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Cost Efficiency and Feasibility of Education Policy in the Presence of Local Social Externalities

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Abstract

What follows is a theoretical exercise aimed at developing an economic analysis of an education system in which the educational output - apart from each individual's propensity to invest in himself or the level of per-pupil spending - is heavily conditioned by the way non-monetary inputs (peer effects operating as local social spillovers) are allocated between schools. Our model actually stresses the influence peer effects can exert on the monetary cost of a policy aimed at equalizing achievement. Unequal allocation of these non-purchasable inputs will cause unequal monetary input requirements and under some realistic assumptions we show here that the best way to ensure cost efficiency is to achieve an equalitarian allocation of peer effects (perfect desegregation according to ability level). But the implementation of such a policy raises many difficulties. To get particular families to voluntarily send their offspring to desegregated schools might require some form of bribery.

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The central aim of this paper is to explore how *peer effects* influence the decision that should made by a social planner who wants to achieve equality of outcome (equity) at minimal monetary cost (efficiency). This objective function largely reflects priorities assigned to primary and secondary education systems across most Western countries. The point here is to explore the specific questions raised by the presence of peer effects at the heart of the human capital production process.

It is clear that human capital accumulation requires a certain number of monetary resources. Yet, people like Hanushek [24] have highlighted the fact that there is no mechanic relationship between the level of resources and pupils' results. Some incentive and organizational problems need apparently to be solved to ensure that more input results into better outcome. But another promising idea, when it come to education policy design, is to consider that a child's ability to accumulate human capital is also influenced by the characteristics of his/her peers. Note that the term 'peer' does not refer here to pupils with the same human capital endowment but to classmates and schoolmates. Human capital production inevitably takes place in classrooms where pupils are together and *interact*. In turn, these classrooms are part of a school where pupils tend also to interact, generating what pedagogues call peer effects and economists local social spillovers. Similar spillovers are to be found in many situations of economic and social life. When public security, quality of urban life, drug addiction or teenage pregnancy are at stake, it is relatively clear that the experience individuals undergo or the behavior they adopt is heavily determined by the characteristics of their neighbors, the behavior of the teenagers they socialize with...

The central role of peer effects in human capital production in this article echoes several empirical studies. It also reflects a conceptual shift in economics of education: the rational bureaucratic model dominant during the 60's and the 70's, synonymous with a functional division of teaching labor into specialized tasks tailored to each child's needs, has been progressively replaced by a more communal view of educational problems. From this relatively new standpoint, educational efficiency is also conditional to an adequate allocation of social, non-monetary inputs like peer effects.

Section 1 summarizes the empirical information available about peer effects. Section 2 formalizes the concept of peer effect through the exposition of a simple model. Section 3, using that model, identifies and discusses the optimal organization of the educational system when peer effects matter. The point is to analyze the decision that would be made by a social planner who wants ensure equality of outcome at minimal monetary cost. The last section discusses the delicate problem of the implementation of first best solutions.

1 What do we know about peer effects?

1.1 Peer effects measurement

A child's attainment can be influenced by the characteristics or behavior - the ability - of his classmates and schoolmates. This is basically the peer group effect idea initially identified by Coleman [9] in the educational context. This phenomenon has been extensively documented in several areas including urban security and crime, drug addiction and teenage pregnancy (Jencks & Meyer [26]; Corcoran, Gordon, Laren & Solon [11]).

Several empirical studies have attempted to 'measure' the peer effect phenomenon. The issue has been addressed by economists (Henderson, Mieskowski & Sauvageau [25]; Summers & Wolfe [39]; Hanushek [14]; Dynarski, Schwab & Zampelli [16]; Duncan [14]; Evans, Oates & Schwab [18]), sociologists (Coleman [9][10]; Jencks & Meyer [26]; Willms & Rodenbush [45]) and pedagogues (Slavin [37], [38]; Grisay [21]; Gamoran & Nystrand [19]).

