

Immigration Options for Skilled Labor and Optimal Investment in Human Capital

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Abstract

We model the decisions to invest in local and global human capital under immigration option. Such an option enables the agent to move to another country when an stochastic "quality of life" index reaches a certain threshold. The agent takes the whole global human capital accumulated in the origin country but only a portion of local human capital will be valued in the destination. Foreseeing this effect, the agent chooses the path of investment in human capital differently from the case of no option. We set up the model and then use numerical procedures to generate various comparative statics.

1 Introduction

In recent years, theory of investment under uncertainty and real options has expanded its domain beyond areas of financial decision making. Analysis of settings in which full or partial irreversibility in decision making, uncertainty and

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embedded options are typical potentially yield quite different policy implications than those in which such issues are absent or assumed away. Just as investment decisions of a firm, individual decision making can be analyzed within such a framework. Recent work on real options and human capital investment is a case in point. Jacobs (2007), for instance, studies investment in human capital under irreversibility and uncertainty and finds that embedded options lead to higher required returns on human capital investment. Hogan and Walker (2007) analyze the education choice under uncertainty and derive policy implications for taxation and education subsidies.¹

Our aim, in this paper, is to understand the policy implications of the immigration option as well as the brain drain phenomenon from the perspective of investment under uncertainty. We model a highly-skilled agent with an option to immigrate and who decides how much to invest in "global" and "local" human capital. In this context, the global human capital mainly refers to technical skills valued all over the world and local human capital refers to those skills valuable mainly in a specific geographical or political/cultural region. Examples of investing in local human capital are learning or getting education in local languages, acquiring knowledge of local business regulations, building social networks and gaining region-specific skills. In a sense, investment in one's global human capital is similar to holding a liquid asset. In our context, this liquidity arises because global human capital represents the transferable part of total human capital. The agent can transfer global human capital worldwide at little or no decrease in value: the agent could look forward to a similar utility gain elsewhere in the world. On the other hand, local human capital is mainly region- or country-specific, which may render it superfluous in other parts of the world. Transfer of any such human capital can result in significant loss of

¹Other papers that recognize the option characteristic of human capital investment include Burda (1995), Feist (1998) and Katz and Rapoport (2005).

value. As opposed to global human capital, therefore, it represents the illiquid part of total human capital.

The distinction between global and local human capital is crucial to analyze, in particular, in the analysis of the brain drain phenomenon. There is a strand of literature that studies whether brain drain spurs economic growth and human capital development in the source country. Articles such as Vidal (1998), Stark, Helmenstein, and Prskawetz (1998) and Mountford (1997) argue that the *possibility* of emigration could save the source country from the poverty trap by increasing the fraction of people investing in human capital in the hopes of emigrating.² Beine, Docquier, and Rapoport (2001) present a theoretical model in which the option to emigrate determines *ex ante* optimal level of investment in human capital (brain effect) and *ex post* probability of immigration (drain effect). Using a cross-section regression, they conclude that the hypothesis that immigration option can have positive effects on human capital accumulation could be supported. Although these arguments may hold, it comes with a qualification. The *type* of education that an agent considering emigration as a viable option chooses to receive can differ from another who values less such an option. At the same time, the agent must develop sufficient skills to ensure that she can earn a reasonable income in the source country in case the outside option becomes less valuable. To fix ideas, consider an individual living in an emerging country such as Turkey and who must decide between two universities to pursue education in business. One university provides education in the local language and the curriculum comprises mainly of courses designed to equip students with local knowledge of the business environment such as

²The mechanism is as follows: although the possibility to emigrate induces people to increase their investment in human capital, only a fraction of them will be able to actually emigrate, either due to recipient country regulations such as quota or source country regulations such as exit visas. The fraction that remains in the country will therefore raise average productivity. For such a result to obtain, probability of emigration should be sufficiently high.

local business law. The school is reputable for placing graduates in state institutions. The second choice is another university that provides education in English with greater emphasis on international aspects. If the individual values the emigration option due either to her preferences or to exogenous factors such as the wage differential, she is more likely to opt for an education in the second university. Since only a fraction of those who acquire "global" human capital at the second university could actually emigrate, the consequence is that remaining agents will be equipped with less "local" human capital element.

