Bringing Space into the Equation: Modeling Social and Spatial Interdependence in Neighborhood Effect Studies

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Abstract

While there is an ever-growing body of research on neighborhood effects on life chances, the suggested social mechanisms still refer to rather ambiguous theoretical concepts. Furthermore, past research generally fails to adequately model the suggested social interdependence at the individual level and instead largely relies on contextual regression models. This paper contributes to both problems by using spatial econometrics to reconstruct neighborhood effects at the individual level. To this end, a rational action model of neighborhood effects is elaborated as a theoretical alternative. Furthermore, using data on the transition to secondary schooling in Switzerland, spatial probit models are used to empirically test different channels of neighborhood effects at the individual level. As expected, neighbors' educational motivation and aspirations, namely the expected utility and the instrumentality of a given educational track, are crucial mediators that contribute to the reproduction of educational inequalities.

Keywords: Neighborhood Effects, Educational Attainment, Rational Choice, Spatial Econometrics, Social Multipliers

Introduction

Although rational choice approaches are quite successful at explaining educational inequalities at the individual level (Breen and Goldthorpe 1997; Breen and Jonsson 2005), the growing literature on contextual and compositional effects on educational outcomes suggests that there might be more to the story (Garner and Raudenbush 1991; Ainsworth 2002; Goldsmith 2009). According to the latter perspective, educational achievement and attainment (as well as other forms of people's life chances) can only be partly explained by individual decisions and are crucially mediated by social contexts such as the school or neighborhood. In regard to the explanatory social mechanisms, however, these contextual influences are usually rather vaguely formulated and researchers refer to broad theoretical concepts such as collective socialization or the epidemic spread of norms (Sampson et al. 2002; Galster 2012; for a critical assessment of such explanations: Boudon 2014).

The present contribution attempts to link the two streams of research. Following the question of how compositional and contextual effects can be explained in an action-centered framework, we focus on the social interdependence of individual decisions and choices within a given context, namely the neighborhood. A theoretical framework is elaborated, which shows how the individual educational motivation and aspirations as well as the subjective assignment of investment risks to different educational tracks are shaped by one's immediate as well as wider social context. To this end, a long line of research on the role of significant others and reference groups (Merton 1957; Sewell, Haller, and Portes 1969; MacLeod 2011), as well as the role of social capital and intergenerational closure (Coleman 1988; Carbonaro 1998; Morgan and Sorensen 1999) is considered. On the one hand, incorporating social interdependencies in the evaluation of the individual theoretical parameters enlarges the explanatory power of a rational choice explanation of educational inequalities without abandoning its theoretical core. On the other hand, such an

approach allows for the formulation and an adequate empirical assessment of the individual level mechanisms in the study of contextual effects in general and in regard to neighborhood effects in particular.

However, by enlarging the theoretical focus in the outlined manner, the need for an adequate treatment of the well-known challenges in the assessment of contextual and compositional effects arises. In this regard, the problem of unobserved selection effects and the simultaneity of interdependent actions are especially crucial concerns (Manski 1993; Galster and Hedman 2013). Furthermore, the social interdependence of people's actions in a given context, say the neighborhood, requires a methodological framework that abandons the assumption of identical and independently distributed observations (Beck et al. 2006). Drawing on data on the educational attainment of pupils at the first transition from primary to secondary school in Switzerland, the present contribution uses spatial econometric techniques in order to adequately model the interdependence of social action within a given context (LeSage and Pace 2009; Elhorst 2014). In doing so, it can be shown how people's educational decisions and careers are not only the result of individual reasoning but also of others' choices and actions within the neighborhood, thereby drawing a more accurate picture of people's social realities. At the same time, the theoretical and especially the methodological framework offers a toolkit for the better understanding and modeling of contextual effects. Finally, understanding the effects of intertwined educational choices in different contexts also bears potential in regard to formulating more adequate policies for reducing educational inequalities (Sewell et al. 1969; Galster 2012). Making use of the multiplying effects of social interdependencies and taking context into account, such policies can promote educational equality beyond the effect of programs that target single individuals.

Background

Putting educational inequalities into context(s): Assessing the evidence

Scholars have proposed different theoretical frameworks for explaining educational inequality: from the role of individual aspirations (e.g. Sewell et al. 1969; Page et al. 2007) to compositional effects in different types of schools (e.g. Coleman et al. 1982). However, when it comes to explaining persisting influences of student's social origins on their later educational and occupational positions in modern societies (Shavit and Blossfeld 1993; Breen and Jonsson 2005), one particular model of educational decision making has received special attention in the literature. Building on Boudon's (1974) distinction of primary and secondary effects of social origin, Breen and Goldthorpe (1997) present a theory of educational inequalities in terms of a rational action framework, focusing on class differentials in the subjective assessment of costs and benefits of different educational alternatives as well as the assigned probabilities of a successful outcome. Ever since, scholars have further developed and extensively tested the validity of this framework (e.g. Becker 2003; Breen and Jonsson 2005; Holm and Jæger 2008).

