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**Working Paper**

## International migration, human capital formation, and saving

ZEF Discussion Papers on Development Policy, No. 174

**Provided in Cooperation with:**

Zentrum für Entwicklungsforschung / Center for Development Research (ZEF), University of Bonn

*Suggested Citation:* Stark, Oded; Agnieszka Dorn (2013) : International migration, human capital formation, and saving, ZEF Discussion Papers on Development Policy, No. 174, University of Bonn, Center for Development Research (ZEF), Bonn,  
<https://doi.org/10.22004/ag.econ.143842>

This Version is available at:

<https://hdl.handle.net/10419/84793>

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Zentrum für Entwicklungsforschung  
Center for Development Research  
University of Bonn

# ZEF-Discussion Papers on Development Policy No. 174

Oded Stark and Agnieszka Dorn

## **International migration, human capital formation, and saving**

Bonn, January 2013

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**Oded Stark and Agnieszka Dorn, International migration, human capital formation, and saving, ZEF - Discussion Papers on Development Policy No. 174, Center for Development Research, Bonn, January 2013, pp. 11.**

**ISSN: 1436-9931**

**Published by:**

Zentrum für Entwicklungsforschung (ZEF)  
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## Acknowledgements

We are indebted to a Referee, to Marcin Jakubek, Barbara Kaltenbacher, and Yong Wang for thoughtful comments and constructive advice, and to Pierre-Daniel Sarte for encouragement and guidance. The support of Georgetown University Edmund A. Walsh School of Foreign Service in Qatar is gratefully acknowledged.

## Abstract

In the model of Stark et al. (1997, 1998), the possibility of employment in a developed country raises the level of human capital acquired by workers in the developing country. We show that this result holds even when workers have the option to save.

*JEL classification:* D91; F22; J22; J24

*Keywords:* Human capital formation; Savings; Intertemporal choice; Prospect of migrating

## 1. Introduction

The idea that the prospect of migrating to a developed, technologically advanced country, where the returns to human capital are higher than in the developing home country, induces individuals in the home country to acquire additional human capital initiated a large “New Economics of the Brain Drain” literature (Stark, 2005). The pioneering writings on this topic, Stark et al. (1997, 1998), did not deal, however, with the possibility of saving.

A natural question is whether the positive human capital formation response identified in the model of Stark et al. (1998) is robust to the introduction of saving. After all, saving is a device for obtaining less variability in one’s lifetime consumption than in income or earnings, so resorting to saving may weaken or even negate the need to employ other instruments; savings could thus “crowd out” the human capital formation response. Whereas there is typically a risk in acquiring human capital,<sup>1</sup> savings can reasonably be assumed to yield fixed and certain returns. The facility of saving as a risk-free investment is of particular relevance for the analysis of Stark et al. (1998) because the main result there is contingent on a particular attitude of the individual towards risk - a low degree of relative risk aversion.

Both saving and human capital formation are means of investing in the future, and an optimizing individual will seek to equalize the marginal returns from them. Indeed, Azariadis and Drazen (1990), who studied the optimal education decision with an option to save, established that the marginal returns to education and saving are equalized at the interior equilibrium, and that any exogenous factor increasing the productivity of human capital raises the time spent in schooling. However, neither they nor others who pursued similar lines of inquiry (for example, Galor and Stark, 1994) incorporated the consideration of a *probable* utilization of the acquired human capital in a foreign country as a feature that renders investment in human capital risky.

In this paper we ask: can the option to save neutralize (“crowd out”) the effect of the prospect of migrating on human capital formation? When saving is an option, under what conditions does the prospect of migrating lead to increased investment in human capital? In particular, when saving is undertaken, does a low degree of relative risk aversion need to be replaced by a more stringent condition for the human capital formation outcome to hold?

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<sup>1</sup> See Levhari and Weiss (1974) for an analysis of the riskiness of human capital formation and its consequences. In a similar vein, see also Tsiddon (1992), and Krebs (2003).

