Chapter 4 - The supply of education

1. Human capital formation

In the second chapter we derived an optimal demand for schooling under the constraint of a given technology in human capital formation, which is reproduced in implicit form in equation (4.1) for ease.

$$\Delta H_{it} = f\left(A_i, S_{it}, E_{it}, H_{it}\right) \tag{4.1}$$

The variable A_i indicates individual (unobservable) ability, S_t the fraction of time devoted to schooling by individual i, E_{it} the per-capita resources used in schooling (teachers, libraries). In an intergenerational framework, H_{it} can be taken as a proxy of the family background (including the social capital which is relevant for acquiring an education); we can consider the effect of peers (namely, the effect of the average quality of class mates on individual performance) as a special case of it.[1] The same set of variables affects the optimal demand for schooling (see equation (2.7) in chapter 2) and the marginal return to education (see equation (2.10)).

Equation (4.1) is known in economic literature as the *educational production function* (Lazear 1999, Pritchett and Filmer 1999), since it relates some inputs (student abilities, schooling resources, cultural environment) to the output of human capital formation. However, this production function has the peculiarity of considering student activity (here denoted by S_{it}) as inputs and outputs at the same time. In fact more resources employed in schooling (higher E_{it}) induce longer school attendance (higher S_{it}), and presumably higher educational attainment; at the same time, longer attendance in schools favours greater formation of new human capital (higher ΔH_{it}). This describes a sort of multiplicative effect of educational resources: there is a direct impact on the current production of new human capital (given by $\frac{\partial\left(\Delta H_{it}\right)}{\partial E_{it}}$), and an indirect effect via the optimal plan revision induced by newly added resources (given by $\frac{\partial\left(\Delta H_{it}\right)}{\partial S_{it}^*} \cdot \frac{\partial S_{it}^*}{\partial E_{it}}$). To take an example, think of the opening of a new library within a school: the direct impact on children's education is given by the newly added opportunities of browsing through new volumes and learning about new subjects. At the same time, a new library makes the school more attractive to families and children, who are now induced to remain longer in school in order to take greater advantage from it. Both effects strengthen the formation of new human capital.

When students are inputs in the production process, it becomes crucial to consider their individual abilities and the overall ability of the group of students. Educationists have made clear that it is much easier (and more rewarding) to teach to bright students: they understand better and more quickly, raise clever questions and are typically more motivated in studying. But the converse is also true: students are brighter when teachers are better qualified and more motivated.[2]

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[1] The effect of social environment can be accounted for either by introducing the crucial variables in the utility function (think of the case of peers esteem) or by taking into account its contribution to individual formation. While Becker and Murphy 2000 follow the first route, most of the literature in the economics of education seems to prefer the alternative strategy.

[2] In formal terms, this corresponds to the case where the cross partial derivatives $\frac{\partial^2 f}{\partial E \partial A} = \frac{\partial^2 f}{\partial A \partial E}$ are positive.

This is only one side of the coin, since unobservable ability is positively correlated with family background (mainly with parental education). Thus in most cases the brightest students are the offspring of educated parents, and this creates an incentive for teachers to teach in schools where better-endowed students are in greater proportion. The reverse is also true: knowing that better teachers are crucial in producing more human capital, parents of abler students have a greater incentive to hunt for better schools. As a consequence, students as educational input is intimately related to the problem of self-sorting in schools (and classes within schools).

While individual ability may be important when interacting with teacher quality, it could also become relevant at the aggregate level of the class (or of the school). Everyone wants to be in a class with good teachers, but everyone wants good classmates too, because it is common knowledge that the "speed of learning" in a class is the average speed, which is positively correlated to the average ability. But this cannot always be the case: being in a class of geniuses may have depressing effects on average students, whereas a middle-to-bottom quality class may encourage the performance of average ability students. The overall effect of average ability in a class (*peer effect*) depends on the hypothesised effect of the social interaction, which can be either of the "complement" variety (human capital formation improves only when there is a generalised increase in the quality of all students) or of the "substitute" variety (the ability of a better endowed student can – at least partially – compensate the low performance of a less endowed student).