Although quite successful in explaining class differentials in educational attainment, this approach assumes that the evaluation of the explanatory parameters (e.g. the costs and benefits) is a purely individual cognitive and motivational process. This view of independent actors, however, is challenged by evidence on neighborhood and peer effects in other contexts (e.g. classrooms and schools) in which one's own educational outcome is partly produced by others' background and behavior (e.g., Ainsworth 2002; Hanushek et al. 2003; Harding et al. 2011; Sacerdote 2011). On the one hand, such effects can take the form of contextual influences due to a shared environment or others' background characteristics, thereby denominating an exogenous effect ($E\left(X_{j\neq i}\middle|Z\right)'$ in equation (1), where Z defines the reference group. On the other hand, if caused by others' current behavior or outcome ($E\left(Y_{j\neq i}\middle|Z\right)$), it is referred to as an endogenous effect (Manski 1993; Sacerdote 2011). Keeping in mind that people choose where to live and which school their children should attend—and that these choices are a function of one's resources and preferences (Lee et al. 1994; Gordon and Monastiriotis 2006)—these exogenous and endogenous effects of context add a further dimension to class differentials in educational inequality.

$$Y_i = \alpha + E(Y_{j\neq i}|Z)\rho + X_i\beta + E(X_{j\neq i}|Z)\gamma + \varepsilon_i \quad (1)$$

Evidence for such effects—although still controversially discussed—can be found in various contexts. Building upon Wilson's (1987) seminal work of the epidemic spread of norms and behavior in areas of concentrated poverty, scholars have reported negative effects of low-status neighborhoods on various types of children's educational outcomes (Crane 1991; Garner and Raudenbush 1991; Harding 2003; Galster et al. 2007). Moreover, research concerned with the theory of collective socialization, focusing on the influence of local social networks, peers, and high status neighbors as role models, has found positive impacts of advantaged neighborhood environments on educational achievement and attainment (Rosenbaum 1995; Ainsworth 2002; Goux and Maurin 2007; Brännström 2008). Finally—and somewhat more directly related to a rational action framework—evidence on peer effects at the school or classroom level stresses the importance of considering heterogeneous rather than linear-in-means effects—as introduced in equation (2) by the interaction with individual i's background variables (Hoxby and Weingarth 2005; Sacerdote 2011). Similar arguments can be found in the literature on neighborhood effects, shortly outlined above. Not only do such contextual and compositional effects on educational outcomes most likely differ according to the individually available resources and therewith with social status (Greenman et al. 2011; Sharkey and Faber 2014) but there is also evidence for distinct effects for different social groups in varying contexts (e.g., the beneficial impact of peers with similar performance and background as oneself (Sacerdote 2011; Zangger 2015)).

$$Y_i = \alpha + \sum_{z=1}^{Z}[E(Y_{j\neq i}|z \in Z) \times X_i]\rho_z + X_i\beta + \sum_{z=1}^{Z}[E(X_{j\neq i}|z \in Z) \times X_i]\gamma_z + \varepsilon_i \quad (2)$$

Summing up the evidence, the social background and behavior of others seems to have an effect upon one's own educational career. Hence, an action-based explanation of educational inequalities needs to take these contextual and compositional effects into account and integrate them into a coherent model. Only in that case we are able to fully and adequately describe the process of individual educational decisions. However, what might such a model look like?

Rational Decisions and Social Interdependence

To see how we can integrate contextual effects and social interdependencies into a rational action framework, let us start with the theoretical parameters of interest at the individual level. In the classical setup of Eriskon and Jonsson (1996), the expected utility U_k of an educational alternative k is determined by the commonly held beliefs about its benefits B_k for future outcomes (e.g., the desired class position) and the therewith associated costs C_k of continuing in education. Furthermore, it is influenced by the subjective beliefs about the likelihood π_k of successfully completing the given alternative. Stressing the importance of relative risk aversion, Breen and Goldthorpe (1997) provide a framework how the shared goal of avoiding downward social mobility together with the success probability π_k—shaped by the knowledge of one's own ability (i.e., primary effects according to Boudon (1974))—and the available resources to make up for the costs C_k, lead to the reproduction of class differentials in educational attainment. A generalized version of this framework of maximizing the subjectively expected utility proposes that an educational alternative k is chosen over l, if

$$U_k = \pi_k B_k + [(1-\pi_k)p_k(-SD) - C_k] > \pi_l B_l + [(1-\pi_l)p_l(-SD) - C_l] = U_l, \quad (3)$$

where $p_{k,l}$ is the likelihood of the expected amount of status decline $-SD$ for the alternatives k and l, respectively (Erikson and Jonsson 1996; Breen and Goldthorpe 1997; Becker 2003). More generally, it follows that the alternative k is chosen if $B_k + p_k \times (-SD) > C_k/\pi_k$.

While π_k, C_k, p_k, and—as a consequence—U_k in equation (3) differ according to individual social origin (Breen and Goldthorpe 1997), the question remains why and how they should be influenced by contextual factors—particularly the educational decisions and behavior of others. In this regard, we can primarily think of two—on first sight contradictory—mechanisms through which the interdependence of the theoretical parameters might work. To start with, let us assume a societal consensus in regard to the hierarchical ordering of social positions ('social classes') and therein of education as a positional good (Breen and Goldthorpe 1997). For the sake of convenience and in accordance with the latter empirical illustration, imagine that an individual i (a student or her parents) is confronted with a decision whether to follow one of two educational alternatives k and l which we might call "higher" and "lower" track. Each of the two tracks is associated with different utilities $U_{k,l}$ to end up in certain social positions. Let S denote a service class position and let us further assume that $U_k(S) > U_l(\mathrm{S})$. Given the literature on peer effects in the formation of aspirations and their role in the reproduction of educational inequalities (e.g. Sewell et al. 1969; Coleman 1988; Carbonaro 1998; Morgan and Sorensen 1999; Page et al. 2007; MacLeod 2011), it can be assumed that aspirations within a given context (e.g., a classroom, a network of peers) are interdependent. However, aspirations do not enter directly in the above outlined model. Nevertheless, in a rational action framework we can think of aspirations $A_i(k)$ $A_i(l)$ as an individual i's motivation for the alternatives k and l, respectively. As others have pointed out (Esser 1999; Becker 2003), the educational motivation for alternatives k and l is given by

$$A_i(k) = B_k + p_k \times (-SD) \quad \text{and} \quad B_l + p_l \times (-SD) = A_i(l). \tag{4}$$

