Investing in Education:

A Sequential Model with Neighborhood-Effects

Mirjam Szillery

Central European University

Department of Economics

In partial fulfilment of the requirements for the degree of Master of Arts

Supervisor: Professor Adam Szeidl

Budapest, Hungary

June, 2015

Abstract

In this paper I analyze the impact of family background on schooling outcomes in the presence of neighborhood-effects. I build a sequential model of educational decisions of the parents and the children. Parents make initial investments in early childhood development and the children later choose the optimal schooling level. Costs of schooling are influenced by the average neighborhood schooling outcome, while returns are affected by initial parental investment and family background. The agent have correct expectations regarding the average schooling outcome and the parents properly anticipate how the child will decide as a function of the early investment level. I find that in the subgame perfect equilibrium of this model, the direct effect of the neighborhood and family background on schooling outcome are multiplied through expectations of the parent. Furthermore, I find that on the long run the initial family background can determine the dynamics of schooling outcomes through generations, where with a low initial level of family background a poverty trap might occur.

Acknowledgments

First, I would like to express my sincerest gratitude towards my supervisor, Professor Adam Szeidl for the valuable discussions and feedback he provided during the process of writing this thesis. I am very thankful for Daniel Horn, who contributed greatly to my understanding of empirical regularities. I am also truly grateful for Pellumb Reshidi and Attila Gyetvai for all their ideas and helpful comments on my work.

Contents

1 Introduction

It is generally observed that children from families with higher incomes and education are themselves more likely to achieve higher education levels (Psacharopoulos and Patrinos, 2004).[1] However, the reasons for this empirical regularity are not evident. A traditional explanation is that families with low income are credit-constrained, therefore they are not able to achieve an optimal level of education (Barham et al., 1995, Solon, 2004). This theory seems to have relevant explanatory power in developing countries (Banerjee, 2004); however, in developed countries it is less supported by empirical research (Carneiro and Heckman, 2002, Shea, 2000, Cameron and Taber (2004), Keane and Wolpin, 2001). A growing literature focusing on the importance of early childhood development, with the seminal work of Cunha et al. (2006), finds that early childhood has a large effect on educational outcomes. However, in the existing literature these factors are generally treated as given, thus, early childhood parenting is not modeled as an economic decision of rational agents.

Motivated by this, in my thesis I build a sequential model of educational decisions of the parents and the children, where the parents make initial investments in the children's early skill formation, while the children decide about the additional schooling that they acquire after completing a mandatory schooling level. Both the decisions of the parents and the decisions of the child affect the future income of the child, which is further affected by the family background, which I capture with a specific parameter. Consequently, background variation will be the main determinant of the possibilities available to the child. Beyond exogenous factors, in my model costs of education also depend on the expected average neighborhood schooling level. This can be argued for via several factors such as gaining

[1] Estimated correlations between education of parents and children for different countries vary between 0.4 and 0.6. (Hertz et al., 2007, Chevalier, 2004) .

motivation from others, having lower alternative costs of leisure when peers are studying, or having better school- and teacher-quality in an environment with a high number of ambitious students. My main focus is the effect that the initial differences in children's background has on educational outcomes, and the implications of these results.

The model consists of two decision making periods. Initially parents decide how much time to invest in the improvement of the child's abilities at an early age. In the subsequent period, after acquiring a mandatory level of education, the child decides how much more years to study. After the chosen level of schooling is complete, payments are realized. When parents decide how much time to invest in the child's early ability forming period, they take into account their effect on the schooling decision of the child, while children take early investment levels as given. The neighborhood schooling equilibrium is reached when the expected average schooling is equal to the actual average schooling level.

In this framework, neighborhood-effects not only have a direct effect on schooling by lowering costs for the children, but also as schooling has an effect on returns and costs of investment, parental investment is indirectly effected by the neighborhood effect as well, which further effects the child's optimal schooling decision. The first main finding of the model is that the total effect of the neighborhood on schooling outcomes is much larger than direct effects. With my parametric assumptions the total neighborhood-effect is twice as large as the direct effects on the child's optimal decision. This effect also operates through early investments that have the same sign and magnitude as the direct effect. This implies that policies targeting neighborhood or peer effects will have a larger impact if they are implemented in a early stage that affects parents decision-making as well. Consequently, numerous empirical studies that identify the magnitude of the neighborhood-effects by analyzing the effects of changing neighborhood at a school age, by ignoring the indirect effect, are unable to identify the whole magnitude of the impact of neighborhoods on schooling outcomes. There are some recent findings on the importance of the timing of neighborhood changes. Chetty et al. (2015) find that moving to a better neighborhood has no effect on educational outcomes for children older than 13, while it substantially effects education decisions if this change happens when the child is young. Unfortunately, at this stage, there is little evidence on the effects of neighborhood changes before schooling age.

More generally, family background effects are also multiplied through different channels. The second main result of my analysis is that the total effect of family background is multiplied to even a larger extent, with my parametric assumptions it is more than three times larger than the direct effect. The total effect is composed of the direct effect it has on children's decision of schooling levels, the indirect effect through investment, which, with the assumed functional forms is twice as large as the direct effect, and a multiplication effect through neighborhood-effects. The intuition for this result is that family background directly impacts the optimal decisions in both stages, while also indirectly affecting early parental investment via the change in schooling. One of the main implication of my model is that expectations play a substantial role in the impact that family background has. This finding differs from the existing literature as it underlines the importance of assuming endogenous initial parental investment.

Moreover, in environments where there is segregation based on early childhood abilities, which in my model depend greatly on family background, the role of family background is further amplified. This comes as a result of family background also determining the neighborhood in which both the parent and the child make the optimal decision. For example, if there is an orientation to group children who are not likely to continue to higher education later on, in one group, and promising children in another, then, family background will have also greatly shaped the surrounding environment of these children. This environment further effects the child and the parent via neighborhood-effects. There are empirical findings on how different environments effect the impact of family background. For exampleBauer and Riphahn (2009) find that earlier school tracking increases intergenerational educational persistence. However, at this stage, there is not much evidence on how expectations of neighborhood-effect multiplies the impact of family background.