## 2. A model of human capital formation, savings, and migration

Consider a workforce in a closed economy  $H$ . Members of the workforce live for two periods. In the first period, they work and can engage in human capital formation. Work is rewarded by a competitive wage,  $w_H$ , per efficiency unit of labor. The cost of forming human capital is equal to forgone earnings. To begin with, every worker is endowed with one efficiency unit of labor. Denoting by  $l \in [0,1]$  the fraction of the unit endowment of labor that a worker chooses to allocate to human capital formation, first-period earnings are  $(1-l)w_H$ . The amount of productive human capital, measured in efficiency units of labor, that is available to a worker in the second period of his life, is given by the continuous production function of human capital,  $\phi(l)$ , which, for  $l \in (0,1)$ , is twice differentiable with  $\phi'(l) > 0$  and  $\phi''(l) < 0$ . We further assume that  $\phi(l) \geq 1$  holds for all  $l \in [0,1]$ , that  $\lim_{l \rightarrow 0} \phi'(l) = \infty$ , that  $\lim_{l \rightarrow 1} \phi'(l) = 0$ , and that human capital does not depreciate. The second-period earnings of the worker are  $\phi(l)w_H$ .

The worker saves a fraction  $s$  of his first-period earnings,  $(1-l)w_H$ . We assume that  $s \in [0,1]$ . This assumption means that borrowing (incurring debt) in order to finance human capital formation, namely that  $s < 0$ , is not allowed.

Assume now that migration in the second period becomes a possibility, such that with probability  $p \in [0,1)$  an  $H$  country worker obtains employment in foreign country  $F$ . Otherwise, the worker works in  $H$  with whatever human capital he has acquired. Human capital is perfectly transferable across countries. To reflect the fact that the foreign country is rich and the home country is poor, it is assumed that the competitive wage per efficiency unit of labor in the foreign country,  $w_F$ , exceeds the competitive wage per efficiency unit of labor in the home country,  $w_H$ . Wages in  $H$  and in  $F$  are independent of migration (that is, migration is relatively small), and the rate of return on savings,  $r \geq 0$ , is exogenously given. Let  $\delta = 1+r$ . Then, the worker's income in the second period will be  $\phi(l)w_H + \delta s(1-l)w_H$  if he works in  $H$ , and  $\phi(l)w_F + \delta s(1-l)w_H$  if he ends up working in  $F$ .

Per period utility, which is given by the function  $U(x)$ , is derived from periodic consumption,  $x$ . The function  $U(x)$  is twice differentiable with  $U'(x) > 0$  and  $U''(x) < 0$  for all  $x \geq 0$ .

The worker's optimization problem involves choosing  $l$  and  $s$  that maximize his intertemporal utility

$$V((l, s), p) = U((1-s)(1-l)w_H) + \rho \left[ pU(\phi(l)w_F + \delta s(1-l)w_H) + (1-p)U(\phi(l)w_H + \delta s(1-l)w_H) \right] \quad (1)$$

where  $\rho \in (0, 1]$  is the worker's subjective time rate of discount.

We assume that  $\lim_{x \rightarrow 0} U'(x) > \rho \delta U'(w_H)$  or, alternatively, that  $\lim_{x \rightarrow 0} U'(x) = \infty$ , which implies that the worker does not save his entire first-period income. Given the limit properties of the production function of human capital, and given the properties of the utility function, the fraction of the endowment of labor allocated to human capital formation is positive, but less than one, namely  $l \in (0, 1)$ .

The model of Stark et al. (1998) is a special case of the model described above without a possibility of saving, namely, in the Stark et al. (1998) model the worker maximizes (1) under the constraint  $s = 0$ . Then, Stark et al. (1998) show that if the condition  $w_F U'(\phi(l)w_F) > w_H U'(\phi(l)w_H)$  is fulfilled for all  $l$ , the optimal level of human capital is higher in the presence of a prospect of migrating than in its absence. Any utility function  $U(x)$  such that  $xU'(x)$  is an increasing function of  $x$ , at least for  $x \in [\phi(0)w_H, \phi(1)w_F]$ , fulfills this condition. Examples of such functions are  $U(x) = \ln(x+1)$ , and  $U(x) = x^\alpha$  where  $\alpha \in (0, 1)$ . Assuming this condition is tantamount to assuming that the worker's preferences exhibit a coefficient of relative risk aversion (*RRA*) that is less than one, namely that  $RRA(x) = \frac{-xU''(x)}{U'(x)} < 1$ . Intuitively, for a worker to engage in the risky ( $p < 1$ ) acquisition of more human capital in anticipation of the high returns to human capital available in the foreign country only to end up not migrating and not reaping those returns, the worker has to exhibit low aversion to risk.