Most researchers come to the conclusion that peer effects exist: the higher the proportion of high-ability pupils, the higher everybody's achievement. In other words, the higher the average abilityof classmates, the higher will be the local social spillover a pupil will benefit from. More precisely, most researchers accept the conclusion that low-ability children benefit from the presence of their more able peers. The reverse and symmetric effect is sometimes put to doubt. Summers & Wolfe [39] conclude for example that more able children are not affected by the presence of less able comrades. However, this conclusion does not resist to more accurate achievement tests as those carried out by Dahllöf [12]. Willms & Echols [44] using Scottish data estimate that the peer effects (also called contextual effects) ranges from 0.15 to 0.35 of a standard deviation. This suggests that a child with national average ability moved from a school where the mean ability is one-half of a standard deviation below the national average to a school where the mean ability is one-half of a standard deviation above the national average, has an expected attainment about one-quarter of a standard deviation higher. This is a substantial effect. This result was already present in previous studies: first in Coleman [9], then Henderson, Mieskowski & Sauvageau [25]. It is also to be found in more recent studies (Duncan [14]; Link & Mulligan [29]; Dynarski, Schwab & Zampelli [16] ; Leroy-Audouin [28]).

1.2 How do peer effects work?

If there is a large consensus concerging the existence of peer effects, the question of their *modus operandi* is still largely debated. Some works known as 'micro-economics of the classroom' help us understand the potential link between ability grouping practices and educational output. Mullingan [31] develops a queuing model to explain how low-ability pupils manage to catch a teacher's attention by forcing their more able classmates to wait longer before moving towards the next topic. The whole idea is that pupils interact by mobilizing the teacher's limited time budget. This time budget tends to be a public good exposed to congestion. For a given curriculum, a teacher is expected to be more frequently interrupted by low-ability pupils while the more able pupils keep silent. Low-ability pupils can represent the whole classroom (segregation)[1] or simply a portion (desegregation)[2]. In the first case, the whole classroom has to share the teacher's unit of time. In the second case the same unit of time is devoted to a portion of the total classroom. Low-ability pupils receive more time when they have more able classmates but this comes at a cost for the latter: the curriculum they eventually cover is less important. The net result - i.e. the existence of a positive spillovers - depends upon each type of pupil's sensitivity to teaching support.

There are other explanations of peer effect phenomena. Some sociologists and pedagogues (Hallinan [23]; Hallinan & Williams [22]) talk about 'behavioral' contagion: high-ability pupils act as 'models' for their classmates. Their willingness to learn helps the teacher establish a 'learning' climate, favorable to the knowledge-transmission process. Oakes, Gamoran & Page [33] insist rather on the curriculum differentiation process: a direct corollary of 'real' ability grouping practices. Hallinan [23] observes in her work that ability grouping routines lead to dramatic differentiation of curricula. Along this line of reasoning, peer effects would simply correspond to the implementation of programs and teaching contents structured along ability grouping practices. If the classroom is entirely composed of low-ability pupils, the teacher tends to significantly lessen the complexity of his teaching contents and both his demands and his expectations. On the contrary, if the classroom is composed of 'gifted' pupils he seems invariably inclined to become more demanding and revise his expectations upwards. This very troublesome empirical observation has led several 'liberal' pedagogues to question the opportunity of greatly personalized curricula. Uniform programs and contents wrongly assume that all pupils are identical. But personalized curricula often lead to excessive differentiation, practically synonymous with unrestrained

[1] Often referred to as the 'tracking' (in the US) or 'streaming' (in UK).

[2] Some people use the word 'mixing '.

classification and implicit ranking (Grisay [21]). To mix 'bright' and 'dumb' pupils, consequently generates curricular adjustments. Dahllöf [12] seems to confirm the idea that ability mixing entails curricular adjustments that are favorable to low-ability pupils but he also claims that it is unfavorable to high-ability pupil. Successive interruptions caused by less able pupils tend to add up and, eventually, come at a certain cost for their more able peers:

> "In the comprehensive classes the bright pupils reach the same level of objectives in the same effective time as their counterparts in the positively selected classes. Having done this they must wait in some way or other for their slower peers in the steering criterion group. This waiting time may be filled by other types of work () so-called enrichment exercises () more difficult from a formal point of view () but of the same general type as in the common core. With regard to fundamental learning, enrichments of this type very soon become overlearning with no further gain. The pupils in this area of the ability distribution may be busy, and certainly do not cause any disciplinary problems, but they are not learning anything more of substantial value in the curriculum unit under treatment. Otherwise bright pupils in comprehensive classes would excel pupils in positively selected classes in elementary curriculum units."