The question of whether local knowledge (notably language skills) is a critical factor in determining an agent's wage is not easy to answer. A simple regression of wages versus language proficiency is subject to huge endogeneity bias. Even using instrumental variables does not solve the problem entirely as many instruments used to capture language ability and not other factors like local networks, may indeed proxy for other unobservable variables such as quality of education and mental/physical capacity. Berman, Lang and Silver (2000) report that language skills play an important role in the level of earning in high-skilled job while it does not change the income in the low-skilled jobs.

The problem studied in this paper is connected to the issue of brain drain and development in two ways. First, we endogenize the *composition* of human capital accumulated by the agent. To the best of our knowledge, the issue of level of accumulated human capital, on the one hand and the composition, on the other hand, has not been extensively studied in the literature.³ An exception is Poutvaara (2008) who develops an overlapping generations model exploring the effect of increased mobility on the provision of different types of education. Although that paper distinguishes between a more internationally-

³The composition of human capital has been studied at the firm and industry level. See, for instance, Neal (1995), Parent (2000) and Sturman, Walsh, and Chermie (2008).

oriented education and country-specific education, the model presented here is different in two important respects. First, in our model, the agent herself chooses the type of education. In Poutvaara (2008), the government screens agents into either an internationally-oriented education or a country-specific education. Second, we introduce uncertainty into the model. We argue the the possibility of emigration may increase the overall investment in human capital but it may cause overinvestment in some elements and underinvestment in others, which, in turn, may decrease the welfare level in the source country *ex post*. Moreover, we characterize the impact of previous period human capital investment on the probability of immigration. Under various settings for feasibility of immigration (free labor movement, quota system, random draw) we look at the relationship between level of human capital and realized immigration and also the feedback effect of this on optimal investment in early periods.

The basic mechanism of the model is as follows. Emigration option is motivated by a stochastic real wage ratio process between the country where the agent is currently living and accumulating human capital and another country where she can emigrate to. The agent observes the random changes in the wage differential. When the wage gap is sufficiently high (i.e. reaches a certain threshold) she exercises her emigration option. Exercising the emigration option requires both a lump-sum monetary cost and forgone future income of staying in the first country. In return, the agent receives the present value of income in the second country. Since the agent is rational, she considers the impact of this emigration option on the optimal rate of investment in local and global human capital and behaves accordingly. We assume in this paper that the agent continues to accumulate global human capital once she emigrates. On the other hand, only a fraction of local human capital is valuable in the destination country and when the immigration occurs the agent loses most of the previous investments

on this type of human capital and in other words all discounted future income stream generated by that. As a result she underinvests in local human capital and increases her investment in global one.

The model has several policy implications. First, from the point of view of developing countries, it indicates one possible channel that the difference in the level of welfare may have positive or adverse effect on growth rate of the developing world. Moreover, if one takes the model to the context of intra-developed-world emigration (for instance, migration from EU countries to US/Canada) the model can provide insights on the impact of various policy instruments on the residual human capital from temporary skilled workers. One such policy tool is the type of income tax levied on those who emigrate. In particular, an income-contingent tax may be more appropriate when there is uncertainty.

The rest of the paper is organized as follows. In Section 2, we introduce the model and derive the valuation equations. Section 3 then carries out numerical analysis and comparative statics. Section 4 discusses policy implications of the model. We conclude in Section 5.

2 The Model

Consider a risk averse agent who must decide how much to invest in her human capital. The accumulation of human capital allows the agent to earn wages in her country of residence. It can also help emigrate to another country where she can improve her expected lifetime earnings. However, not all types of human capital are equally valuable in the home country and the prospective destination country. In particular, let $g(t)$ and $k(t)$ denote, respectively, the *stock* of *global* and *local* human capital that the agent has accumulated by time

t. Global human capital refers to any knowledge and skill that can help the agent more easily find a job abroad. An Indian student who studies information technology and at the same invests in her language skills is an example. In this case, both the chosen profession and language skills are crucial factors in facilitating prospective mobility. On the other hand, local human capital is the accumulation of skills that are mainly valuable in the home country but need not be as crucial in the destination country. A person specializing in the local language of a small country can be an example. The agent in the model determines at what rate she accumulates global and local human capital. The law of motions are therefore given by:

$$\left. \begin{aligned} dg(t) &= u(t)dt, \quad u \in [0, \bar{u}] \\ dk_h(t) &= q_h(t)dt, \quad q \in [0, \bar{q}] \end{aligned} \right\} \quad (1)$$

where the initial stock of global and local human capital are given by g_0 and k_0 , respectively. Accumulation of human capital in the home country comes at a quadratic cost:

$$c^h(u, q) = \frac{c_1 u^2}{2} + \frac{c_2 q_h^2}{2} \quad (2)$$

where $c_1, c_2 \in \mathbb{R}_{++}$ are constants.

Next, we turn to the modeling of the option to emigrate. The agent has an irreversible option to emigrate to another country. The decision to emigrate is motivated by an index of quality of life. Quality of life can essentially incorporate factors such as security, labor market conditions, schooling and education opportunities and real wages. For simplicity, normalize the life quality in the home country to 1. Denote the quality-of-life ratio of the destination country to the home country by the process $w(t)$. We assume that this ratio follows a

geometric Brownian motion:

$$dw(t) = \mu w(t)dt + \sigma w(t)dB(t) \tag{3}$$

where $dB(t)$ denotes the increments of a standard Brownian motion and μ and σ are the constant drift and diffusion parameters. The riskless interest rate in the home country economy is fixed at r and satisfies $r > \mu$. In addition to optimizing the investment rates in global and local human capital, the agent must also endogenously determine the optimal time to apply for emigration. The optimal time to emigrate is characterized by a stopping time τ defined as $\tau \equiv \inf \{t > 0 : w(t) \geq w^*\}$. In this formulation, w^* is said to be the trigger value of the quality of life differential that induces the agent to emigrate. It is important to note that this trigger is a function of the stock of global and local human capital accumulated by the agent. In particular, one should expect that w^* is an decreasing function of the global human capital, $g(t)$.

Emigration to another country is costly and uncertain. The literature discusses the importance of social networks for migration dynamics. Vergalli (2008), for instance, draws attention to the importance of an extant immigrant community in the destination country. Such a network may facilitate integration provided that the the community is not oversized. In our model, the network may pertain to business contacts in the country of residence as well as to the lack of such a community in the destination country. Although an immigrant community may facilitate integration into the destination country, the agent is nevertheless likely to lose the established network in the home country and establish a new one in the destination country. On top of the network effect, the agent may have to give up some benefits accrued to her in the home country such as pension plans. The model summarizes these costs by I . Economically,

I captures the opportunity cost of moving to another country. Note that due to the above factors, I can indeed be an increasing function of the stock of human capital accumulated by the agent. For simplicity, we take this cost as a fixed, one-time cost incurred at the time of emigration, τ .

Having described the human capital accumulation process and the option to emigrate, we can now turn to the payoff functions. From the standpoint of the agent, accumulating local human capital is more valuable to maintain subsistence in the home country while investing in global human capital increases the value of the option to emigrate. We capture the tradeoff between investing in global and local human capital in the payoff functions. In particular, assume that only a fraction, $\beta \in [0, 1]$, of the local human capital accumulated in the home country is valuable in the destination country. Furthermore, the agent stops accumulating local human capital pertaining to the home country after emigration. Therefore, after emigration, her stock of home-country local human capital is fixed at $k_h(\tau) = \bar{k}_h$. The agent, however, continues to optimize her global and local human capital in the destination country after emigration. It is important here to distinguish between local human capital in the home country and the local human capital in the destination country, $k_d(t)$. The fact that the agent loses some of her local human capital accumulated in the home country and must start over to accumulate local human capital in the destination country increases the option value of waiting before emigration. The law of motion for the local human capital after emigration is given by:

$$dk_d(t) = q_d(t)dt \tag{4}$$

The cost of accumulating human capital in the destination country is gain assumed to be convex:

$$c_d(u, k_d) = \frac{c_3 u^2}{2} + \frac{c_4 q_d^2}{2} \quad (5)$$

The payoffs in the home country, π^h , and in the destination country, π^d , are given by:

$$\left. \begin{aligned} \pi_h(g, k_h, w) &= U_h(g(t) + k(t)) - \frac{c_1 u^2}{2} - \frac{c_2 q_h^2}{2} \\ \pi_d(g, k_d, w) &= U_d(w(g(t) + k_d(t) + \beta \bar{k})) - \frac{c_3 u^2}{2} - \frac{c_4 q_d^2}{2} \end{aligned} \right\} \quad (6)$$

where $u(\cdot)$ is a strictly concave utility function.

With this given structure, the agent has to solve a 2-stage optimal control problem with an optimal stopping time. We tackle the problem by first conditioning upon the decision to emigrate and derive the optimal investment in global human capital and the associated value function in the immigration country (second-stage problem). Given this value function, the initial stage problem is solved.

After the agent has emigrated, the agent optimizes $u(t)$ to maximize:

$$\max_{u, q_d} V(g, k_d, w) = \mathbb{E}_\tau \left\{ \int_\tau^T \pi^d(g, k_d, w) e^{-rt} dt \right\} \quad (7)$$

where T denotes the finite terminal time. The variable T is the time horizon of the agent. It is intended to capture the impact of age on the human capital accumulation. Age is an important factor for countries trying to attract skilled labor. Furthermore, as the agent ages, the option to emigrate may have less value since the opportunity costs of moving rise.

Optimizing the Bellman equation yields the following rule for investment in global human capital after emigration:

$$\left. \begin{aligned} u^*(t) &= \frac{V_g(t)}{c_3} \\ q_d^*(t) &= \frac{V_{k_d}(t)}{c_4} \end{aligned} \right\} \quad (8)$$

After emigration, investment in global and local human capital in the destination country relates positively to the marginal products of an additional unit of investment, V_g and V_{k_d} and negatively to the cost parameters, c_3 and c_4 .

On the other hand, before emigration, the agent optimizes both u and q and chooses τ to maximize:

$$\max_{u, q_h, \tau} Z(g, k_h, w) = \mathbb{E}_0 \left\{ \int_0^\tau \pi_h(g, k_h, w) e^{-rt} dt + e^{-r\tau} [V(g, k_d, w) - I] \right\} \quad (9)$$

Similar arguments establish that the agent invests in her global and local human capital taking into account the marginal products of each and the cost parameters:

$$\left. \begin{aligned} u^*(t) &= \frac{Z_g(t)}{c_1} \\ q_h^*(t) &= \frac{Z_{k_h}(t)}{c_2} \end{aligned} \right\} \quad (10)$$

Note that equations (8) and (10) imply that the investment rates are discontinuous at the optimal exercise of the emigration option. That is, the rate at which the agent accumulates global human capital jumps from $\frac{Z_g(\tau)}{c_1}$ to $\frac{V_g(\tau)}{c_3}$ while the investment rate in local human capital jumps from $\frac{Z_{k_h}(\tau)}{c_2}$ to 0. Using (8) and (10) in the Bellman equations yields a system of nonlinear, second-order PDEs. In particular, we have the following system before and after emigration,

respectively:

$$\left. \begin{aligned} \frac{\partial Z}{\partial t} + \frac{1}{2}\sigma^2 w^2 \frac{\partial^2 Z}{\partial w^2} + \mu w \frac{\partial Z}{\partial w} + \frac{1}{2c_1} \left(\frac{\partial Z}{\partial g} \right)^2 + \frac{1}{2c_2} \left(\frac{\partial Z}{\partial k_h} \right)^2 - rZ + U_h(g + k_h) &= 0 \\ \frac{\partial V}{\partial t} + \frac{1}{2}\sigma^2 w^2 \frac{\partial^2 V}{\partial w^2} + \mu w \frac{\partial V}{\partial w} + \frac{1}{2c_3} \left(\frac{\partial V}{\partial g} \right)^2 + \frac{1}{2c_4} \left(\frac{\partial V}{\partial k_d} \right)^2 - rV + U_d(w(g + k_d + \beta \bar{k}_h)) &= 0 \end{aligned} \right\} (11)$$

In the next section, we resort to numerical procedures to characterize the value functions and the ensuing optimal policies of the agent.