To streamline notation, we denote the worker's consumption as follows: in the first period, by  $c_0$ ; in the second period by  $c_F$  if the worker migrates, and by  $c_H$  if the worker stays in the home country. Thus,  $c_0 = (1-s)(1-l)w_H$ ;  $c_F = \phi(l)w_F + \delta s(1-l)w_H$ ; and  $c_H = \phi(l)w_H + \delta s(1-l)w_H$ .



We obtain the properties of the solutions to the maximization problem that follows from (1) upon drawing on the necessary Karush-Kuhn-Tucker conditions, which are determined by the derivatives of (1) with respect to  $l$  and  $s$ , namely, by

$$V_l((l, s), p) = -(1-s)w_H U'(c_0) + \rho \left[ p(\phi'(l)w_F - \delta s w_H) U'(c_F) + (1-p)(\phi'(l)w_H - \delta s w_H) U'(c_H) \right] \quad (2)$$

and

$$V_s((l, s), p) = (1-l)w_H \left\{ -U'(c_0) + \rho \delta \left[ p U'(c_F) + (1-p) U'(c_H) \right] \right\}, \quad (3)$$

respectively. Because we can restrict our attention to the case of  $l \in (0, 1)$ , it follows from (3) that  $V_s((l, s), p)$  has the same sign as  $\{-U'(c_0) + \rho \delta [p U'(c_F) + (1-p) U'(c_H)]\}$ . We denote the pair  $(l, s)$  that maximizes (1) as  $(l^p, s^p)$ . Then,  $c_i^p$  is  $c_i, i=0, F, H$  taken for  $(l, s) = (l^p, s^p)$ .

The effect of the probability  $p$  of migrating on human capital formation is  $E^p = l^p - l^0$ . We denote by  $\tilde{l}^p$  the optimal fraction of labor endowment allocated to human capital formation in the model of Stark et al. (1998). Without an option to save, the effect of a probability of migrating on human capital formation is  $\tilde{E}^p = \tilde{l}^p - \tilde{l}^0$ .

We first formulate a lemma which allows us to characterize the optimal fraction of the endowment of labor allocated to human capital formation in terms of the relationship between the marginal returns to the fraction of the endowment of labor allocated to human capital formation at the optimum, namely,  $\phi'(l^p)$ , and the marginal returns to savings,  $\delta$ . When migrating is not possible ( $p = 0$ ), both human capital formation and saving are riskless. We expect the worker to form human capital up to the point at which a further increase in future consumption is not desirable, or up to the point at which the marginal returns from investment in human capital are equal to those that accrue from saving. When migrating is a possibility ( $p > 0$ ), the marginal returns from investment in human capital are uncertain: the returns to be reaped from human capital are either low,  $\phi(l^p)w_H$ , or high,  $\phi(l^p)w_F$ . With  $s^0$  and  $s^p$  standing, respectively, for the optimal level of saving when the economy is closed and when migration is possible ( $p > 0$ ), we have the following lemma.

**Lemma 1.**

**I.** If  $s^0 = 0$ , then  $\phi'(l^0) \geq \delta$ ; namely, when migrating is not possible, if the worker does not save, then, at the optimum, the marginal returns from investment in human capital are not lower than the marginal returns from saving;

**II.** If  $s^0 > 0$ , then  $\phi'(l^0) = \delta$ ; namely, when migrating is not possible, if the worker saves, then, at the optimum, the marginal returns from investment in human capital formation are the same as the marginal returns from saving;

**III.** If  $p > 0$  and  $s^p > 0$ , then  $\phi'(l^p) < \delta$ ; namely, when migrating is possible, if the worker saves, then, at the optimum, the marginal returns from investment in human capital formation are lower than the marginal returns from saving.