2 Formal Presentation of the Peer Effects Idea

Our aim in this section is to develop a simple model presenting an educational system and an education production function in which peer effect matter. We will begin in section 2.1 with a brief non technical presentation of the model. Section 2.2 presents the educational system, its schools, the characteristics of the population. The human capital production function is exposed in section 2.3. This formal apparatus will be used in section 3 to discuss the problem of finding the best allocation of peer effects in order to minimize cost per pupil.

2.1 General presentation

Although empirical identification of peer effects is not something new (Coleman [9]; Henderson, Mieskowski & Sauvageau [25] ; Summers & Wolfe [39]; Link & Milligan [29]), systematic treatment of the concept by theoretical literature has occurred relatively recently (Arnott & Rowse [1]; Durlauf [15]; Nechyba[32]). This line of research has stressed the sensitivity of normative results - the desirability of desegregation vs. segregation - to the specification of the production function with peer effects. Bénabou [2][3][4][5] incorporates that question into his analysis of schools and cities and identifies the necessary condition for segregation to be dominated by desegregation in terms of social optimum. Three assumptions are central to the model we developp here:

- First, like Bénébou, we assume *heterogeneity* among individuals. Parents do not have the same human capital or do not offer the same socio-economic environment to their offspring. As part of human capital is produced within the family, pupils will vary in human capital endowment (or ability) when entering the educational system.

- The second assumption, which is also central to Bénabou's work, corresponds to the existence of *peer effects* (local social spillovers) in the human capital production function. The level of peer effects prevalent in a school is "produced" by the agregation of pupils' abilities. Simultaneously, this level of peer effects can be condered as a (non-monetary) input entering the production function: the higher the level of peer effects in a school, the higher the outcome in terms of human capital.

- We personally add a third assumption. We suppose that besides the pupil's contribution to final outcome, there is a net *contribution from his/her teacher*, and that the latter is positively linked to the level of peer effects prevaling in the classroom. Referring to the arguments exposed in section 1.2, the reason for this could simply be that pupils interact by mobilizing the teacher's limited time budget. For a given curriculum, a teacher is expected to be more frequently interrupted by low-ability pupils - possibly because of a lack of discipline - while the more able pupils keep silent. Consequently, the teacher has less time to spend per pupil or to knowledge transmission if the classroom is entirely composed of low-ability pupils and this inevitably affects his contribution to a pupil's achievement.

Both a direct (assumption 2) and an indirect (assumption 3) contribution of peer effects to human capital production seem plausible. Some analysts argue that children benefit automatically from the presence of more able classmates and schoolmates (Jencks & Meyer [26]). However, some other specialists suggest that the measurement of a relation between ability grouping practices and human capital achievement simply reflects teachers' tendancy to adapt curriculum coverage depending on abiliy grouping practices (Hallinan [23]).

2.2 Parents pupils, domestic education and schools

The total number of children is 1. Families have one child. Parents are of two types. Some have a high level of human capital β^h and the others have a lower one β^l. The two types' proportions/number in the total population are respectively Ω and $1-\Omega$. Parents transmit human capital to their children. If parents have unequal human capital levels so are the endowments of their children. For simplicity of exposition[3] we assume that the ratio of parental human capital and private human capital production is equal to 1. Thus, children are either of type β^h (high human capital endowment) or of type β^l (low human capital endowment) to the proportions Ω and $1-\Omega$. We suppose that the educational system consists of a geographical area of limited size (a district or an urban area) where two schools ($i = 1, 2$) of equal size (1/2) are accessible to all children living that area. Transport costs are nil or at least uniform for all inhabitants. Number of type β^h children ('rich' in terms of human capital endowment) in school 1 is R_1 while the corresponding number of type β^h children in school 2 is $R_2 = \Omega - R_1$. For both schools we have $0 < R_i \leq 1/2$.