3 Numerical Analysis and Comparative Statics

In this section, we numerically solve the system (11) and investigate the time path of both global and local human capital. The numerical results show, in particular, how the dynamics of human capital acquisition change with the parameters of the model and the introduction of the option to emigrate.

One important feature of the paper is that it takes a real options approach to model emigration. Therefore, Figure 1 compares the dynamics of human capital accumulation with an without the option to emigrate. When the agent has no option to emigrate, both global and local human capital increase over time. Note also that stock of local human capital is higher than that of global human capital. This contrasts with the time path of human capital when the agent has an option to emigrate. Although both global and local human capitals start at similar levels, the agent accumulates global human capital at a faster rate than that of local human capital. This is because global human capital allows the agent to take advantage of any difference in quality-of-life differential between the two countries while local human capital in the home country is of limited value, captured by the parameter β in the model. A second important effect of the emigration option concerns the monotonicity of the stock of human capital.

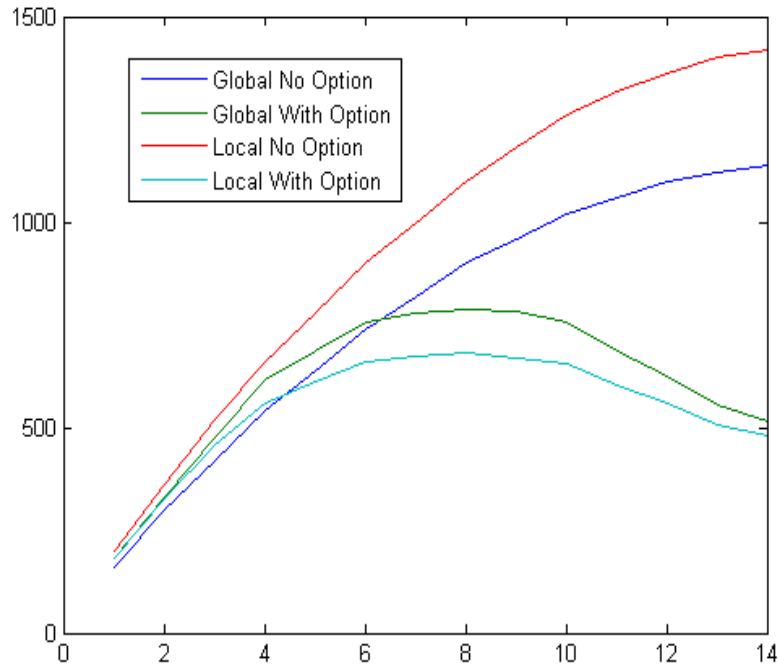


Figure 1: Impact of Immigration Option on Global and Local Human Capital. The horizontal axis represents time while the vertical axis shows the stock of human capital.

As opposed to the monotonic increase in both global and local human capitals without the option, human capital first increases then decreases over time. In other words, the emigration option causes a brain drain effect over time as the emigration option is exercised.

Figures 2 and 3 illustrate the comparative statics with respect to volatility for global and local human capitals, respectively. Figure 2 plots the time path of global human capital stock for high and low volatility. Although global human with high volatility starts at a higher initial level, it eventually decreases below that with low volatility. This is in line with standard real options models of

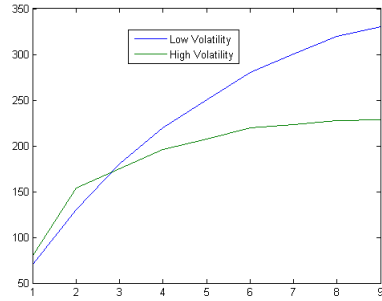


Figure 2:

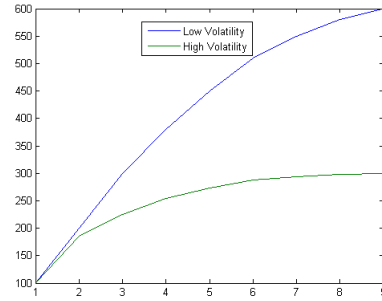


Figure 3:

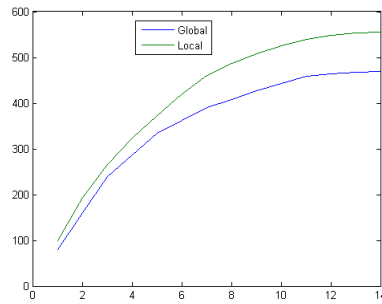


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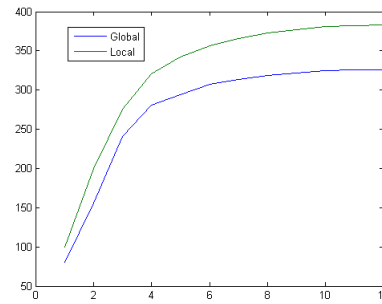


Figure 5:

investments in which volatility increases the value of waiting. Since a higher volatility increases the emigration trigger, the agent accumulates less global human capital when volatility is high. Interestingly, the same effect is observable for local human capital level in Figure 3. Although local human capital is initialized at the same value, higher volatility implies a slower accumulation of local human capital.

Recall that the model posits that only a fraction of local human capital accumulated in the home country can be transferred to the destination country after emigration. Figures 4 and 5, therefore, compare investment in global and local human capitals over time for low and high transferability parameter, β . In

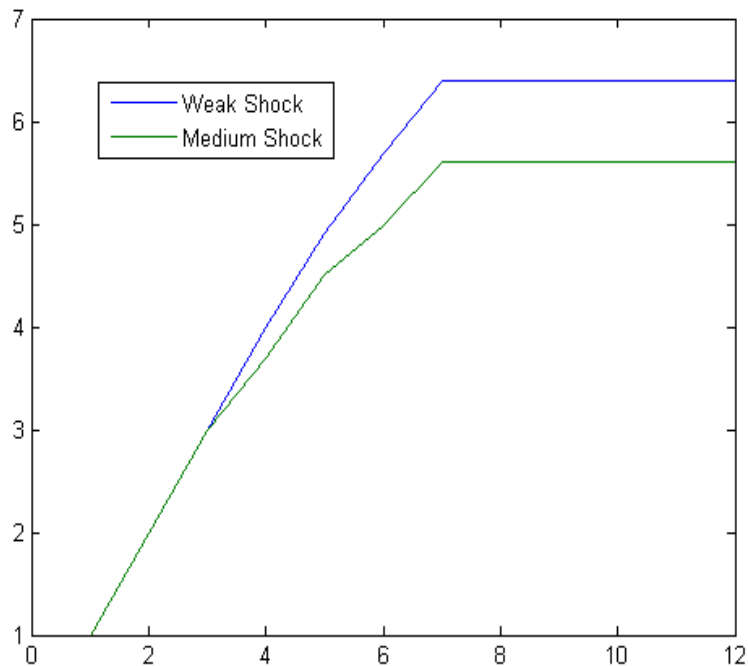


Figure 6:

both figures, stock of local human capital is higher than that of global human capital. Although the stock of human capital does not change significantly for high and low β , the wedge between local and global human capitals increases when β becomes large. In other words, a higher transferability of local human capital induces the agent to accumulate more of it.

In Figure 6, we explore the role of expectations in the accumulation of local human capital. On the vertical axis, therefore, the stock of local human capital is plotted against time. The figure shows the stock of local human capital for two different levels of shocks, weak and medium. The emigration trigger, \bar{w} , has been normalized to the same level and is shown by the kink in the figure. When