By varying student qualities (whenever schools can sort students according to their observable abilities, as in the admission to some private schools and/or to most high schools) and class size, school managers can vary the possibility of human capital formation in each class. Since families choose schools according to their expectations with respect to admission and class formation policies, actual human capital formation comes out as the equilibrium result of supply and demand for school quality. Let us now discuss the issue of class formation in greater detail.

2. Class formation and peer effects

There are three main problems in defining the optimal class formation: the selection of students according to their ability, the class composition (i.e. mixing students of different ability in the same class or creating ability-homogenous classes) and the class size. The first two issues arise whenever students are differently endowed with abilities that are relevant in educational achievement (attentiveness, brightness, cooperation). Otherwise, only the third one remains relevant.

The problem of screening students arises from the unobservable nature of individual ability. A large part of schooling activity is devoted to testing students in order to obtain indirect measures of these unobservables. Test scores are in turn used as screening devices for admission to further education. On the whole, one could state that one by-product of schooling activity is information about students' quality.[3] This view supports the idea of educational certificates as signals for prospective employers: the longer a student remains in school, the more extensive selection has been passed, the greater must be her unobservable ability.[4]

While testing is the only alternative in the case of imperfect symmetric information (neither the student, her family or the teachers know her ability in advance), whenever students and families have an informational advantage on unobservable ability, admission fees can be an alternative device to

[3] Bertola and Cohen Pirani 1998 propose a model where schooling is described as a screening activity (they term it "allocative education"), the precision of which depends on the amount of invested resources.

[4] For a signalling interpretation of educational achievement see Spence 1973

screening students. Suppose one intends to create an élite school by admitting only the best students, in a context where families have superior information about students' abilities (imperfect asymmetric information). All families would like to gain access to the exclusive élite school, because this will grant higher returns to education in the future, thanks to the better human capital formation. There are two alternative ways of sorting out the best students: either through submitting all applicants to specific exams, or by selecting them in accordance with their willingness to pay.

The main drawback of the allocation mechanism based on testing is that it wastes resources: students spend time to prepare for the admission tests, families spend money in order to provide extra tutoring for the same aim, schools have to pay teachers (or external examining agencies) to mark exams. In addition, student performance is very often correlated to family background, and therefore the final result does not always identify "pure" ability in the students.[5] The market mechanism (selecting students by means of admission fees, increasing with perceived school quality) is in principle more efficient: by ordering people according to the maximum fees they are willing to afford, they indirectly reveal their hidden abilities. Seen from this perspective, in order to obtain the best students it is sufficient to raise fees adequately. Under the maintained assumption that private schools provide better quality education, the empirical counterpart is that we should observe better ability students in private schools, because only for high quality children is rational to pay more for better education.[6]

However, the market allocation mechanism works properly only when financial markets operate perfectly, that is when families can borrow money to afford high fees on the expectation of high ability children. Otherwise, if markets for education financing do not exist, poor parents of high ability children will be outspent by rich parents of lower ability children. Since financial markets for education financing typically either do not exist or are heavily subsidised by the state, meritocratic selection is in general Pareto-superior as an allocative device in class formation. Better students could still be prevented from participating in higher education by high opportunity costs. For this reason, the combination of meritocratic selection and publicly financed scholarships contingent on family income can yield the most efficient matching of student to schools.[7]

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The problem of sorting students in order to obtain an appropriate match between students and schools arises not only in schools of different qualities. If learning activity in class is affected by the ability and behaviour of classmates, families are not indifferent to the class assignments of their children. Whenever other people's features affect one's current behaviour, we speak of *peer effect* indicating the externality created by each individual on other people. Peer effects can take different forms: conformity, competition, envy, and so on. School classes are a typical example where peer effects reveal themselves. Consider for example the case where student abilities are technical complements.[8] In such a

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[5] In addition, the incentive to undergo an exam declines when students do not have an informational advantage on their own ability. Stiglitz 1975 discusses this case, in the context of a general theory of screening.

[6] Fernandez 1998 studies the case of allocating students of different abilities across schools of different quality. She shows that under perfect capital markets two allocative mechanisms (admission fees and test scores) yield efficient outcomes (in terms of human capital production). Under borrowing constraints, exams dominate market mechanism in terms of matching efficiency (allocating better students to better schools). A crucial assumption for this result is the complementarity between ability and school quality.

