtained when the return to education is high, compared to the costs of education and migration. If such an interval exists, brain drain effectively increases human capital formation. Remittances received by each young are such that an important part of the population gets the access to education.

FIGURE 3. ON THE POSSIBILITY OF A BENEFICIAL BRAIN DRAIN

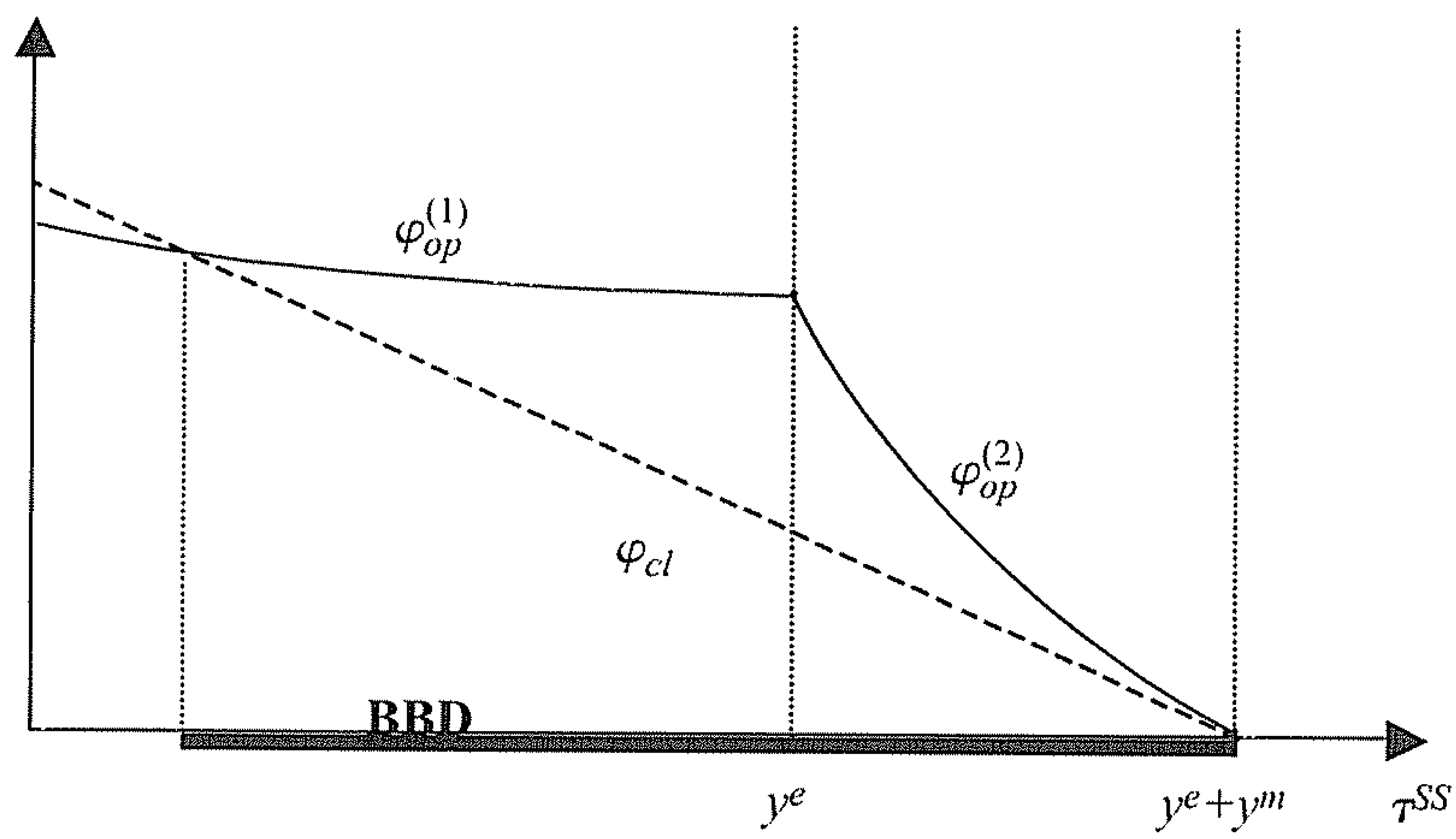
Case (a): Detrimental brain drain



Case (b): Beneficial brain drain for intermediate migration rates



Case (c): Beneficial brain drain for high migration rates



Conclusion

In this paper, we examine the consequences of the migration of skilled workers on human capital accumulation in the source country. Our model relies on two major assumptions: (i) liquidity constraints impede human capital investment in low-income classes and (ii) migrants altruistically remit a part of their earnings into the source country. In the long-run, brain drain involves two opposite effects on human capital formation:

- the most educated (those who can afford paying for both education and migration costs) are leaving the source country, reducing the average level of human capital for those staying put (*traditional effect*);

- international remittances enable some liquidity constrained agents to pay for education costs, raising the proportion of agents opting for education (*better access to schooling*).

A beneficial brain drain can be obtained when the *better access to schooling* dominates the *traditional effect*: the migration of skilled workers associated to altruistic transfers can then be beneficial for human capital accumulation.

We thus explore the theoretical conditions under which such an outcome appears. It is shown that a beneficial brain drain is obtained under some restricted conditions. More precisely, it requires that the level of altruistic transfers per capita must be such that a large share of population gets the access to education. Such a condition does not hold in developing countries. Hence, despite the fact that remittances is a major source of income for remaining residents, they should not be large enough to stimulate the economy-wide average level of education. Once negative spillover effects are considered (intergenerational and intragenerational externalities associated to human capital), the net impact on remaining residents' welfare is ambiguous.

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