Hence, the empirically documented interdependence of aspirations, translated into a rational action framework, can be expected to happen through one or several of the parameters $B_{k,l}$, $p_{k,l}$, or $-SD$. As outlined above, the original model assumes a societal consensus regarding the hierarchical order of different social positions.[1] Thus, the educational motivation of acquiring a given status can be expected to mutually contribute to and be influenced by this consensus. More specifically, we can assume an effect of this consensus on the individual assessment of the risk of status decline $p_{k,l}$. Given individual social status, one's beliefs about the risk of status decline when pursuing alternative k are partially shaped by the interaction with others. In these interactions one obtains information about other's assessment of p_k, which in turn contributes to the formation of the mentioned societal consensus. A similar argument can be made in the case of the benefits B_k. Although the individual assessment of the benefits of alternative k are assumed to be constant within a given social stratum (Esser 1999; Becker 2003), the exchange with others might change its evaluation—especially in the case of cross-cutting social ties (Burt 2000; McPherson et al. 2001; MacLeod 2011). Finally, the importance attributed to maintaining one's social status ($-SD$) most likely constitutes an individual assessment—at least in the present rational action framework. Although the societal context clearly structures in how far a decline in social status can be termed a 'loss', it seems rather unlikely that the interaction with others directly changes one's evaluation of a potential status decline. Thus, so far we can rewrite the educational motivation for tracks k and l as

$$A_i\big[k|A_j(k)\big] = A_{i,k} + \theta_{j,k} w_{ij} \underbrace{\big[B_{j,k} + \big(p_{j,k} \times -SD_j\big)\big]}_{A_j(k)}$$

and

$$A_i\big[k|A_j(l)\big] = A_{i,l} + \theta_{j,l} w_{ij} \underbrace{\big[B_{j,l} + \big(p_{j,l} \times -SD_j\big)\big]}_{A_j(l)}, \tag{5}$$

[1] In the original framework of Breen and Goldthorpe (1997) this process is captured in the societal consensus regarding the parameters α, β, and γ which express the expected returns to various educational outcomes.

where w_{ij} is an element of a binary contiguity matrix $\boldsymbol{W}$, indicating whether two observations i and j are 'neighbors'. In addition, the likelihood $\pi_{k,l}$ of successfully completing alternatives k and l is assumed to be interdependent due to the same arguments just made for $p_{k,l}$. Although one can imagine that the subjective evaluation of the costs might also change as a function of additional information provided by others, the effective costs $C_{k,l}$ can generally be assumed to be fixed. Hence, the individual assessment of the costs is not expected to change with other's evaluation. When it comes to the investment risk $C_{k,l}/\pi_{k,l}$ (Esser 1999; Becker 2003), we therefore would expect an interdependence—if at all—to work through $\pi_{k,l}$.

Focusing on the assumed direction of the interdependence, however, a second assumption about the explanatory mechanisms can be made. While we would generally expect a positive correlation between two interdependent observations i and j with regard to the evaluation of $B_{k,l}$, $\pi_{k,l}$, and $p_{k,l}$ ('social learning'), the very nature of a stratified educational system also suggests negative effects in terms of the likelihood of attending the higher, more advantageous track. To this end, imagine a classroom of N elementary students whose parents are all motivated to send their children to the higher of the two tracks k and l, i.e. $B_{i,k} + p_{i,k} \times (-SD_i) > B_{i,l} + p_{i,l} \times (-SD_i) \quad \forall i \in \{1, \dots, N\}$. Let us further assume that only half of all the elementary students of said classroom will be able to attend the higher track due to limited places. As previous research has shown (e.g. Becker 2003; Breen and Jonsson 2005), higher educational motivation for track k increases the propensity to actually attend it—independently of a student's performance. Hence, a particular student's probability of attendance can be expected to diminish as the educational motivation of other parents increases. Given partial knowledge of the ratings of others and the educational performance of their children, one might therefore adjust own educational motivation.

In the present context we therefore expect a positive interdependence of the outlined theoretical parameters in the neighborhood context. If one's neighbors assign a high value to the benefits $B_{k,l}$, the likelihood of success $\pi_{k,l}$, and the instrumentality $p_{k,l}$ of educational tracks k and l, then one's own rating is expected to increase as well (*Hypothesis 1*). On the other hand, the last mentioned restriction is likely provoke negative effects in the case of the higher track. The higher the educational motivation of neighbors for the more advantageous track, the lower the likelihood that one's child will attend said track (*Hypothesis 2*). Before we turn to the empirical evaluation of these hypotheses, we present the data and the methodological strategy—namely how the social interdependence in equation (5) enters into the analysis in form of direct and indirect multiplier effects (Durlauf and Ioannides 2010).