Finally, a natural extension of this framework is to link family background with the previews generation's education level. I assume this decision making process is repeated numerous times, and also that next period's family background is a function of current schooling outcomes. With certain properties of this function, I identify a critical level of family background, under which schooling decreasing over generations, while above which schooling increases over generations. An interpretation of this finding is that as the effect of family background is multiplied through several channels, families with initial low background levels can be trapped in poverty. If returns to schooling are affected by family background in a multiplicative manner, long run determinacies of this nature become more likely. Thus a possible change that could raise schooling above the critical value will have permanent, growing effect on schooling. This potentially great long term effect can reveal that optimal short run oriented policies, such as ones advocating for segregation, can prove to be greatly inefficient in the long run.

The rest of this paper is organized as follows. In Section 2 I characterize the setup of the baseline model. I describe the costs and returns to education and the decisions of the parent and the child. In Section 3 I present the outcomes of the model and my main findings regarding the effects of family background and neighborhoods. In Section 4 I add two extensions. Firstly, I demonstrate an illustration of the repeated version of my model. Second, I describe a case with heterogeneous agents and show the implications of its results. In Section 5 I conclude the main findings with policy implications of my model.

2 The Model

The model consists of two parts: the initial investment decision of the parents and the schooling decision of the child. First, parents decide how much time to invest in improving the child's abilities at an early age ($t = 1$). In the subsequent period ($t = 2$) the child decides how much additional years to study. Thus, when the child reaches the age limit of mandatory schooling, he can make a decision about how many more years to study, and afterwards I assume the agent must commit himself to this decision. In the last period ($t = 3$), when the chosen school level is completed, payments are realized. I rely on the subgame perfect Nash equilibrium concept to solve this model.

First, I describe costs and returns of education in the model, as this point is crucial in my analysis. Then I examine the child's decision using the logic of backward induction as I assume that parents take the child's expected behavior into account when deciding about early investments. Finally, I describe the decision of the parents at the initial state.

2.1 Costs and returns to schooling

Investment in education has different costs distributed in the first two time periods. First, at $t = 1$, parents can choose to invest a particular amount of hours (h) in raising the skill stock of their child. Costs increase in the magnitude of the investment. For convenience I choose the following functional form to represent the initial costs:

$$l(h) = \frac{1}{3}h^3$$

Second, in $t = 2$ there are costs of schooling including fees, efforts of the child, additional alternative costs such as not earning a wage, and so on. These costs are increasing in schooling (s) and decreasing in the years of schooling that others choose in the neighborhood ($\bar{s}$). The latter assumption represents the neighborhood effect. I assume that the number of agents are large enough so that they do not take their own influence into account; hence the expected outcome of others is an exogenous variable for the agents. In the baseline version of my model I assume that a neighborhood consists of homogeneous agents, having the same family background. For convenience I choose the following functional form [2]:

$$C(s,\bar{s}) = \frac{s^2}{2\sqrt{a\left(1+\alpha\bar{s}\right)}}$$

The assumption that the environment has an effect on schooling decisions is supported by numerous empirical works. School-quality can differ due to the variation in resources in different neighborhoods. Card and Krueger (1990) find that school and teacher quality explain a substantial part of the variation between schooling outcomes. Peers can also have an impact through social norms, motivation and expressed effort (Akerlof and Kranton, 2002). A given environment can affect the behavior of the agents via the information access it provides. As Streufert (2000) shows, if some families in a less privileged neighborhood do not observe the upper part of the income distribution, they underestimate the return to education and choose suboptimal levels.

The following functional form represents returns to schooling and initial investment:

$$P(b,h,s) = bhs$$

Where b represents family background, h represents hours that parents invest in the child's early skill formation, and s represents the additional schooling years (above the minimal required by law) that the child decides to pursue. The payoff from education increases in the number of completed schooling years and in initial parental investment. The former assumption is a usual and straightforward one. While for the latter is largely motivated from empirical research on the effect of early parental investment on final outcomes. A growing literature emphasizes the importance of early childhood development on later outcomes. Cunha

[2] This cost function presents the net present value of these costs discounted to the second period.

et al. (2006) claim that early childhood investment has high returns and is a compliment to later years in education.

Payments also depend on family background (b) which is an exogenous parameter for the agents. The better the family background, the higher the payment will be. The interpretation of this is that for parents with better educations (and conditions in general), the same time investment in their child's early years has higher returns. Many factors make this relationship valid. The fact that the education of parents might have an impact on the productivity of the time spent on improving the skills of the children, leads to different levels of time spent on early childhood development. Guryan et al. (2008) find that there is a strong positive relation between parental education, and time spent with children that is not explained with general patterns of leisure. Furthermore, there is strong evidence, that children from families with low incomes have worse health conditions, which clearly has implications on the child's education as well (Currie, 2009). Returns can be higher with a better family background as a result of superior connections, and the importance and practicality of family reputation (Neuman, 1991). Moreover, genetic factors might play some role as well (Black and Devereux, 2011).

2.2 Investment in skill formation

The importance of initial investment in skill formation, in this framework, originates from the fact that it effects later payments from schooling. In reality, both costs and payments from schooling are expected to be dependent on skills. However, when modeling, it is sufficient to make one of thee factors dependent on skills, as only relative terms matter. Thus, I choose the payments of schooling to be dependent on parental investment on skill formation. I assume perfect altruism in the case of the parent and the child as well. I apply this assumption as I have found that allowing for imperfect altruism would not change my main findings, and because the results are more comparable to other models without imperfect altruism. A version of this model with imperfect altruism can be found in A.2. The utility of the parent is therefore the following:

$$U_{parent} = \delta P(b, h, s) - \delta C(s, es) - l(h)$$

2.3 Optimal schooling choice

After setting up assumptions regarding the cost structure, I specify the decision of the child. In the second period ($t = 2$), which I interpret as the time when the child has just completed mandatory years of schooling, she decides to invest in education to maximize her utility. The agent can choose to study any number of extra years (treated as continuous). Thus, from now on, schooling outcomes refer to the additional schooling years after the mandatory schooling period. As discussed above, both agents have perfectly altruistic preferences, consequently, regardless of who actually pays the costs, they will appear in both the utility function of the child and the parent[3]:

$$U_{child} = P(b, h, s) - C(s, \bar{s})$$

Having specified the model, in the next section I find the subgame perfect equilibrium and interpret the results.