2.3 The educational production function

Human capital K attained by a pupil $j = h, l$ in school i is positively influenced by three variables: [1] initial human capital endowment (β), [2] peer effects (L) and [3] per pupil expenditure (E). Formally, the production function can be stated as:

$$K_i^j(\beta^j, L_i, E_i) = P\left(\beta^j, L(R_i, \beta^h, \beta^l)\right) + T\left(E_i, L(R_i, \beta^h, \beta^l)\right) \tag{1}$$

where:

- $i = 1, 2$; the school index; $j = h, l$; the initial human capital endowment (β) index;
- $L(R_i, \beta^h, \beta^l)$ corresponds to the peer group effect (the non-monetary input);
- $P\left(\beta^j, L(R_i, \beta^h, \beta^l)\right)$ represents the *pupil's contribution* to human capital production. It is positively influenced by [1] his/her ability or human capital endowment when entering (β^j) and [2] the peer effect level $L(R_i, \beta^h, \beta^l)$.

[3] For a more sophisticated treatment of domestic production of human capital see Borjas [7] .

- $T\left(E_i, L(R_i, \beta^h, \beta^l)\right)$ represents the *teacher's net contribution* to human capital production. It is positively influenced by [1] the level of per-pupil expenditure i.e. the monetary input (E_i) financing a certain teacher time budget and [2] the level of peer effect $L(R_i, \beta^h, \beta^l)$.

In order to simplify notations hereafter, we will use $L(R_i)$ instead of $L(R_i, \beta^h, \beta^l)$.We will also use $P^h(R_i)$ instead of $P\left(\beta^h, L(R_i, \beta^h, \beta^l)\right)$, $P^l(R_i)$ instead of $P\left(\beta^l, L(R_i, \beta^h, \beta^l)\right)$, and $T(E_i, R_i)$ instead of $T\left(E_i, L(R_i, \beta^h, \beta^l)\right)$.

The first term of expression 1 represents the *pupil's* contribution to human capital. It aggregates his/her human capital endowment $\beta^j$and the impact of his peers on his achievement $L(R_i)$. We assume that the higher the peer effect level L, the higher child j's attainment ($P_L'^j > 0$). The peer group term $L(R_i)$ captures the non-monetary channels through which children accumulate human capital in schools. Conceptually, $L(R_i)$ amounts to a social spillover that should be considered hereafter as a production factor[4] in its own right: the higher $L(R_i)$. Note that the question of the 'production' of a certain level of L must not be confused with the issue of its final impact on each pupil's achievement. Each pupil attending a particular school (marginally) contributes to the production of the peer effect level characterizing his school or classroom[5]. Simultaneously, each pupil benefits from the peer effect[6]. Analytically, we will suppose here that $L(R_i)$ is continuous and twice differentiable in R_i, in particular that the level of $L(R_i)$ is positively influenced by the proportion of type β^h pupils ($L'_{R_i} > 0$).

The second term $T(E_i, R_i)$ in expression 1 represents the *teacher's* net contribution to human capital. It also incorporates the level of peer effect because we assume that time really spent on teaching is positively influenced by the level of peer effects. The time *actually* devoted to curriculum coverage can be specified as the difference between [1] the total amount of time E_i can buy given a teacher's hourly wage w (we will assume $w = 1$ hereafter) and [2] the time *not* devoted to teaching $\Psi(.)$ due to a lack of discipline for example.

$$T(E_i, R_i) = E_i/w - \Psi\left(L(R_i)\right) \tag{2}$$

[4] Social capital as suggested by Coleman [9]

[5] Bénabou [3][4] uses a CES specification: $L(R_i) = [R_i.(\beta^h)^\delta + (1/2 - R_i).(\beta^l)^\delta]^{1/\delta}$. This is a convenient way to illustrate the idea that L is 'produced' by the combination of individual human capital endowments β^h, β^l.