Data & Methodology

In order to model the outlined interdependence within a shared neighborhood, we rely on spatial econometrics as an adequate methodological framework. Using data on elementary students' educational career and achievement in two Swiss cities (Zangger 2015), we are able to explicitly model the multiplicative effect of aligned decision making within the presented theoretical framework.

Analytical Strategy

To determine how the social interdependence within a neighborhood affects the parental decision making process and therewith might add to an explanation of persistent educational inequalities, we turn our attention to the probability of attending the higher track in a stratified educational system (Becker 2003; Breen and Jonsson 2005). Using a latent variable representation, where Y_i denotes the outcome for subject i and $Y_i = \begin{cases} 1, & if\ Y_i^* > 0 \\ 0, & otherwise \end{cases}$, the equation of interest can be written in matrix notation as

$$\boldsymbol{Y}^* = \rho \boldsymbol{W}\boldsymbol{Y}^* + \boldsymbol{\theta}\boldsymbol{W}\boldsymbol{X}_{\boldsymbol{a}\in\boldsymbol{A}} + \boldsymbol{\beta}\boldsymbol{X}_{\boldsymbol{b}\in\boldsymbol{B}} + \boldsymbol{\varepsilon}. \qquad (6)$$

As the estimation of models for limited dependent variables in a spatial econometric context has been discussed elsewhere (e.g. McMillen 1992; Fleming 2004; Calabrese and Elkink 2014), the relevant characteristics of such models are outlined only briefly, stressing their advantage for the purpose of the present study. $\boldsymbol{Y}^*$ represents a continuous random vector for the $i = 1, 2, \ldots, n$ observations, $\boldsymbol{X}$ is a $n \times k$ matrix of k independent variables with $\boldsymbol{\beta}$ as a vector of the corresponding effects. The error vector $\boldsymbol{\varepsilon}$ is assumed to follow either a multivariate normal (probit model) or a multivariate logit distribution. The spatial probit or logit model differs from the non-spatial setting by introducing spatial dependence through the weights matrix $\boldsymbol{W}$ (LeSage and Pace 2009; Elhorst 2014). The $n \times n$ weights matrix captures the interdependence between the observations and is usually row standardized. The corresponding scalar ρ is referred to as spatial lag and reflects spillover effects through the dependent variable. Similarly, the parameter vector $\boldsymbol{\theta}$ denotes direct spillover effects of explanatory variables $\boldsymbol{X_j}$ on Y_i^*. However, when looking at the reduced form of equation (6), it becomes apparent that, apart from these direct spillover effects, there are also indirect spillovers through ρ.

$$\boldsymbol{Y}^* = (\boldsymbol{I} - \rho\boldsymbol{W})^{-1}(\boldsymbol{\theta W X_{a\in A}} + \boldsymbol{\beta X_{b\in B}} + \boldsymbol{\varepsilon}) \qquad (7)$$

Unlike common applications of spatial logit or probit models, we focus less on the effect of ρ but rather on the different $\boldsymbol{\theta}$. These effects capture the interdependence of the parameters in the theoretical section (i.e. the individual assessment of the benefits, costs, likelihood of success, importance of status maintenance, instrumentality, educational motivation, and the investment risk). It also follows, that the vectors $\boldsymbol{\theta}$ and $\boldsymbol{\beta}$ do not necessarily relate to the same set of explanatory variables $\boldsymbol{X}$. More specifically, $\boldsymbol{X_{a\in A}} \subseteq \boldsymbol{X_{b\in B}}$.

In order to determine the extent, source and direction of any spatial interdependence, we first check the different theoretical parameters univariately using a Moran's I test statistic (Cressie 2015). We then test whether the observed interdependence might be attributed to unobserved selection mechanisms using Robust Langrage Multiplier tests after ordinary regression models (LeSage and Pace 2009). Finally, the above outlined model is estimated using a Maximum Likelihood estimator that jointly maximizes ρ, $\boldsymbol{\theta}$, and $\boldsymbol{\beta}$. In what follows, the data is briefly presented before turning to the empirical assessment of the two hypotheses.

Data & Operationalization

Table A1 in the appendix provides summary statistics for all the variables used in the analysis. The data stems from a research project concerned with the educational attainment of elementary students at the first transition from elementary to secondary school after completing 6th grade. The investigation took place in two major Swiss cities (Bern and Zurich). Students and their parents were interviewed two times – during 5th and in the second half of 6th grade. Missing values were imputed using chained equations (White et al. 2011), resulting in 690 observations.

The dependent variable, the assigned track in secondary school, consists of a binary choice between a lower, less demanding and a higher, more demanding track. Additionally, in some cantons there is a third alternative available—the grammar school. However, as this option is only available to some of the cases, we focus on the two mentioned alternatives. The main determinant of assigning a particular student to one of the two different alternatives are his or her grades in both, math and German. There is, however, some room left for teachers and parents to negotiate the final choice. Following Boudon's (1974), students' social as well as migration background (operationalized as parental class position according to the Erikson-Goldthorpe-Portocarero class scheme and language spoken at home, respectively) are included in order to determine the extent of primary effects at the first transition. Furthermore, gender as well as the financial situation of the household are included as additional controls.