[3]Including the costs of initial investment in the child's utility function is not necessary as cost has already been realized in a previous time period, thus the child can not impact it.

3 Results

Proposition 1: *In the subgame-perfect equilibrium of this model, the initial investment level of the parents and the chosen level of schooling by the child are:*

$$h = b^2\delta\sqrt{a(\alpha\bar{s}+1)} \tag{1}$$

$$s = b^3\delta a(\alpha\bar{s}+1) \tag{2}$$

Moreover, under the assumption of agents with homogeneous family background, the optimal quantities become:

$$h = b^2\delta\sqrt{\frac{a}{1-a\alpha b^3\delta}} \tag{3}$$

$$s = \bar{s} = \frac{ab^3\delta}{1-ab^3\alpha\delta} \tag{4}$$

(For derivations of these values see A.1)

From these optimal decisions, it becomes clear that the neighborhood-effects individual schooling level through different channels. Firstly, it has a direct effect on schooling by directly changing the costs for the child. Secondly, as schooling has an effect on returns and costs of investment, parental investment decisions are also influenced, leading to an additional indirect effect.

When I solved for the optimal value of schooling as a function of neighborhood average schooling and family background parameter (equation(2)), the optimal level of investment is already substituted and the optimal level of schooling is only a function of parameters and neighborhood. If we take the derivative of this expression with respect to neighborhood average schooling we get the total effect of neighborhood in the subgame perfect Nash equilibrium. However, to understand more through what channels neighborhood-effects operate, this derivative can be expressed as a sum of the neighborhood-impacts on the child's and the parent's decision, expressed as a function of the decision of the other[4]:

$$\frac{ds(\bar{s},b)}{d\bar{s}} = \underbrace{\frac{\partial s(\bar{s},h,b)}{\partial \bar{s}} |_{h(s)=\bar{h}}}_{Direct\ Effect} + \underbrace{\frac{\partial s(\bar{s},h,b)}{\partial h}\frac{\partial h(s(\bar{s}),b)}{\partial s}\left(\frac{\partial s(\bar{s},h,b)}{\partial \bar{s}} |_{h(s)=\bar{h}}\right)}_{Indirect\ Effect} \tag{5}$$

Proposition 2: *The indirect effect of the neighborhood on schooling has the same sign and magnitude as the direct effect, thus, the total neighborhood effect on schooling outcome is twice as large as the direct effect.* (The explicit calculations can be found in).

As costs are decreasing in neighborhood-effects, when schooling increases due to an improvement of the neighborhood, marginal returns of investment from the increased schooling will be higher than the increased marginal costs, therefore initial parental investment will increase as well (see in). neighborhood-effects are accordingly multiplied through expectations at the initial time period. All effects are operate in the same direction as neighborhood effect changes (positive derivatives).

This result differs from previous analysis as it takes into account how expectations about the neighborhood affect initial investment decision and how this has an additional effect in schooling outcomes. This is important for several reasons. Firstly, policies that aim to improve neighborhood or peer effects will have a much larger impact if parents expect its effects to be long lasting. By long lasting I mean that the parents take into account that the policy may change their children's school choices in the future. Secondly, this points out that estimations that attempt to identify the magnitude of neighborhood-effects by analyzing effects of changing neighborhoods at a school age, are unable to identify the whole impact of

[4]Substituting the equilibrium values into the derivatives gives back the the total effect on schooling in subgame perfect Nash equlibrium.

neighborhoods to schooling outcome, since these studies will miss the initial effect that this change has on parents decisions.

From the results obtained above, it can be seen that family background effects are also multiplied through different channels. Initially, the return to early parental investment increases in family background and schooling. The latter is effected by family background in itself as well. Furthermore, if the neighborhood is composed by agents with the same family background, the effect of family background is strengthened by neighborhood-effects as well.

As before, when I solved for the optimal value of schooling as a function of neighborhood-effects and parameters, such as family background parameter, (equation(2)), the optimal level of investment is already substituted and the optimal level of schooling is only a function of parameters and neighborhood. If we take the derivative of this expression with respect to the family background parameter we get the total effect of background in the subgame perfect Nash equilibrium. However, to understand more through what channels family background operates, this derivative can be expressed as a sum of the neighborhood-impacts on the child's and the parent's decision, expressed as a function of the decision of the other.[5]

Proposition 3: *Family background affects the optimal schooling decision via three channels: (1)the direct effect to schooling, (2) the indirect effect through investment, which is twice as large as the direct effect, and (3) a multiplication effect operating through neighborhood-effects.* (The explicit calculations can be found in).

$$\frac{ds(\bar{s},b)}{db} = \frac{\overbrace{\frac{\partial s(\bar{s},h,b)}{\partial b}\Big|_{h(s)=\bar{h}}}^{Direct\ Effect} + \overbrace{\frac{\partial s(\bar{s},h,b)}{\partial h}\frac{\partial h(s(\bar{s}),b)}{\partial b}}^{Indirect\ Effect}}{\underbrace{\left[1-\frac{\partial s(\bar{s},h,b)}{\partial \bar{s}}\right]}_{Multiplication\ Effect}} \qquad (6)$$

The intuition behind this result is that in both stages family background enters as a pa-

[5]Substituting the equilibrium values into the derivatives gives back the the total effect on schooling in subgame perfect Nash equlibrium.

rameter determining the returns to education, and in the first stage it also enters indirectly through the parents expectations about the schooling level chosen by child. An additional effect originates if the neighborhood is composed of agents with the same family background, in both stages the expectations towards this neighborhood enters as well when deciding about the optimal level of investment or schooling. Consequently, through the two stages and the interaction effects between different agents family background becomes more and more important.