[6] A different way to expose the same idea is to use the local public good analogy (Tiebout [40]). A certain level of peer effect in a school or classroom can be seen as a 'local' public good. It is produced by the members of the community with the particularity that individuals contribute with their human capital endowment instead of money or labor. But in turn, each individual benefits from this good in an unrestricted - though not necessarily uniform - way.

with $0 < \Psi(.) < E_i$; $T_E^{'} > 0$ and $T_L^{'} < 0$ as $\Psi_L^{'} < 0$.

Note finally that $T(E_i, R_i)$ directly adds itself to this first term in expression 1 This additive specification means that we a priori exclude cross effects between the two terms. In non technical words, this means that each pupil, no matter his human capital endowment, uniformly benefits from her teacher's contribution[7].

3 Equalizing outcome at minimal cost

We suppose that the social planner's priority is to equalize opportunities at minimal monetary cost. Practically speaking, this could mean that each child must come out the of the educational system - imagine it consists of primary or secondary education - with the same human capital, significantly superior to his/her initial endowment ($\bar{K} > \beta^h > \beta^l$). Subsequent differentiation in terms of social and professional success would then principally be attributed to each individual's personal responsibility (effort) and not to the lack of educational justice (Roemer [34]). Note that the results we derive here can be replicated using other normative criteria. One example is to maximize the level of human capital coming out of school 1 and school 2 with a certain level of educational expenditure. The interested reader should refer to (Vandenberghe [42]) for a full development.

If the social planner's objective is to achieve equality of gross achievement ($\bar{K}$) at a minimal total cost, the problem can be re-stated as follows.

$$Min_{R_1} C(\bar{K}, R_1) = C_1(\bar{K}, R_1) + C_2(\bar{K}, R_2) \tag{3}$$

with $R_2 = \Omega - R_1$ and C_1 and C_2 the *total cost* function specific to school 1 and school 2.

[7] Justification for this could be that the teacher can organise some egalitarian allocation of his/her time so that each pupil in his/her classroom — no matter his/her ability — finishes the school year having achieved the same progress. By contrast, an egalitarian allocation is more difficult to imagine for peer effects that mecanically and directly influence achievement. By definition, this phenomenon is beyond teachers'control. This argument justifies that human capital endowment (β^j) and the peer effect term ($L(R_i)$) interact non-additively. Indeed, empirical studies support the idea that pupils do not benefit uniformly from peer effects (Leroy-Audouin [28])

3.1 Optimal allocation of peer effects: first and second order conditions

The values of R_1 defining the extrema of $C(\bar{K}, R_1)$ in expression 3 can be found by computing the first-order derivatives.

$$C'_{R_1} = C'_{1,R_1}(\bar{K}, R_1) + C'_{2,R_2}(\bar{K}, R_2)\ \ [\partial R_2/\partial R_1] = 0 \tag{4}$$

as $R_1 = \Omega - R_2$ and consequently $\partial R_2/\partial R_1 = -1$, expression 4 becomes:

$$C'_{1,R_1}(\bar{K}, R_1) - C'_{2,R_1}(\bar{K}, R_2) = 0 \Longleftrightarrow \hat{R}_1 = \hat{R}_2 = \Omega/2 \tag{5}$$