More interestingly in the present context are secondary effects. Given a student's educational performance, it is assumed that the subjective assessment of the benefits, costs, and the likelihood of success differs according to individual social origin. Using Likert scales for all the following concepts, the expected benefits are measured as the parental judgment whether their children will have a well-payed job as a result of each of the educational alternatives. Similarly, the costs are assessed as their rating of how much each of the alternatives would constitute a financial burden. Furthermore, parents estimated how likely it is that their children would successfully complete each track. Parents also rated the importance of status maintenance in general and additionally the likelihood for their children to end up with an occupation as prestigious as their own for each track separately. Finally, the highest desired degree their children should successfully complete is included as a variable measuring parental aspirations more generally.

As the data permits not only the identification of students within classrooms and schools but also within neighborhoods, the latter information was used to construct the above introduced weights matrix $\boldsymbol{W}$. Two observations i and j are considered to be neighbors if they belong to the same neighborhood $k \in K$. A binary coding was used to construct the adjacency matric $\boldsymbol{W}$ with $w_i \in \boldsymbol{W} = \begin{cases} 1, & if\ i \in k \\ 0, & otherwise \end{cases}$. In order to obtain consistent estimates, cases with less than 3 neighbors were omitted from the analysis and the rows of $\boldsymbol{W}$ were standardized as $w_i^* = w_i / \sum_{j=1}^{I} w_j$. Note that this definition of neighbors—although allowing the construction of 'neighborhoods' comparable to the ones experienced by people in their everyday life—still relies on administrative boundaries and the therewith associated problems (Lupton 2003). Finally, as schools have specific catchment areas and as these coincide with neighborhood boundaries (a school catchment area consists of several neighborhoods), we control for the classroom level educational achievement of all other students to distinguish potential effects of the interdependence at the neighborhood level from school or classroom effects.

Results

In what follows, we examine the amount of spatial interdependence of the theoretical parameters as introduced in equation (5) and (6) and the consequences in terms of the propensity to be assigned to either the lower or the higher track of secondary education. Thereby, the pursued approach enables a rigorous testing of the supposed mediating mechanism of neighborhood effects at the transition from elementary to secondary school. First, the patterns of spatial association between adjacent units as defined by $\boldsymbol{W}$ are briefly discussed. We then switch to multivariate models trying to explain the observed pattern before describing the consequences in terms of the reproduction of educational inequalities.

Spatial Association of the Theoretical Parameters

It was argued that the interdependence at the neighborhood level should mainly take place through the parameters that influence people's educational motivation and aspiration, i.e. $B + p \times (-SD)$—especially the benefits B and the instrumentality p. Furthermore, it was proposed that the assessment of the likelihood π of successfully completing a given alternative might also be shaped by the interaction with others. The subjective evaluation of the costs C and the importance of status maintenance $(-SD)$, however, should be less influenced by others' judgements of the same parameters.

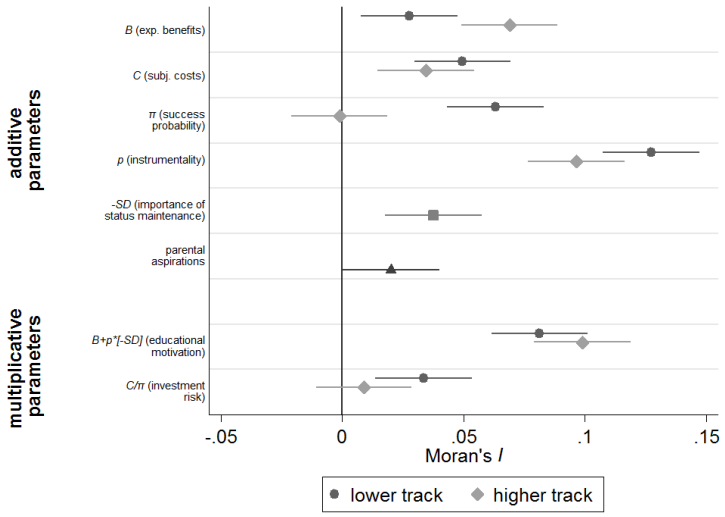
As a first test of these assumptions, Figure 1 presents Moran's I test statistics for all the theoretical parameters. Positive values depict a positive association of adjacent units as defined by $\boldsymbol{W}$ whereas negative values would indicate a negative association (Cressie 2015).[2] As expected, an individual i's educational

[2] Moran's I can be thought of as a spatial version of the Pearson correlation and is defined as

$$I = \frac{\sum_{i=1}^{n}\sum_{j=1}^{n}(y_i - \bar{y})(y_j - \bar{y}) / \sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}}{\sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2/n}\ \sqrt{\sum_{i=1}^{n}(y_i - \bar{y})^2/n}},$$

motivation does depend quite strongly on the motivation of his or her neighbors j. This interdependence can thereby be attributed to the spatial association in the instrumentality and—to a lesser extent—the benefits

Figure 1: Univariate Spatial Association



of the different tracks as well as the importance of status maintenance. Rather unexpected is the low interdependence for the evaluation of the success probability on the one hand and, on the other, the consistent positive spatial association in the assessment of the costs. As a consequence, the investment risk of the two educational tracks is also spatially interdependent. Although there is indication of an interdependence, Figure 1 does not provide any information whether this is due to unobserved selection processes and omitted characteristics or if the individual assessment is indeed shaped by one's neighbors.