[7] Fernandez and Gali 1999 propose a model where meritocratic selection (in relative terms, like a tournament) reach matching efficiency, associating better students to better schools in absence of financial markets. Here the crucial assumption relates to the assumed negative correlation between unobservable ability and the cost signalling, thus allowing to the best students to emerge irrespective of their social origin.

[8] In formal terms, let us consider a simplified version of equation (4.1), where the only relevant inputs are given by student abilities in a class. To make the complement/substitute issue clear, we assume that the f function is in the CES (constant

case each student benefits from being in a class of bright students, because she gets more insights in class discussion, feels more pressure to compete and in general obtains additional stimuli by being associated with intellectually rich classmates.

While the empirical relevance of peer effects is far from being ascertained on empirical grounds,[9] it has strong implications with respect to class formation and class size. Lazear 1999 has proposed an interesting model that shows the importance of interaction between students' abilities. If student ability is correlated with attending classes without disrupting other people's learning activities, one can empirically measure it by the fraction of time during which a student pays attention to the teacher; let us define it $p_i, 0 \leq p_i \leq 1, \forall i$. As a consequence, teaching is possible only when all students in a class pay attention, that is for a fraction of time equal to $\prod_{i=1}^{n} p_i$, where n is the class size. When all students in a class are of equal quality, then the teaching activity is possible for a fraction p^n of time: in such a context teaching and learning directly depend positively on students quality and negatively on class size (since $p_i \leq 1$).[10] In order to grasp the extent of this effect, let us consider the case where each student is able to pay attention for 98% of her class time; then teaching and learning activities in a class of 25 similar students will be possible only for 60% of time (as a result of $0.98^{25} = 0.60$). If student quality declines paying attention only 94% of time, learning and teaching becomes possible only for 21% of the time, and it would be necessary to reach a class of 8 students to restore the possibility of teaching the 60% of the time.

Even though this example may seem extreme, it makes clear that schools themselves have incentives to attract better students. In order to analyse this aspect, let us consider a case where a given number of identical schools exist. Each school is able to accommodate the same number of students, but students are different in terms of ability. When peer effects matter, each school has an incentive to attract better students, because this will improve the quality of its teaching.[11] Whenever a preassigned school order exists, the first school will choose the best students. Since being admitted to the best school can be priced (either directly through admission fees, or indirectly through the price of housing whenever vicinity to the school is a necessary requirement for admission), the school can use either exams or market mechanisms. Then the second school chooses the second best students, and so on. The final outcome is perfect segregation of students according to their abilities and of schools according to the

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elasticity of substitution) class, as for example $\Delta H_i = \left[\sum_{k=1}^{n} A_k^{\sigma} \right]^{\frac{1}{\sigma}}$ where n is the class size. The education production function is symmetrical for simplicity, but a more complicated version could be in principle be considered. Since the elasticity of substitution between two students is equal to $-\frac{1}{\sigma - 1}$, whenever $\sigma > 1$ students' qualities are technical substitutes and human capital production is enhanced by mixing students of different qualities (*integration*). On the contrary, if $\sigma < 1$ it is more productive to form classes with students of equivalent levels (*segregation*) in order to obtain the highest production of human capital.

[9] As in many other cases in labour economics, detecting the existence of peer effects requires the existence of control cases, which are not easy to identify unless in case of random class assignment. Minter-Hoxby 2000b, using a difference in difference approach, has considered gender and race class differences in order to investigate whether different class composition affects average class performance, finding a limited impact.

[10] Given this specification of teaching technology, students' abilities are technical complements, and segregation of students into classes of identical quality is efficient from a production point of view.

[11] Robertson and Symons 1996 and Fernandez and Gali 1998 offer similar models. Both papers assume students differentiated in terms of quality. In the first paper schools are different in equilibrium, due to peer effect; therefore they compete to attract better students (*cream skimming*). In the second paper, schools are assumed different, and they accept students passively, depending on their willingness to pay.

average quality of admitted students,[12] irrespective of whether sorting occurs either through tests or through market channels.