**Proof.** See the Appendix.

We next show that if, in the closed economy, the returns to saving are so unattractive compared to the returns that accrue from the formation of human capital that the worker does not save, then, other things held constant, the appearance of a prospect of migrating will not cause the worker to save. The next lemma formalizes this intuitive reasoning.

**Lemma 2.** If  $s^0 = 0$ , then  $s^p = 0$  for all  $p > 0$ ; namely, if the worker does not save when migrating is not possible, then he does not save when migrating is possible either.

**Proof.** See the Appendix.

By linking the choice of whether to save with the relationship between the returns from investment in human capital formation and the returns from saving, Lemma 1 enables us to investigate three possible types of saving behavior. First, a worker might save regardless of whether the economy is closed or open. Second, saving might be an attractive option when the economy is closed, but not when the economy is open. Third, a worker might not save regardless of whether the economy is closed or open, in which case the current model reduces to the model of Stark et al. (1998), and a positive probability of employment in a foreign country leads to the formation of more human capital under the condition  $w_F U'(\phi(l)w_F) > w_H U'(\phi(l)w_H)$  for all  $l$ . Lemma 2 implies that a configuration in which a worker switches from not saving when the economy is closed to saving when the economy is open is not possible.

As the following two claims show, *the opportunity to save that is exercised by a worker* does not negate the human capital acquisition effect identified in Stark et al. (1998).

Moreover, if the worker saves when the economy is open to migration, the human capital acquisition effect does not hinge on the condition that  $w_F U'(\phi(l)w_F) > w_H U'(\phi(l)w_H)$  for all  $l$ . Intuitively, when a worker saves under both regimes, the worker is already “cushioning” his future by means of savings and, thus, with savings rendering the future safer, the worker is less reluctant to invest in the risky human capital prospect. If the worker does not save when the economy is open to migration, his risk attitude comes forcefully into play.

**Claim 1.** If the worker saves when the economy is open to migration, then the optimal level of human capital acquired in the presence of the opportunity to migrate *exceeds* the optimal level of human capital acquired in the absence of the opportunity to migrate.

**Proof.** If  $s^p > 0$  for a positive  $p$ , then Lemma 1.III applies and  $\phi'(l^p) < \delta$ . Due to Lemma 2,  $s^0 > 0$  and Lemma 1.II applies and, thus,  $\phi'(l^0) = \delta$ . Therefore,  $\phi'(l^0) > \phi'(l^p)$ , which implies that  $l^p > l^0$ .  $\square$

**Claim 2.** If  $w_F U'(\phi(l)w_F) > w_H U'(\phi(l)w_H)$  for all  $l$ , and if the worker saves when the economy is closed to migration but not when the economy is open to migration, then the optimal level of human capital acquired in the presence of an opportunity to migrate *exceeds* the optimal level of human capital acquired in the absence of an opportunity to migrate.

**Proof.** We seek to show that if  $s^0 > 0$  and  $s^p = 0$ , then, for a positive  $p$ ,  $l^p > l^0$ . We prove that  $l^p > l^0$  by contradiction. Let us assume then that  $l^p \leq l^0$ , which consequently implies that  $(1-l^p)w_H > (1-s^0)(1-l^0)w_H$  and that  $\phi(l^0)w_H + \delta s^0(1-l^0)w_H > \phi(l^p)w_H$ , entailing that  $U'(c_0^0) > U'(c_0^p)$  and that  $U'(c_H^p) > U'(c_H^0)$ , and, together with Lemma 1.II, that  $\phi'(l^p) \geq \phi'(l^0) = \delta$ . From the conditions  $V_s((l^0, s^0), 0) = 0$  and  $V_l((l^p, s^p), p) = 0$ , together with  $U'(c_0^0) > U'(c_0^p)$ , we obtain that

$$\rho \delta w_H U'(c_H^0) = w_H U'(c_0^0) > w_H U'(c_0^p) = \rho \phi'(l^p) \left[ p w_F U'(c_F^p) + (1-p) w_H U'(c_H^p) \right], \quad (4)$$

which, because  $\phi'(l^p) \geq \delta$  and  $U'(c_H^p) > U'(c_H^0)$ , implies that

$$w_H U'(c_H^p) > p w_F U'(c_F^p) + (1-p) w_H U'(c_H^p). \quad (5)$$

After rearranging terms, (5) implies that  $w_H U'(\phi(l^p)w_H) > w_F U'(\phi(l^p)w_F)$ , which contradicts the assumption of the claim. It is the inequality  $l^p \leq l^0$  that brings about this contradiction; hence,  $l^p > l^0$ .  $\square$