As theory and previous research suggest that $B, C, \pi, p,$ and $(-SD)$ differ according to individual social origin (Boudon 1974; Breen and Goldthorpe 1997; Becker 2003) and that the resources associated with social origin crucially determine residential choices and mobility (Lee et al. 1994; Galster and Hedman 2013), the observed spatial association might be the reflection of differences in individual tastes and resources. All the theoretical parameters were therefore regressed on social class, gender, language spoken at home, financial situation, and the city of residence. Parental aspirations were additionally regressed on children's achievement in German and math in order to capture any feedback from the observed to the aspired performance. The residuals of these regressions were than tested for any remaining spatial dependence (first column of *Table 1*) as well as its source. To this end, robust Lagrange Multiplier tests (RLM), testing against the alternative of spatial autoregression (spatial lag) and spatial autocorrelation (spatial error) were used (LeSage and Pace 2009).[3] As reported in *Table 1*, the observed interdependence is considerably reduced and—comparing the corresponding χ^2 statistics of the RLM tests—can generally be attributed to spatial autoregressive processes. Hence, we find strong evidence for spillover effects in the case of the educational motivation which work through both, the benefits and the instrumentality (third column of *Table 1*). On the other hand, there is almost no evidence for such spillovers in the assessment of the costs and the importance of status maintenance.

where i and j are adjacent units as defined by $\boldsymbol{W}$ (Cressie 2015).

[3] A spatial dependence that takes place through the errors rather than the characteristic under examination would suggest a potential selection problem rather than true interdependence.

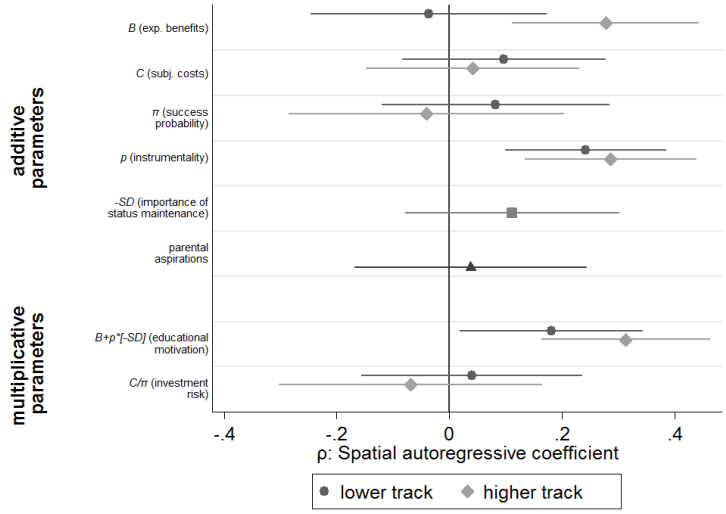
Table 1: Residual Spatial Dependence

	Moran's I (SE)	RLM: Spatial Error (df)	RLM: Spatial Lag (df)	R^2
Benefits (B)				
Lower Track	-0,017 (0,012)	6,438* (1)	4,742* (1)	0,090
Higher Track	0,038*** (0,012)	6,013* (1)	11,099*** (1)	0,042
Costs (C)				
Lower Track	0,003† (0,012)	1,822 (1)	2,990† (1)	0,202
Higher Track	0,003** (0,012)	0,055 (1)	0,184 (1)	0,193
pr(success) (π)				
Lower Track	0,002 (0,012)	4,044* (1)	4,720* (1)	0,092
Higher Track	-0,002 (0,012)	1,162 (1)	1,220 (1)	0,003
Instrumentality (p)				
Lower Track	0,015 (0,012)	11,035*** (1)	25,148*** (1)	0,230
Higher Track	0,032 (0,012)	13,791*** (1)	27,156*** (1)	0,116
Status Maintenance ($-SD$)	0,008 (0,012)	1,656 (1)	2,752† (1)	0,081
Parental Aspiration	0,0003 (0.012)	0,647 (1)	0,780 (1)	0,143
Educational Motivation ($B + p \times [-SD]$)				
Lower Track	0,016† (0,012)	2,262† (1)	6,618** (1)	0,160
Higher Track	0,047*** (0,012)	2,935† (1)	12,790*** (1)	0,087
Investment Risk (C/π)				
Lower Track	-0,002 (0,012)	1,500 (1)	1,649 (1)	0,121
Higher Track	-0,008 (0,012)	0,193 (1)	0,040 (1)	0,091

Source: DEBIMISS, own calculations; N=690; Moran's I: One sided test, all other 2-sided tests; controlled for individual class position, financial situation, gender, city, and language spoken at home (& grades in math and German for parental aspirations). † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Finally, using spatial autoregressive models[4], the same pattern emerges. As reported in Figure 2, there is evidence for significant and positive spillover effects in the case of one's educational motivation and the therewith associated expected benefits and the instrumentality of different educational tracks. Thus, the higher one's neighbors educational motivation, the higher the personal motivation will be – independently of individual characteristics and resources. We will now assess to what extent children's educational attainment is shaped by the observed interdependence at the neighborhood level. To this end, we estimate the multiplying impact of neighbors using a spatial probit model as outlined in equation (6).