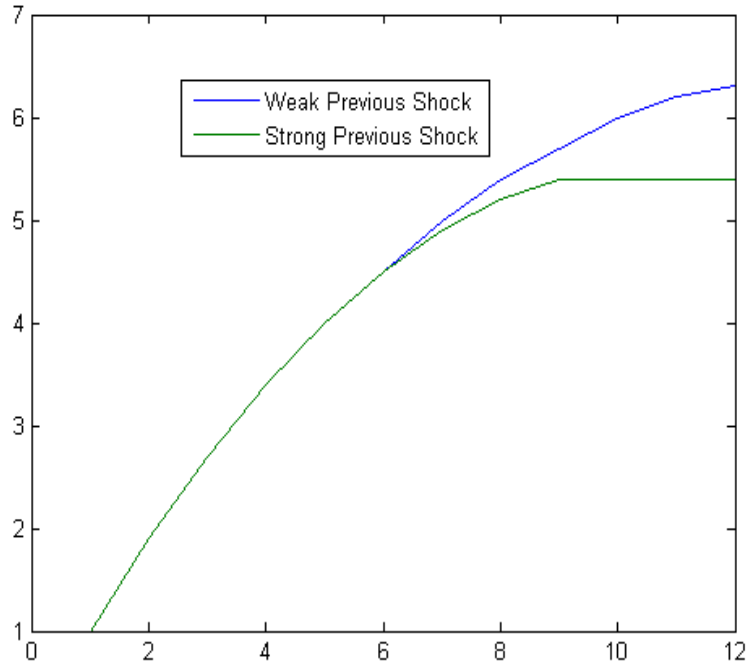


Figure 7:

the agent is subject to a weak shock, she expects to reach the emigration trigger at a later date than if she were subject to a higher shock. Therefore, with weak shocks, the agent accumulates more local human capital. Put differently, lower expectations about the prospect of emigration lead the agent to invest more in her local human capital.

What implications does the history of local human capital accumulation have for the eventual emigration decision? Figure 7 investigates the effect of accumulating different levels of local human capital on the emigration decision for 2 agents. The underlying assumption in Figure 7 is that one agent is subject to a weaker shock than the other agent. Figure 6 showed that weaker shocks lead the

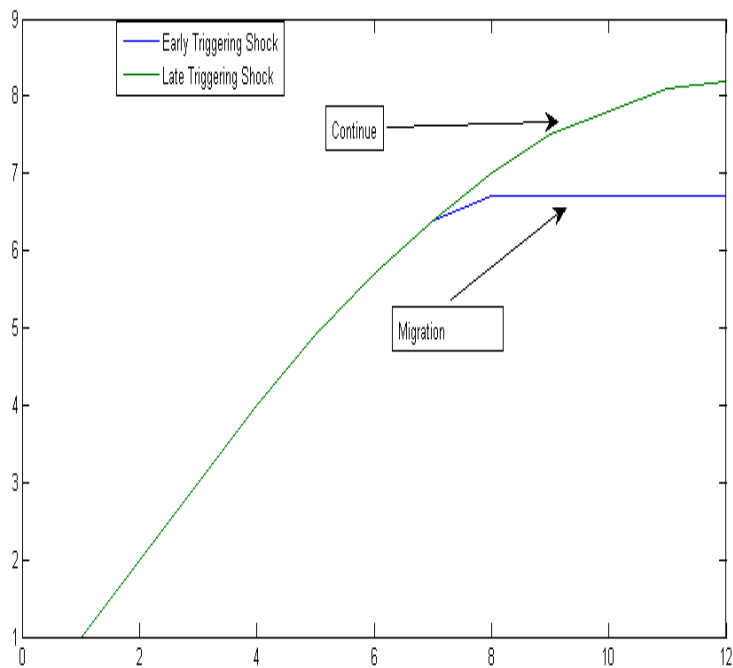


Figure 8:

agent to accumulate more local human capital. After letting agents accumulate different levels of local human capital, we subject both agents to the same sample path of the shock process. As can be seen in Figure 7, the agent with less local human capital emigrates at an earlier date than the agent with more local human capital. The agent who has been subject to a stronger previous shock emigrates after about 9 years whereas the agent subject to the weaker shock continues to accumulate human capital in the home country. In other words, this figure goes to illustrate the significance of quality-of-life differentials among countries for the option to emigrate.

In Figure 8, we are interested in the effect of an early or late realization of a high shock that might induce the agent to take the emigration option. Figure 8 shows that when the agent is closer to the terminal time, she continues to accumulate more local human capital and requires a higher quality-of-life differential to emigrate.

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