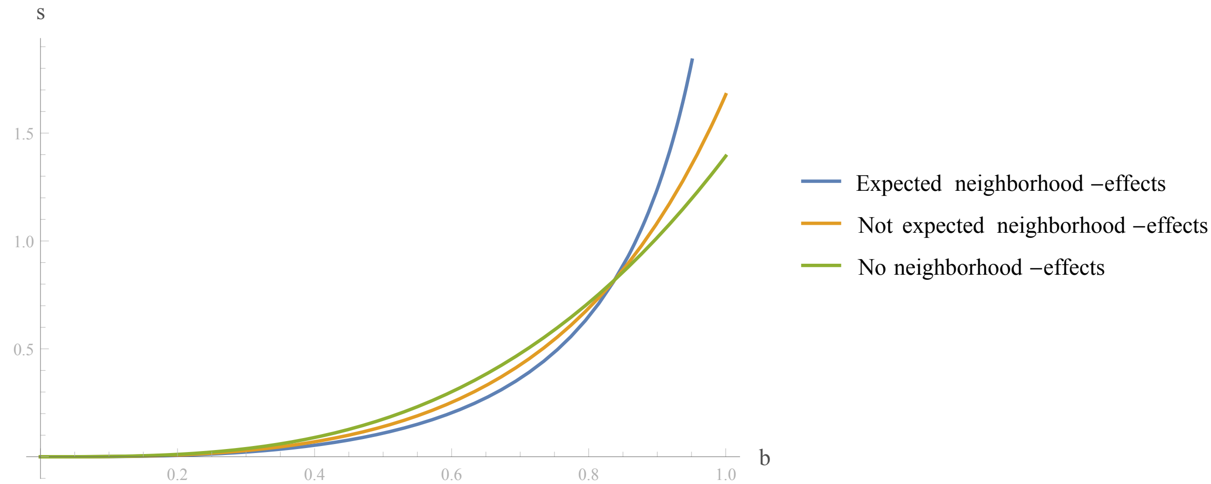
This finding differs from the existing literature as it underlines the importance of assuming endogenous initial parental investment. As returns to initial investment is increasing in both family background and expected schooling, and returns to education is also increasing in both family background and initial investment, the effect of family background are multiplied. One of the main implication of my model is that expectations plays a substantial role in the impact that family background has. This comes as a result of agents expecting other members to act in accordance with a given background parameter, thus, this variable becomes even more important, than its per se effect. Modifying the extent to which family background effects optimal decisions in a single stage, will indirectly effect the decision making process in other stages as well. For example, if there is mandatory schooling until a given age, for certain individuals (for those who would otherwise choose lower schooling levels than is mandatory) schooling becomes higher than without the policy. In these cases, the policy will additionally effect early childhood investment through increased returns, as well as through expectations regarding the average schooling level of the neighborhood (especially in the homogeneous agents case). Thus, potentially, through these effects the child can be made better off even if his decision set became more constrained.

Furthermore, a homogeneous neighborhood strengthens the impact that family background has, where $\frac{1}{\left[1-\frac{\partial s}{\partial \bar{s}}\right]}$ will be the multiplication parameter[6]. This multiplicative effect operates

[6]This should be always bigger than one, because if $\frac{\partial s}{\partial \bar{s}}$ is not smaller than one, there is no equilbrium in peer effects to begin with. In our case this multiplication parameter is $\frac{1}{1-a\alpha b^3\delta}$.

through all channels in which family background influences schooling decisions. The figure below (Figure 1) illustrates this by showing how family background determines schooling in three cases.

Figure 1: Schooling outcome as a function of family background



In Figure 1 there is a starting point of family background (at the crossing point of the curves) for which we have an equilibrium. Imagine, that family background moves away from this point, for instance as a consequence of a transfer that helps families (in this case we move to the right from this point). Reaction to such a change will be affected by supposed neighborhood-effects.I consider three different setups. The first setup is the baseline model, with neighborhood-effects and with parents taking into account these neighborhood-effects. In the second case neighborhood-effects still operate, but parents does not take this into account, they calculate with the costs that were determined by the earlier neighborhood-equilibrium. In the last case, there are no neighborhood-effects, costs are not affected by the change in family background. This thought experiment shows the role of the two channels through which neighborhood operates. Neighborhood-effects make schooling more responsive to family background, and the total affect is a composition of the direct effect and the indirect effect through expectations when the early investment decision is made.

4 Extensions

In this section I present two extensions of the baseline model. Firstly, I show an illustration of the repeated version of my model to interpret what kind of implications does the multiplicity of effects might have regarding the intergenerational dynamics of schooling. Second, I describe a case with heterogeneous agents and I also show how implications might change on long term.

4.1 Long term outcomes

A natural extension of this framework is to link family background with the previews generation's education level. As the background parameter mostly captures factors that are connected to the parents' education, such as productivity in child-enhancing activities, or access to good healthcare, it seems plausible to consider that current schooling outcomes will be transformed in a given way to a family background parameter in a repeated version of my model. Thus, we can consider a case when b, the parameter representing family background, is a function of previous periods schooling. By doing so, I attempt to capture a long-term intergenerational version of the model. After assuming a certain functional form that transforms schooling outcome to next period's family background, we can analyze the dynamical behavior of family background and schooling.