Figure 2: Spatial Autoregression of the Theoretical Parameters



A Spatial Probit Model of Educational Inequalities

To what extent does the educational motivation of neighbors affect the chances that one's own child will attend the lower or the higher track of secondary schooling? In order to answer this question, models with indirect and direct spillover effects (i.e. $(\boldsymbol{I}-\rho\boldsymbol{W})^{-1}(\boldsymbol{\beta X_{b\in B}}+\boldsymbol{\varepsilon})$ and $(\boldsymbol{I}-\rho\boldsymbol{W})^{-1}(\boldsymbol{\theta W X_{a\in A}}+\boldsymbol{\beta X_{b\in B}}+\boldsymbol{\varepsilon})$, respectively) were estimated. The effects in *Table 2* are reported as the odds $\widehat{\boldsymbol{\beta}}$ and $\widehat{\boldsymbol{\theta}}$ of attending the lower (higher) instead of the higher (lower) track, conditional on ρ. To begin with, we focus on the propensity of being assigned to the lower track before turning to the higher track in order to test the second hypothesis of negative externalities of others' educational motivation for the more prestigious track.

We might recall that the main determinant of the assignment to one of the two tracks is a student's prior educational achievement. Nevertheless, there is still room for parental influences as reported in the significant coefficients for the benefits B, likelihood of success π, parental aspirations and their educational motivation $U+p\times(-SD)$—even after additionally controlling for individual social background, resources and the educational achievement at the classroom level. However, as ρ, the autoregressive coefficient, is far from being significant, there is no evidence for indirect spillover effects that work through the dependent variable. Focusing on the chances of attending the lower track, however, significant direct effects of one's

[4] In their structural form, these models are comparable to the latent variable notation used in equation (6) and can be written as $\boldsymbol{Y}=\rho\boldsymbol{WY}+\boldsymbol{\beta X}+\boldsymbol{\varepsilon}$ (LeSage and Pace 2009).

neighbors are detected (denoted by the coefficient vector $\boldsymbol{\theta}$ in Model 4 and 5).[5] A student i's probability of attending the lower track is significantly increased if his or her neighbors are motivated to attend said track. Similarly, if they have high aspirations for their children, i's likelihood of attending the lower track diminishes. Hence, the evidence presented so far confirms the hypothesized general model of social interdependencies at the neighborhood level (Hypothesis 1). Linking these effects to educational inequalities, they suggest a reinforcing impact: Students who might otherwise attend the more advantageous higher track of secondary schooling are diverted from doing so due to the neighborhood contacts of their parents. Hence, rather than divergent norms (Wilson 1987; Crane 1991), differences in people's educational motivation seem to cause the observed negative neighborhood effect. At the same time, the impact of educational aspirations of one's neighbors also strengthens an interpretation in line with the effects assumed by theories of collective socialization and social capital (Coleman 1988; Morgan and Sorensen 1999; Galster 2012).

Table 2: Spatial probit estimates

	Lower track					**Higher track**		
		Indirect		Direct		Indirect		Direct
	M1	M2	M3	M4	M5	M1	M3	M5
Benefits	0.117					-0.662***		
(B)	(0.098)					(0.165)		
pr(Success)	1.236***					1.931***		
(π)	(0.347)					(0.551)		
Costs	0.024					-0.025		
(C)	(0.1114)					(0.126)		
Instrumentality	0.675					-0.334		
(p)	(0.452)					(0.624)		
Status Maintenance	0.066					-0.023		
$(-SD)$	(0.069)					(0.078)		
Parental		-0.095*		-0.103*				
Aspirations		(0.040)		(0.043)				
Educ. Motivation			0.223***		0.194**		-0.241***	-0.189**
$(U + p \times [-SD])$			(0.068)		(0.076)		(0.071)	(0.071)
Investment Risk			0.021		0.004		-0.006	0.014
(C/π)			(0.022)		(0.022)		(0.045)	(0.051)
Lagged Terms:								
$\boldsymbol{\theta}_{Aspirations}$				-0.507**				
				(0.185)				
$\boldsymbol{\theta}_{B+p\times(-SD)}$					1.366***			-1.316***
					(0.467)			(0.387)
$\boldsymbol{\theta}_{C/\pi}$					0.047			-0.455*
					(0.071)			(0.200)
Spatial Lag (ρ)	0.0005	-0.0006	-0.0005	-0.0026	-0.0059	-0.0003	0.0009	-0.0072
	(0.0034)	(0.0037)	(0.0036)	(0.0041)	(0.0054)	(0.0036)	(0.0036)	(0.0053)
AIC	281.61	293.91	291.74	287.14	268.66	269.16	290.75	262.09
N	690	690	690	690	690	690	690	690

Source: DEBIMISS, own calculations; Controlled for parental social class, language spoken at home, sex, financial situation, city, grade in math and German, and educational achievement of other student's at the classroom level; Standard errors in parentheses. † $p < 0.10$, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

[5] It should be mentioned that models with lags of the single additive parameters $B, \pi, C, p,$ and $-SD$ could not be estimated due to quasi complete separation (Agresti 2013), reflecting the determining effect of grades in the assignment to one of the tracks.