To determine whether $\hat{R}_1 = \Omega/2$ corresponds to a maximum or a minimum, we need to look at the second-order derivatives. We can actually focus on the sign of $C''_{1,R_1R_1}(\bar{K}, R_1)$ to determine the concavity (convexity) of $C(\bar{K}, R_1)$. Indeed, $C'_{R_1} = C'_{1,R_1}(\bar{K}, R_1) + C'_{2,R_1}(\bar{K}, R_2).[\partial R_2/\partial R_1] = C'_{1,R_1}(\bar{K}, R_1) - C'_{2,R_1}(\bar{K}, R_2)$ as $R_1 = \Omega - R_2$ and consequently $\partial R_2/\partial R_1 = -1$. Hence and for the same reason, $C''_{R_1R_1} = C''_{1,R_1R_1}(\bar{K}, R_1) + C''_{2,R_2R_2}(\bar{K}, R_2)$. The sign of $C''_{R_1R_1}$ is thus totally prescribed by the (second-order) sensitivity of a school's cost to marginal changes in the proportion of type β^h pupils i.e. $C''_{i,R_iR_i}(\bar{K}, R_i)$, $i = 1, 2$. If $C_1(\bar{K}, R_1)$ is *concave* ($C''_{1,R_1R_1}(\bar{K}, R_1) < 0$), the extremum ($\hat{R}_1 = \Omega/2$) corresponds to the situation where cost per pupil is at its *maximum*. Hence, the optimal allocation of pupils corresponds to the corner solution $R_1^* = \Omega$. All high-ability children should be in the same school (here school 1). Maximal segregation is socially optimal. In contrast, if $C_1(\bar{K}, R_1)$ is *convex* ($C''_{1,R_1R_1}(\bar{K}, R_1) > 0$) the extremum ($\hat{R}_1 = \Omega/2$) is synonymous with *minimal* cost. The social optimum requires to retain that solution. In other words, full desegregation (or perfect mixing) should be recommended.

Using the specification of the production function (see expression 1), we can say that a teacher's contributions ensuring $\bar{K}$ for a type β^h pupil in school 1 will be :

$$T_1^h(\bar{K}, R_1) = \bar{K} - P^h(R_1) \tag{6}$$

and for a type β^l pupil:

$$T_1^l(\bar{K}, R_1) = \bar{K} - P^l(R_1)$$

Now using expression 2 we can rewritte left-hand terms of these expressions so that the per pupil expenditure requested by $\bar{K}$ appears:

$$
\begin{aligned}
T_1^h(\bar{K}, R_1) &= E_1^h(\bar{K}, R_1) - \Psi\left(L(R_i)\right) = \bar{K} - P^h(R_1) \\
T_1^l(\bar{K}, R_1) &= E_1^l(\bar{K}, R_1) - \Psi\left(L(R_i)\right) = \bar{K} - P^h(R_1)
\end{aligned} \tag{7}
$$

Total expenditure ensuring $\bar{K}$ in school 1 simply corresponds to the following linear combination:

$$
C_1(\bar{K}, R_1) = R_1 \left[\bar{K} - P^h(R_1) + \Psi\left(R_1\right)\right] + (1/2 - R_1) \left[\bar{K} - P^l(R_1) + \Psi\left(R_1\right)\right] \tag{8}
$$

and a similar expression can be computed for $C_2(\bar{K}, R_2)$.

Using expression 8 we find after some algebraic developments that the second order derivative is :

$$
\begin{aligned}
C''_{1,R_1R_1} &= 2\left[P'^l_L - P'^h_L\right] L'_{R_1} \\
&\quad - \left(L'_{R_1}\right)^2 \left[R_1\ P''^h_{LL} + (1/2 - R_1)\ P''^l_{LL} - 1/2\ \Psi''_{LL}\right] \\
&\quad - L''_{R_1R_1} \left[R_1\ P'^h_L + (1/2 - R_1)\ P'^l_L - 1/2\ \Psi'_L\right]
\end{aligned} \tag{9}
$$

We know by assumption that $L'_{R_1} > 0$; $P'^h_L > 0$; $P'^l_L > 0$ and $\Psi'_L < 0$. Hence, the sign of C''_{1,R_1R_1} is determined by:

- $P''_{\beta L}$: which represents the interaction between human capital endowment (ability) and peer effects (first term of expression 9). If there is complementarity ($P''_{\beta L} > 0$ i.e. $P'^l_L < P'^h_L$), the type β^h pupils benefit more for a certain level of peer effects L. And a strong complementarity pleads in favor of socio-economic segregation in order to minimize costs. Inversely, substitutability ($P''_{\beta L} < 0$, i.e.$P'^l_L > P'^h_L$) indicates that peer effects are more profitable to type β^l, and this is an argument in favor of desegregation.

- P''_{LL}: this expression (second term of equation 9) corresponds to the slope of peer effects' marginal productivity regarding the pupil's direct contribution to the outcome. $P''_{LL} < 0$ pleads in favor of desegregation while $P''_{LL} > 0$ goes in line with segregation.