However a stratified educational system does not necessarily represent the most efficient allocation of students. If the peer effect linearly affects the educational production function, then exchanging students between schools does not alter the overall production of human capital.[13] In contrast, when the educational production function exhibits increasing marginal returns in the peer effect, then perfect segregation is effectively the most efficient allocation of students. On the contrary, whenever we observe decreasing marginal productivity of average ability, then mixing students of different abilities may prove superior in terms of human capital production.[14]

3. Integration or segregation ?

In order to show how previous elements interact in the process of class formation, we now propose a simplified version of a model originally proposed by Benabou (1996a) to analyse the territorial segregation (i.e. the endogenous formation of rich and poor neighbourhoods), but that can easily be adapted in terms of class formation.[15] The model focuses on the relevant concept of *social capital*, that summarises all relevant factors of the environment that affect individual behaviour: thus it extends from average (unobservable) ability of classmates, to incomes and wealth of their families (which become relevant when schools are locally financed), up to social networking (that may become relevant when entering the labour market). The model predicts social integration or segregation as an endogenous result of optimising agents according to the role played by social capital in human capital formation. As a consequence, school choice will shape the distribution of human capital in the society, and is strictly related with income inequality.

We start by considering an overlapping generation model where agents live for two periods. Each agent attends the school chosen by her parents in the first period of her life. School attendance provides newly formed human capital, which depends on family background (summarised by parent human capital) and by the quality of the school attended. The quality of the school is determined by a peer effect (here proxied by the average human capital possessed by parents of school mates) and by a resource effect (the amount of resources available from local taxation). Then the agent earns an income that is proportional to the newly formed human capital, gives birth to a child and chooses a school for her education. Given the fact that schools gather students from local neighbourhoods, school choice and residential choice coincide; it is therefore plausible that the agent gets indebted in order to finance the school/residence choice. Labour earnings are used for consumption and payment for school/residence sunk costs in the first period of life. In the second period of life the agent works,

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[12] This is the main result obtained by Robertson and Symons 1996, where ex-ante schools start identical and differ in the order they follow in admitting students; ex-post they are different on the average ability of their students, and therefore are forced to charge different fees.

[13] This is straightforward, because exchanging a good student for a bad student reduces the average ability in the good-type school and raises the average ability in the bad type school. Given an identical educational production function, the reduced production of human capital in good schools is matched exactly by the increase in bad schools. See Minter-Hoxby 2000b.

[14] Continuing the example introduced in the previous footnote, when we exchange students between high-ability schools and low-ability schools under decreasing marginal productivity of the average ability (*peer effect*) the human capital loss in the first type of schools is overcompensated by the gain in the second type of schools.

[15] We reproduce here a modified version of basic model presented in Benabou 1996a; a more concise version of the same model can be found in Benabou 1994. The original model describes the endogenous formation of a city composed of two distinct zones, where self-selection works through the possibility to pay the settling cost and the quality of local schools depends on the average "quality" of local inhabitants. In addition, schools are financed through taxation on real estate (as is typically the case in United States), thus proving greater economic resources to schools located in richer environments.

consumes, repays the possible debts and dies. In the meanwhile the child starts attending the school chosen by her parent.

Given this basic structure of the model, we assume for simplicity that only two schools make the entire society (be it a district or a metropolitan area), indexed by index $j, j = 1,2$; each of them can host one half of the student population. The schools have access to the same teaching technology and therefore ex-ante they are identical. Again for simplicity, we assume that there exist only two possible levels of human capital: H_A corresponds to the case of high education type (call it "college graduate" or "skilled worker" type), while H_B corresponds to low education type. By definition $H_A > H_B$ holds. The population is assumed constant and normalised to unity. When n indicates the high educated fraction in the population, the average human capital in the society is given by

$$\overline{H} = nH_A + (1-n)H_B \tag{4.2}$$

We denote with n^j the fraction of students from high-educated parents in each school. We also take as convention the first school to be the "best" school in terms of social capital, given the assumption of $n^1 > n^2$.