To formalize this, we can introduce the concept of a transition function ($b_{t+1} = f(s_t)$), that captures the way current schooling will be transformed into some level of background nect period. The dynamics of schooling outcomes depends on the relationship between this transition function and the impact of family background on schooling outcomes (equation (4)). For a certain initial value of b, if the transition function is above the the schooling outcome, the value of b will decrease to a lower equilibrium point, while if the transition function is below the schooling outcome function, b will increase. As a demonstration, a simple example of the transition function is when family background b, is a linear function of previous period's schooling ($b_{t+1} = c\bar{s}_t$). As was previously shown, schooling is a convex function of family background, implying that the dynamics will depend on the initial level of family background.

Assumption: The transition function is a linear function of schooling in the following form: $f(\bar{s}_t) = cb_{cr}$, where: $\frac{a\delta}{1-a\alpha\delta} < c < \frac{3a\delta}{(1-a\alpha\delta)^2}$.

Under the above assumption, I state the following proposition.

Proposition 4: *There exists a threshold of family background, under which schooling decreasing over generations, while above which schooling increases over generations.* (The exact value can be found at .)

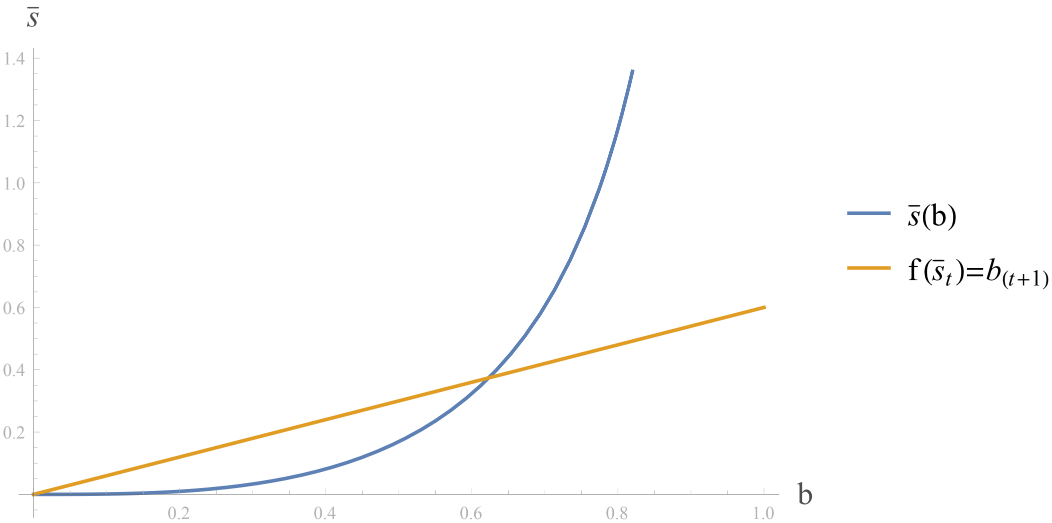
The intuition behind this claim is that if family background is low, schooling will be even lower in relative terms (because of the multiplicative effect of family background on schooling), therefore this level of schooling will be transformed into an even lower level of family background in the next period. So with an initially low level of background there will be a decreasing trend until family background and schooling reaches the minimum level. The minimum in my model is when the background parameter is zero, and children decide not to study any more years after the mandatory school years. While if family background is high enough, it will have a large enough effect so that it is transformed into a higher family background than the current one. With a high level of inital family background education has a growing trend, until it reaches some maximum, if it exists[7].

The main property that makes this type of dynamics possible is that the effect of family background on schooling is increasing (thus the higher the background level is, the more it impacts the optimal schooling level), as a result of the multiplicative nature of family background on equilibrium schooling. The illustration of this can be seen in Figure 2, where I plot the equilibrium schooling function and the transition function. Starting with some initial level of family background, the equlibrium schooling function gives us the corresponding schooling outcome. If we project this value vertically to the transition function, we get the

[7]The existence of a maximum depends on the parameter-values. In my model it can be infinity in the limit, when $b \to 1$ and $a \to 1$.

value of the next period's background. From this, we can see next period's schooling and by repeating this we can observe the dynamics of schooling with different initial level of background.

Figure 2: Dynamics of schooling outcomes



The interpretation of this finding is that as the effect of family background is multiplied through several channels, families with low background levels can be trapped in poverty. Since returns to schooling are affected by family background in a multiplicative manner, a long run deterministic outcome becomes more likely. A change that could raise schooling above this critical value will have permanent, growing effect on schooling.

The implication of this model, via the addition of this extension, is that policies that can move agents out from this poverty trap on the long term are highly beneficial, as their effects multiply through time. However, the effect of a policy that can achieve a change not sufficient to move the schooling level beyond the critical value will disappear through time. Thus creating a great distinction in the long term effects between policies, in those that can and those that can not shift schooling level beyond the critical threshold.

4.2 Agents with different family backgrounds

In the previous section I considered an equilibrium schooling level for agents with homogeneous family backgrounds. To analyze the neighborhood-effects in a setting where the backgrounds of the agents may differ, consider a case where there are two different types of family background levels in the neighborhood. The equilibrium in neighborhood-effects is reached when average neighborhood schooling equals its expected value, thus, solving the following equation leads to the average schooling in the neighborhood and the schooling outcomes of the children with the two different background:

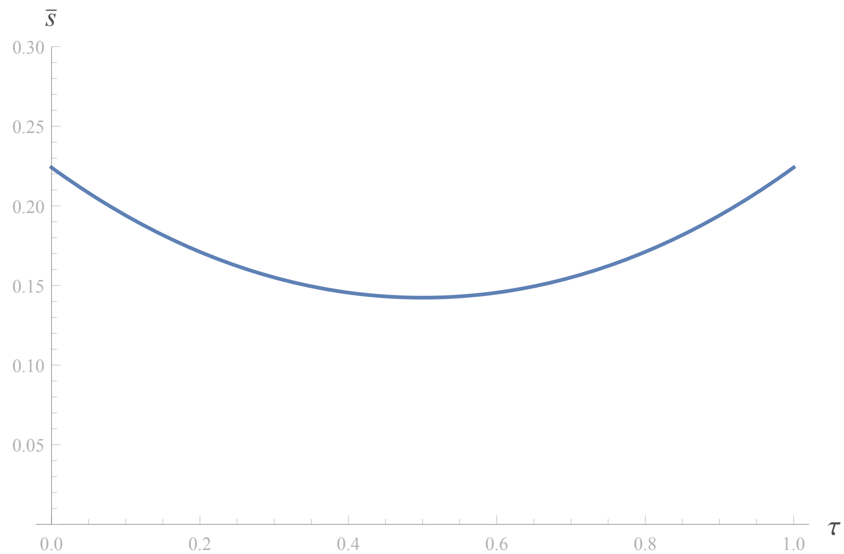
$$\lambda a b_1^3 \delta(\alpha \bar{s} + 1) + (1 - \lambda) a b_2^3 \delta(\alpha \bar{s} + 1) = \bar{s}$$

Consider also that we are able to create two separate classes from the low and high background students. And we can decide what fraction of the students with a low background to position in the first class, τ, leaving the remaining 1-τ of the students with a low background in the other class. Looking at the derivative of schooling outcome with respect to neighborhood average schooling level (see equation below) it is noticeable that the impact that the peer-effect has on the optimal schooling level, directly depends on the background level (the higher the family background is, the more responsive is the schooling level towards the average level of schooling).

$$\frac{ds}{d\bar{s}} = a\alpha b^3 \delta$$

This implies that within this framework increasing the fraction of students with a low background has a higher negative impact on students with high background levels, than on students with low background levels. Empirical research seems to support this claim as well, where, several papers find that peer effects impact good students more significantly(Sacerdote, 2011). This higher responsiveness of the high background level students implies that in this framework if we would want to maximize total schooling, segregation would be optimal. The graph below shows how total schooling changes as a function of the fraction of low background students we decide to put in a class. The graph is symmetric, since when we decide to position a τ fraction of the bad students in the first class, by default the 1-τ fraction will be positioned in the second class. As can be seen in the graph the total schooling of both classes, is maximized when either all low background students are in the first class, or either when all low background students are in the second class. Thus, total segregation, because of the above discussed reasons, maximizes total schooling.

Figure 3: Total schooling as a function of τ



This, however, will not necessarily be the case in the long run. It could be the case that segregation can lead one of the groups to have a quite low schooling level, one that is below the threshold identified in the previous subsection(as was discussed in 4.1). As a consequence, this group would be caught up in the poverty trap and experience a fall in its education levels with each passing generation. Consequently, this can lead to a decrease of total schooling in the long run. However, consider a case in which separating the group of low background students into both classes changes the average schooling level in both classes such that schooling outcomes of students with both types of family backgrounds become above the previously identified threshold. In this case, since none of the classes will be caught in the poverty trap, going from segregation to an integrated system can increase long term efficiency. The aim of this section is to point out the importance of the time horizon that the policy considers, where, while a short term oriented policy may find segregation to be optimal (since it lowers the "total costs"), a long term oriented policy can find the opposite approach optimal, by integrating low and high background students, it can ensure that no one is caught in the poverty trap.

5 Conclusion

My model underlines the importance of expectations in decisions that build on each other, and their implications for optimal educational outcomes. My first main finding is that the total effect of neighborhood on schooling outcomes is twice as large as the direct effect, as it also operates through early investments. This indirect effect has the same sign and magnitude as the direct effect. My second main result is that the total effect of family background is composed of (1) the direct effect on optimal schooling outcomes, (2) the indirect effect through investment (which I find to be twice as large as the direct effect), and (3) the multiplication effect operating through neighborhood-effects. The third main finding is that if we assume this game is repeated several times, and assume that next period's family background is a function of the current schooling outcome, with certain properties of this function, there exists a critical level of family background, under which schooling decreasing over generations, while above which schooling increases over generations.

From this framework, several policy implications arise. Firstly, if instead of a perfectly coordinated family model, we assume a sequential decision model of parents and children on educational investments, policies that restrict the decision set of the children might prove to be Pareto improving. Policies that represent a credible commitment, such as age limit of mandatory schooling, can change parental investment in a way that children benefit from loosing the option to quit school earlier.

Secondly, policies that aim to improve neighborhoods of students with low backgrounds, not only influence optimal decision during school years, but even at an earlier age if they are expected to last for a period long enough for the parents initial decisions to be affected. Thus long term policies might not only have a greater impact because of their longer effects in school years, but also because of their effect on expectations and changed early investment behavior. This implies that experiments that measure neighborhood-effects by moving families when the child is already in school age might not measure the whole effect of neighborhoods on educational outcomes.

Thirdly, I pointed out that short term and long term optimal policies may drastically differ. As was seen, although in the short run segregation may prove to maximize total schooling, on the long run, since there are more factors to be taken into account, such as potential poverty traps, there may be cases in which an integrated system outperforms tracking programs.

A Appendix

A.1 Solving the model

Child's maximization problem

Utility of the child:

$$U_{child} = P(b,h,s) - C(s,\bar{s}) = bhs - \frac{s^2}{2\sqrt{a\left(1+\alpha\bar{s}\right)}}$$

Taking the derivative with respect to school years:

$$\frac{\partial U_{child}}{\partial s} = bh - \frac{s}{\sqrt{a(\alpha\bar{s}+1)}} = 0$$

Optimal level of schooling:

$$s = bh\sqrt{a(\alpha\bar{s}+1)}$$

Parent's maximization

Utility of the parent:

$$U_{parent} = \delta P(b,h,s) - \delta\nu C(s,es) - l(h) =$$

$$= \delta bhs - \frac{\delta s^2}{2\sqrt{a\left(1+\alpha\bar{s}\right)}} - \frac{h^3}{3} = \frac{h^2\left(3b^2\delta\sqrt{a\left(1+\alpha\bar{s}\right)} - 2h\right)}{6}$$