- Ψ''_{LL}: (also in the second term of equation 9) reflecting the slope of peer effects' marginal productivity concerning the teacher's contribution (i.e. the reduction of the time not devoted to teaching when L rises). If the teaching time bonus generated by a unit rise of L decreases with its level ($\Psi''_{LL} > 0$) then desegregation is preferable. The reverse ($\Psi''_{LL} < 0$) pleads for segregation.

- the sign of $L''_{R_1R_1}$ (third term of expression 9). If the peer effect production function is concave ($L''_{R_1R_1} < 0$), the chance of C_1 being convex increases. Inversely, convexity ($L''_{R_1R_1} > 0$) is a factor contributing to the concavity of the cost function.

Proposition 1 *This discussion of expression 9 reveals that concavity of the peer effect function (the sign of $L''_{R_1R_1}$) is not the sufficient condition to proclaim that total desegregation or segregation is socially desirable. Segregation can be optimal if, for example, L is 'weakly' concave, peer effects' marginal productivities are almost constant (P''_{LL} and $\Psi''_{LL} \approx 0$) and human capital endowment (ability) is a complement of peer effects ($P''_{\beta L} > 0$) i.e. more able children benefit more from a better social environment than their less able comrades. By contrast, if [1] the peer effect is concave ($L''_{R_1R_1} < 0$), if simultaneously [2] pupils with a low human capital endowment are more sensitive to peer effects than others ($P''_{\beta L} < 0$) and [3] the marginal productivites of the peer effect input are decreasing with its level ($P''_{LL} < 0$ and $\Psi''_{LL} > 0$), then perfect desegregation is necessarily optimal.*

4 Implementation: how to control allocation of peer effects?

So far, we have considered that the only source of regulatory difficulty was the identification of the best allocation of peer effects. Nonetheless, one could reasonably argue that the regulator's problem is a bit more complex. If the first best solution requires segregation, one can expect this equilibrium to emerge spontaneously. Inter-school segregation along the ability line at a very early stage of the curriculum is something observable in many countries, particularly those where parents and pupils can choose their publicly financed school, are extremely mobile in terms of residential choice (Vandenberghe [41][42]) or in places where admission and evaluation policy is decentralized at the school level. But imagine that the first best solution requires desegregation[8]. Our point is that this regulator will most likely faces two categories of strategic actors (schools and parents or pupils) that will somehow oppose his project.

If the regulator judges that there is excessive segregation between schools, the first policy that will probably be considered is school zoning. Each child

[8] Some empirical studies (Leroy-Audouin [28] ; Gamoran & Nystrand [19]) seem indeed to confirm that the formal conditions ensuring the superiory of desegregation over segregation (see our discussion of 9) are met for primary and early secondary education.

would be assigned to a particular school, depending on his residence. The regulator could divide the territory into districts showing some socio-economic heterogeneity. But this option has its problems. One should refer to some theoretical and empirical work (Bénabou [2]; Kazal-Thresher [27]) illustrating the general tendency of people to reproduce socio-economic segregation through residential mobility.

If school zoning is discarded, the other policy that comes to mind consists of using the financing formula in order to incite schools to revise their recruitment strategies. Heads of schools maximise the utility of their teachers. As per-pupil expenditure is a central determinant of that utility level, the regulator can steer recruitment practices simply by making E conditional on the socio-economic composition of the school (the human capital endowment of the recruited pupils)[9]. This variable is probably publicly known or, at least, observable at a limited cost. Conditional allocation could (for example) correspond to the suppression of financial subsidy to schools insufficiently 'mixed' (i.e. their proportion of type β^h pupils does not correspond to the district's proportion). In that extreme situation, the participation constraint) would obviously not be satisfied, and school heads would modify their recruitment policy. This is rather trivial.