We next compare the amount of human capital formed in a setting with an option to save and in a setting without an option to save. If the worker does not save when the economy is closed, then (Lemma 2)  $l^p = \tilde{l}^p$  for all  $p$ , and we have that  $E^p = \tilde{E}^p$ . Suppose, however, that a worker saves when the economy is closed. If the worker saves also when the economy is open, the relation between  $\tilde{E}^p$  and  $E^p$  can go both ways, depending on the values of the parameters and on the properties of the functions involved. The case of a worker who saves only when the economy is closed is, however, more interesting. We next attend to this case.

Consider the situation in which the worker saves when the economy is closed but not when the economy is open. In the next two lemmas we show that such a constellation is possible. Then, we have that  $l^0 < \tilde{l}^0$ ,<sup>2</sup> and  $l^p = \tilde{l}^p$  for some  $p > 0$ . Consequently, the prospect of migrating has a stronger effect on human capital formation in the model with an option to save, namely  $E^p > \tilde{E}^p$ .

**Lemma 3.** If  $\rho\delta U'(\phi((\phi')^{-1}(\delta))w_H) > U'((1 - (\phi')^{-1}(\delta))w_H)$ , then  $s^0 > 0$ ; namely, the worker saves in the absence of a prospect of migrating.

**Proof.** See the Appendix.

**Lemma 4.** If  $p > 0$  and  $U'(w_H) > \rho\delta[pU'(w_F) + (1 - p)U'(w_H)]$ , then  $s^p = 0$ ; namely, it is possible that the worker does not save in the presence of a prospect of migrating.

**Proof.** See the Appendix.

Because the conditions stated in Lemmas 3 and 4 can hold simultaneously, it is possible that a worker who saves when the economy is closed will not save when the economy is open. Having started this paper pondering whether the option to save could crowd out the human capital formation response to the prospect of migration, we now find that the prospect of migrating could crowd out saving.

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<sup>2</sup> The conditions  $V_l(l^0, s^0, 0) = V_s(l^0, s^0, 0) = 0$ , together with  $\phi'(l^0) = \delta$  (cf. Lemma 1.II), can be used to infer that  $V_l(l^0, 0, 0) > 0$ . Because  $V_{ll}(l, 0, 0) < 0$ , then  $V_l(l^0, 0, 0) > 0$  and  $V_l(\tilde{l}^0, 0, 0) = 0$  imply that  $l^0 < \tilde{l}^0$ .

### 3. Conclusions

We expanded the setting introduced in Stark et al. (1998) and in Stark et al. (1997), and established the robustness of the finding in Stark et al. (1998) that the prospect of migrating increases optimal human capital formation. We showed that when saving is possible, the sufficient condition needed to yield this result is the same as in Stark et al. (1998), namely, we require the worker's preferences to exhibit a low degree of relative risk aversion. Moreover, a worker *who saves* when a prospect of migrating presents itself acquires more human capital than he would have acquired without a prospect of migrating *even if the condition specified in Stark et al. (1998) is not satisfied*.

In addition, we find that a worker who saves when migrating is not possible, and who does not save when migrating is possible, increases his investment in human capital in response to the prospect of migrating by more than in a comparable setting without an option to save.

The importance of these findings stems from the fact that developing countries differ in the level of their financial development, and whereas in some countries saving is more attractive and practiced fairly widely, in others saving is much less prevalent. Thus, our findings accord a degree of universality to the effect of the prospect of international migration on human capital formation.