Taking the derivative with respect to initial investment:

$$\frac{\partial U_{parent}}{\partial s} = -\frac{ab^2\delta h\left(1+\alpha\bar{s}\right)}{\sqrt{a\left(1+\alpha\bar{s}\right)}} + 2b^2\delta h\sqrt{a\left(1+\alpha\bar{s}\right)} - h^2$$

Optimal investment level:

$$h = b^2\delta\sqrt{a\left(1+\alpha\bar{s}\right)}$$

Substituting optimal investment level in schooling years:

$$s = bh\sqrt{a(\alpha\bar{s}+1)} = b^3\delta a(\alpha\bar{s}+1)$$

Equilibrium in neighborhood-effects

In the case of homogeneous agents, $\bar{s}$ equals s. Solving this for to get the equilibrium schooling level:

$$\bar{s} = b^3 \delta a(\alpha \bar{s} + 1) = \frac{b^3 a \delta}{1 - b^3 a \alpha \delta}$$

I assume that $b^3 a \alpha \delta$ is smaller than one; otherwise there is no equilibrium in neighborhood-effects. $\alpha$and δ are at maximum one, so I in my analysis a and b can also be between 0 and 1, this guarantees that there is always an equilibrium in the neighborhood.

A.2 Solving the model with imperfect altruism

In this modified version of the model, I allow for different types of altruism. Payments from education are in the parent's utility with total weight, while costs can matter less. There is at least a part of the costs that the children pay (in effort at least), and parents might not care totally about these. The parameter ν is the sum of the fraction the parent pays and the fraction the children pays multiplied with a weight that expresses to what extent the parent care about costs of the children. The assumption that parents might not care about some costs that children pay while payoff from schooling appears in their utility leads to a paternalistic utility form (Bisin and Verdier, 2001); this expresses that parents are imperfectly altruistic and do not take some sources of utility of children into account, such as time spent with peers.

$$U_{parent} = \delta P(b, h, s) - \delta \nu C(s, es) - l(h)$$

As in the case of the utility of the parents, I assume that total costs are multiplied with a fraction (η) in the child's utility function. As before, this is not a fraction the child pays, but the sum of the paid fraction and the fraction the parents pay multiplied with a weight that expresses to what extent the child care about costs of the parent. So the two parameter both can be between 0 and 1, and they do not have to add up to one, but can take up any value between 1 and 2. However, to have a maximum of the parent's optimization, I restrict my analysis to cases where 2η is larger than ν. If 2η is bigger than ν, parent's utility is decreasing in h when we substitute the optimal decision of the child. In this case the value that maximizes utility of the parent is zero and there is no initial investment and schooling is also zero.

$$U_{child} = P(b,h,s) - \eta C(s,\bar{s})$$

Child's maximization problem

$$U_{child} = P(b,h,s) - \eta C(s,\bar{s}) = bhs - \frac{\eta s^2}{2\sqrt{a\,(1+\alpha\bar{s})}}$$

$$\frac{\partial U_{child}}{\partial s} = bh - \frac{\eta s}{\sqrt{a(\alpha\bar{s}+1)}} = 0$$

$$s = \frac{bh\sqrt{a(\alpha\bar{s}+1)}}{\eta}$$

Parent's maximization

$$U_{parent} = \delta P(b,h,s) - \delta\nu C(s,es) - l(h) =$$

$$= \delta bhs - \frac{\delta\nu s^2}{2\sqrt{a\,(1+\alpha\bar{s})}} - \frac{h^3}{3} = \frac{h^2\left(3b^2\delta(2\eta-\nu)\sqrt{a\,(1+\alpha\bar{s})} - 2\eta^2 h\right)}{6\eta^2}$$

This utility function only have a maximum with a positive value of h if $2\eta > \nu$.

$$\frac{\partial U_{parent}}{\partial s} = -\frac{ab^2\delta h\nu\,(1+\alpha\bar{s})}{\eta^2\sqrt{a\,(1+\alpha\bar{s})}} + \frac{2b^2\delta h\sqrt{a\,(1+\alpha\bar{s})}}{\eta} - h^2$$

$$h = \frac{b^2\delta(2\eta-\nu)\sqrt{a\,(1+\alpha\bar{s})}}{\eta^2}$$

then

$$s = \frac{bh\sqrt{a(\alpha\bar{s}+1)}}{\eta} = \frac{b^3\delta a(\alpha\bar{s}+1)(2\eta-\nu)}{\eta^3}$$

Equilibrium in peer effects

$$\bar{s} = \frac{b^3\delta a(\alpha\bar{s}+1)(2\eta-\nu)}{\eta^3} = \frac{b^3 a\delta(2\eta-\nu)}{\eta^3 - b^3\alpha\delta(2\eta-\nu)}$$

A.3 Decompositions

Family background

$$\frac{\partial s}{\partial b} = \frac{\partial s}{\partial \bar{s}}\frac{\partial \bar{s}}{\partial b} + \frac{\partial s}{\partial b}\,|_{h=\bar{h}} + \frac{\partial s}{\partial h}\frac{\partial h}{\partial b}$$

$$\frac{\partial s}{\partial b} = \frac{\frac{\partial s}{\partial b}\,|_{h=\bar{h}} + \frac{\partial s}{\partial h}\frac{\partial h}{\partial b}}{\left[1 - \frac{\partial s}{\partial \bar{s}}\right]}$$

$$\frac{\partial s}{\partial \bar{s}} = a\alpha b^3\delta$$

$$\frac{1}{\left[1 - \frac{\partial s}{\partial \bar{s}}\right]} = \frac{1}{1 - a\alpha b^3\delta} > 1$$

$$\frac{\partial \bar{s}}{\partial b} = \frac{3ab^2\delta\eta^3(2\eta-\nu)}{(1 - a\alpha b^3\delta)^2}$$

$$\frac{\partial s}{\partial b}\,|_{h=\bar{h}} = ab^2\delta(\alpha\bar{s}+1)$$

$$\frac{\partial s}{\partial h} = b\sqrt{a(\alpha\bar{s}+1)}$$

$$\frac{\partial h}{\partial b} = 2b\delta\sqrt{a(\alpha\bar{s}+1)}$$

$$\frac{\partial s}{\partial b} = 3ab^2\delta(\alpha\bar{s}+1) = \frac{\partial s}{\partial b}\,|_{h=\bar{h}} + \frac{\partial s}{\partial h}\frac{\partial h}{\partial b}$$