But schools and teachers are not the only source of regulatory difficulties. A public choice perspective would indeed indicate that parents are political clients, that they can dismiss politicians (regulators) or boycott their fiscal duties when displeased with an educational policy. By imposing financial sanctions, the regulator can persuade teachers and heads of schools to renounce 'cream-skimming' privileges. But how would parents - especially those with high human capital endowment - react to this sort of desegregation policy? Note that even if the cost of attending a desegregated school is extremely limited, bypass if feasible is likely to occur. Private parties are sensitive to peer effects when these are beneficial to their children. Yet, they most likely ignore the social benefits or costs of their individual decision: they ignore the effect of their school choice on the quality of peer effects in the rest of the educational system.

In that context, it rapidly turns out that some form of *bribery* is necessary to get desegregation. In a system of vouchers, it could mean that type β^h families receive larger vouchers conditional to their participation in a desegregated public school. In a Tiebaut local public good scheme, it means that type β^l families pay higher local tax. This result echoes some recent developments of local public good literature (Brueckner & Lee [8] ; Schwab

[9] For a development of a similar reasoning in the health care sector see Matsaganis & Glennerster [30]; Van de Ven & Van Vliet [43].

& Oates [36]) as well as Rothschild & White's recent paper [35] concerning optimal pricing of higher education. Under some conditions, these authors conclude that social optimality requires that each participant pays a fee or a tax inversely proportional to his human capital endowment. In the context of higher education this means that students should be charged for what they get as net profit (output minus input). This pricing rule internalises the mutual effect of students with different human capital endowment. Schwab & Oates [36] indicate that optimality in the Tiebaut model with local social spillover depends heavily on the possibility (or political feasibility) of intra-club transfers (ofter refered to as side-paiements). Brueckner & Lee [8] for example assume that local regulators can charge different prices to individuals, depending on the influence they exert on the production process, and conclude that the local public scheme is socially optimal. This idea is also developed by Epple & Romano [17]. In contrast, de Bartolome [13] supposes that local regulators (must) treat all their clients equally and consequently concludes that the existence of local social spillover leads to inefficient outcomes.

5 Conclusion

The interest of the results derived here is threefold. First, they confirm the importance of non-monetary inputs and the need for an efficient allocation of those resources whatever the social planner's exact objective. If peer effects really enter the production function, as most empirical work seem to confirm, they must be properly used. As their - direct or indirect - productive contribution is local by nature, they must also be properly allocated between entities. We have seen that desegregation is preferable if [1] the presence of an additional high-ability pupil in school 1 generates a peer-effect improvement that does not offset the negative consequences of the presence of an additional low-ability pupil in school 2 (i.e. the peer effect function is concave), [2] if simultaneously pupils with a low human capital endowment are more sensitive to peer effects than others and [3] the marginal productivity of peer effect in terms of human capital increment is decreasing.

Second, these results have some interesting empirical implications. They actually stress the influence peer effects can exert on the monetary cost of local public services[10]. Unequal allocation of non-purchasable inputs (here peer effects) will cause unequal monetary input requirements although efforts made by agents (here teachers) across schools are equivalent. This result is particularly important if one aims at interpreting efficiency measures based

[10] See Bradford, Malt & Oakes [6] for an early exposition of that idea

on (monetary) input-output ratios - see Hanushek [24] for a review of those studies. It can also help us explain average cost differences between educational systems or between different sections of a particular system.

Third, our model conveys the message that the role of public authority in Western societies should expand beyond public financing of education. Inefficiency or inequity can occur despite the public nature of the financing. Regulatory challenges call for other forms of intervention. In this model, the social planner's problem is to find ways to influence the allocation of heterogeneous individuals in order to fully exploit social interactions. These policies are probably complex to implement when they aim at desegregating schools. Glennester & Le Grand [20] judiciously tell us that middle class families are more and more reluctant to accept systematic socio-economic mixing when education (or health) is at stake, possibly because the socio-economic gap is widening. In more economic terms, this probably means that individuals (parents, pupils, heads of school or teachers) incorporate peer effects in their optimization program but ignore their own influence on the quality of peer effects. A family with low human capital wants to attend a 'good' school but doesn't care about the resulting decrease of peer effects. Similarly, a head of school can organize some 'cream-skimming' in order to maximize the level of peer effects in his institution while ignoring the deterioration this option will necessarily entail in the rest of the educational system.

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