## Appendix

**Proof of Lemma 1.I.** The conditions  $V_l((l^0, 0), 0) = 0$  and  $V_s((l^0, 0), 0) \leq 0$  must be fulfilled.

Then, from (2) and (3),

$$-w_H U'(c_0^0) + \rho \phi'(l^0) w_H U'(c_H^0) = 0, \quad (\text{A1})$$

and

$$-U'(c_0^0) + \rho \delta U'(c_H^0) \leq 0, \quad (\text{A2})$$

which, upon simple algebraic operations, implies that  $\phi'(l^0) \geq \delta$ .  $\square$

**Proof of Lemma 1.II.** The conditions  $V_l((l^0, s^0), 0) = V_s((l^0, s^0), 0) = 0$  must be fulfilled.

Then, from (2) and (3),

$$-(1-s^0)w_H U'(c_0^0) + \rho(\phi'(l^0)w_H - \delta s^0 w_H)U'(c_H^0) = 0, \quad (\text{A3})$$

and

$$-U'(c_0^0) + \rho \delta U'(c_H^0) = 0, \quad (\text{A4})$$

which, upon simple algebraic operations, implies that  $\phi'(l^0) = \delta$ .  $\square$

**Proof of Lemma 1.III.** From (2), the inequality  $p(\phi'(l)w_F - \delta s w_H)U'(c_F) > p(\phi'(l)w_H - \delta s w_H)U'(c_F)$ , which holds for all  $(l, s)$ , and the necessary condition  $V_l((l^p, s^p), p) = 0$  entail that

$$-(1-s^p)w_H U'(c_0^p) + \rho(\phi'(l^p)w_H - \delta s^p w_H) \left[ p U'(c_F^p) + (1-p)U'(c_H^p) \right] < 0, \quad (\text{A5})$$

which, using  $U'(c_0^p) = \rho \delta \left[ p U'(c_F^p) + (1-p)U'(c_H^p) \right]$  as implied from (3) by the condition  $V_s((l^p, s^p), p) = 0$ , leads, upon simple algebraic operations, to  $\phi'(l^p) < \delta$ .  $\square$

**Proof of Lemma 2.** We prove the lemma by contradiction. Let us assume that  $s^p > 0$  and thus, from Lemma 1.III,  $\phi'(l^p) < \delta$ . From Lemma 1.I we know that  $\phi'(l^0) \geq \delta$ . Therefore,  $\phi'(l^0) > \phi'(l^p)$ , which implies that  $l^p > l^0$ .

Consequently, it follows that  $(1-l^0)w_H > (1-s^p)(1-l^p)w_H$ , implying that  $U'(c_0^0) < U'(c_0^p)$  which, together with the necessary conditions  $V_s(l^0, 0, 0) \leq 0$  and  $V_s(l^p, s^p, p) = 0$  entails, from (3), that

$$\rho\delta U'(c_H^0) < \rho\delta [pU'(c_F^p) + (1-p)U'(c_H^p)]. \quad (\text{A6})$$

However, it also holds that  $\phi(l^p)w_F + \delta s^p(1-l^p)w_H > \phi(l^0)w_H$  and that  $\phi(l^p)w_H + \delta s^p(1-l^p)w_H > \phi(l^0)w_H$ , implying that  $U'(c_F^p) < U'(c_H^0)$  and that  $U'(c_H^p) < U'(c_H^0)$ , which contradicts (A6).  $\square$

**Proof of Lemma 3.** We prove the lemma by contradiction. Let us assume that  $s^0 = 0$  and thus, from Lemma 1.I, we have that  $\phi'(l^0) \geq \delta$  or, equivalently, that  $l^0 \leq (\phi')^{-1}(\delta)$ .

The condition  $V_l(l^0, 0, 0) = 0$  together with  $V_{ll}(l, 0, 0) < 0$  implies that  $V_l((\phi')^{-1}(\delta), 0, 0) \leq 0$ , which is in contradiction with the assumption of the lemma.  $\square$

**Proof of Lemma 4.** Whenever  $l \neq 0$ , the conditions  $U'(c_0) > U'(w_H)$  and  $\rho\delta [pU'(w_F) + (1-p)U'(w_H)] > \rho\delta [pU'(c_F) + (1-p)U'(c_H)]$  hold. Under the assumption of the lemma, these conditions imply that  $V_s(l, s, p) < 0$  whenever  $l \neq 0, 1$ , and in particular for  $(l^p, s^p)$ . Consequently, we have that  $s^p = 0$ .  $\square$

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