Effect of others

$$\frac{ds}{d\bar{s}} = \frac{\partial s}{\partial \bar{s}} + \frac{\partial s}{\partial h}\frac{\partial h}{\partial s}\frac{\partial s}{\partial \bar{s}}$$

$$\frac{\partial s}{\partial \bar{s}} = a\alpha b^3\delta$$

$$\frac{\partial s}{\partial h}\frac{\partial h}{\partial s}\frac{\partial s}{\partial \bar{s}} = \frac{\left(b\sqrt{a(\alpha\bar{s}+1)}\right)(a\alpha b^3\delta)}{2\left(b\sqrt{a(\alpha\bar{s}+1)}\right)}$$

A.4 Extensions

Long term critical value

The critical value of family background, is given by solving the following equation:

$$cb_{cr} = \frac{ab^3\delta}{1 - a\alpha b_{cr}^3\delta}$$

to have have a point for which this is satisfied in the relevant interval of b, the followings need to be true: $c < \frac{3a\delta}{(1-a\alpha\delta)^2}$ and $c > \frac{a\delta}{1-a\alpha\delta}$.

$$b_{cr} = \frac{1}{12\alpha}\left[\frac{4\sqrt[3]{-2}a\delta}{\sqrt[3]{3\sqrt{3}\sqrt{a^4\alpha^2c^3\delta^4\left(27\alpha^2c^3 - 4a\delta\right)} + a^2\delta^2\left(2a\delta - 27\alpha^2c^3\right)}}\right.$$

$$\left. -4 - \frac{2(-2)^{2/3}\sqrt[3]{3\sqrt{3}\sqrt{a^4\alpha^2c^3\delta^4\left(27\alpha^2c^3 - 4a\delta\right)} + a^2\delta^2\left(2a\delta - 27\alpha^2c^3\right)}}{a\delta}\right]$$

Theoretically there is more solution for the equation above, but after simulating this with several numerical examples, I saw that this the only positive root and for the values that the parameters can have, this simplifies to a real solution. Thus this is the one that expresses the critical value we are looking for.

References

Akerlof, G. A. and Kranton, R. E. (2002). Identity and schooling: Some lessons for the economics of education. *Journal of economic literature*, pages 1167–1201.

Banerjee, A. V. (2004). Educational policy and the economics of the family. *Journal of Development Economics*, 74(1):3–32.

Barham, V., Boadway, R., Marchand, M., and Pestieau, P. (1995). Education and the poverty trap. *European Economic Review*, 39(7):1257–1275.

Bauer, P. C. and Riphahn, R. T. (2009). Age at school entry and intergenerational educational mobility. *Economics Letters*, 103(2):87–90.

Bisin, A. and Verdier, T. (2001). The economics of cultural transmission and the dynamics of preferences. *Journal of Economic theory*, 97(2):298–319.

Black, S. E. and Devereux, P. J. (2011). Recent developments in intergenerational mobility. *Handbook of labor economics*, 4:1487–1541.

Cameron, S. V. and Taber, C. (2004). Estimation of educational borrowing constraints using returns to schooling. *Journal of political Economy*, 112(1):132–182.

Card, D. and Krueger, A. (1990). Does school quality matter? returns to education and the characteristics of public schools in the united states. Technical report, National Bureau of Economic Research.

Carneiro, P. and Heckman, J. J. (2002). The evidence on credit constraints in post-secondary schooling*. *The Economic Journal*, 112(482):705–734.

Chetty, R., Hendren, N., and Katz, L. F. (2015). The effects of exposure to better neighborhoods on children: New evidence from the moving to opportunity experiment. Technical report, National Bureau of Economic Research.

Chevalier, A. (2004). Parental education and child's education: A natural experiment.

Cunha, F., Heckman, J. J., Lochner, L., and Masterov, D. V. (2006). Interpreting the evidence on life cycle skill formation. *Handbook of the Economics of Education*, 1:697–812.

Currie, J. (2009). Healthy, wealthy, and wise: Is there a causal relationship between child health and human capital development? *Journal of Economic Literature*, 47(1):87–122.

Guryan, J., Hurst, E., and Kearney, M. S. (2008). Parental education and parental time with children. Technical report, National Bureau of Economic Research.

Hertz, T., Jayasundera, T., Piraino, P., Selcuk, S., Smith, N., and Verashchagina, A. (2007). The inheritance of educational inequality: International comparisons and fifty-year trends. *The BE Journal of Economic Analysis & Policy*, 7(2).

Keane, M. P. and Wolpin, K. I. (2001). The effect of parental transfers and borrowing constraints on educational attainment. *International Economic Review*, pages 1051–1103.

Neuman, S. (1991). Parental background, educational attainments and returns to schooling and to marriage: The case of israel. *Applied Economics*, 23(8):1325–1334.

Psacharopoulos, G. and Patrinos, H. A. (2004). Returns to investment in education: a further update. *Education economics*, 12(2):111–134.

Sacerdote, B. (2011). Peer effects in education: How might they work, how big are they and how much do we know thus far? *Handbook of the Economics of Education*, 3:249–277.

Shea, J. (2000). Does parents' money matter? *Journal of public Economics*, 77(2):155–184.

Solon, G. (2004). A model of intergenerational mobility variation over time and place. *Generational income mobility in North America and Europe*, pages 38–47.

Streufert, P. (2000). The effect of underclass social isolation on schooling choice. *Journal of Public Economic Theory*, 2(4):461–482.