The picture of competing positive and negative neighborhood effects is further illustrated when focusing on the probability of attending the higher track. The results for parental aspirations are not reported as they are the same as before, just with the opposite sign, suggesting a reinforcing influence of one's neighbors' aspirations on the probability of attending the more demanding track. However, focusing on educational motivation reveals a—on first sight—unexpected negative impact of the benefits of the higher track. The higher parents evaluate the benefits in terms of getting a well-payed job after completing the higher track, the lower the probability their children will actually attend said track. Given that we not only control for individual attainment (positive impacts) but also the one of peers at the classroom level (negative impact), this negative effect could be caused by a subgroup of parents who are highly motivated but whose children do not show the necessary performance. However, once allowing for direct spillover effects ($\boldsymbol{\theta_{B+c\times(-SD)}}$ and $\boldsymbol{\theta_{C/\pi}}$), the interpretation changes somewhat. Rather than a true individual effect, it seems to be an interdependence effect: If i's neighbors depict a high educational motivation for the upper track, i's odds of actual attendance are drastically lowered. Furthermore, if these neighbors assign a higher investment risk to the attendance of the higher track, i's chances are further reduced. Taken together with the negative impact of peers' achievement at the classroom level, these negative influences suggest competition effects (Sacerdote 2011; Galster 2012) as proposed by the second hypothesis.

Discussion

While there is an ever-growing body of research on neighborhood effects on different forms of life chances (e.g. Ellen and Turner 1997; Sampson et al. 2002; Galster 2012), the underlying theoretical concepts still rely on rather broad assumptions such as collective socialization or the epidemic spread of norms. Not only is there a considerable lack of elaborating the relevant social mechanisms but also of using adequate empirical modelling strategies. More specifically, the existing literature fails to articulate and model the assumed social interdependence in terms of individual social actions.

Using the transition to secondary education in Switzerland as an example, this paper demonstrates how neighborhood effects can fruitfully be incorporated in a rational action framework (Boudon 1974; Breen and Goldthorpe 1997). On the one hand, an additional, contextual path for the reproduction of educational inequalities in terms of individual rational action is proposed. On the other hand, modelling the social interdependence using spatial econometrics sheds further light on the mechanisms of neighborhood effects. Using spatial autoregressive linear and probit models, it is demonstrated how people adjust their evaluation of the benefits and the instrumentality of different educational tracks according to their neighbors' views. Furthermore, it is shown how this interdependence shapes their educational choices. As expected, the main source of interdependence at the neighborhood level is identified in people's educational motivation ($B + p \times (-SD)$) rather than the investment risk (C/π). This interdependence cannot be attributed to individual resources or tastes and suggests a spillover from adjacent observations. However, when it comes to the consequences of said interdependence, competing effects emerge. On the one hand, there is evidence for a positive influence of the aspirations of neighbors on the propensity of attending the higher rather than the lower educational track. Nevertheless, when examining these aspirations closer in terms of neighbors' educational motivation, effects that reinforce the reproduction of educational inequalities appear.

The positive influence of neighbors' motivation for the lower track on the propensity that one's child will attend said track suggests, on the one hand, a diversion of children who otherwise might attend the more demanding higher track. Hence, rather than norms according to the epidemic theory (Wilson 1987; Crane 1991), neighbors' evaluation of the utility as well as the instrumentality of the lower track for maintaining social status seems to be one source of the observed (negative) neighborhood effect. On the other hand, neighbors with a high educational motivation for the higher, more demanding educational alternative lower the individual chance to attend this track. Taken together with the observed negative impact of peers' achievement at the classroom level, this suggests a competition or relative deprivation process to be at work (Galster 2012). Finally, the finding of simultaneous positive and negative neighborhood influences strongly

suggest to abandon a linear-in-means interpretation of neighborhood effects in general (Sacerdote 2011; Sharkey and Faber 2014). Instead, future research should consider various, even competing social mechanisms simultaneously. Furthermore, these results advocate the importance of policies that abandon the view of atomized individuals. Hence, successful interventions to reduce educational inequalities should carefully examine the possible consequences of multiplying effects within a neighborhood context (Durlauf and Ioannides 2010). While such policies might make use of these social and spatial multipliers, they also raise concerns. Pursuing the best for one—as has been demonstrated—might lower the life chances of others.

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Appendix

Table A1: Summary Statistics

Variable	Obs.	Mean	Min.	Max.
Dependent variable				
Higher vs. lower track	690	0.778	0	1
Theoretical parameters				
Benefits (B)				
Higher	690	0.678	-2	2
Lower	690	-0.546	-2	2
Costs (C)				
Higher	690	-0.862	-2	2
Lower	690	-0.954	-2	2
Likelihood of success (π)				
Higher	690	0.690	0.1	0.9
Lower	690	0.516	0.1	0.9
Importance of status maintenance (-SD)	690	0.354	-2	2
Instrumentality (p)				
Higher	690	0.637	0.1	0.9
Lower	690	0.379	0.1	0.9
Parental aspirations	690	7.074	1	9
Educational motivation ($B + p \times [-SD]$)				
Higher	690	0.941	-3.5	3.8
Lower	690	-0.375	-2.5	3.8
Investment risk (C/π)				
Higher	690	-1.514	-20	20
Lower	690	-4.310	-20	20
Controls				
Math 6^{th} grade	690	4.799	3	6
German 6^{th} grade	690	4.861	2.5	6
$\emptyset$ in math of others in same classroom	690	4.613	3.67	5.19
Gender (1=Female)	690	0.543	0	1
Social Class				
EGP I	690	0.201	0	1
EGP II	690	0.233	0	1
EGP III & IV	690	0.235	0	1
EGP V, VI & VII	690	0.272	0	1
Other	690	0.058	0	1
Language at home				
German	690	0.458	0	1
Other language & German	690	0.417	0	1
Other language	690	0.125	0	1
Financial Situation				
Tense	690	0.145	0	1
In between	690	0.274	0	1
Relaxed	690	0.581	0	1