Altruistic individual preferences are defined over own consumption in the two periods of life (where C_t^t and C_{t+1}^t indicate consumption of generation t when young and when old respectively) and over the human capital accumulated by the child H_{t+1}. Each agent chooses the school where to enrol her child $E^j, j = 1,2$ by maximising her indirect utility function, which corresponds to the solution of the following problem

$$U^j(H_t) = \max_{D_t} U\left(C_t^t, C_{t+1}^t, H_{t+1}\right) = \max_{D_t}\left[\log C_t^t + \log C_{t+1}^t + \log H_{t+1}\right] \tag{4.3}$$

subject to the following constraints

$$C_t^t + B^j = H_t(1-\tau) + D_t \tag{4.4}$$
$$C_{t+1}^t + D_t(1 + R(D, H_t)) = H_t \tag{4.5}$$
$$H_{t+1} = f\left(H_t, L^j, E^j\right) \tag{4.6}$$

The budget constraint (4.4) specifies that consumption when young plus enrolment fees B^j for sending your child to school E^j can be financed either through labour income (for simplicity equal to the endowment of human capital), net of taxes (to be used to finance local schools), or through borrowing an amount D_t. Similarly, the budget constraint (4.5) for the second period indicates that consumption when old and debt repayment (where financial market imperfections make the borrowing rate R dependent on earning capability and the extent of the loan) must balance second period earnings (which for simplicity are not taxed). Finally, the constraint (4.6) corresponds to the educational production function, where the newly produced human capital depends on parents' human capital H_t, on the quality of the school attended L^j (*peer effect*) and on the resources available to the same school E^j.

To characterise the effect of social capital, it is crucial to define whether heterogeneity of family backgrounds within the same school is beneficial or detrimental to human capital formation. To formalise this idea, we assume that school environment quality L^j takes the form

$$L^j = L\left(n^j; H_A, H_B\right) = \left(n^j H_A^{\sigma} + \left(1 - n^j\right) H_B^{\sigma}\right)^{1/\sigma} = L\left(n^j\right),\ L' > 0 \tag{4.7}$$

When $\sigma < 1$, the heterogeneity is detrimental because two individual types are complements in "producing" the quality of social capital: to see it, it is easy to prove that $L^j < \overline{H}$ for $n^j \neq 0$ and $n^j \neq 1$).[16] Vice versa when $\sigma > 1$, heterogeneity is beneficial because two types are (technical) substitutes, and L is concave in n^j (and therefore $L^j > \overline{H}$).

Educational attainment also depends on local neighbourhood through the channel of funding, obtained through local taxation. If we do not take into account voting on different tax rates in each area for simplicity, we have that educational expenditure per student E^j is financed by admission fees that are made progressive by a lump sum payment B^j plus an additional component that is proportional to family income. In the absence of central redistribution of funds between schools, a balanced budget constraint requires

$$E^j = B^j + \tau\left(n^j H_A + \left(1 - n^j\right) H_B\right) = E\left(n^j\right),\ E' > 0 \tag{4.8}$$

As a consequence, schools attended by students from educated parents receive more financial resources.[17]

By making use of equations (4.4)-(4.8), the maximand of equation (4.3) can be re-expressed as

$$U^j\left(H_t\right) = \max_{D_t}\left[\log\left(H_t(1-\tau) + D_t - B^j\right) + \log\left(H_t - D_t\left(1 + R\left(D_t, H_t\right)\right)\right) + \log\left(f\left(H_t, L\left(n^j\right), E\left(n^j\right)\right)\right)\right] \tag{4.9}$$

Equating the marginal rate of intertemporal substitution to market interest rate identifies the optimal level of borrowing

$$\frac{\dfrac{\partial U}{\partial C_t^t}}{\dfrac{\partial U}{\partial C_{t+1}^t}} = \frac{C_{t+1}^t}{C_t^t} = \left(1 + R\left(D_t, H_t\right) + D_t \frac{\partial R}{\partial D_t}\right) \tag{4.10}$$

While the optimal consumption path is defined by equation (4.10), we still need to define the optimal school choice. Given its nature of discrete choice (choose the "good" school 1 or the "bad" school 2), each agent will consider the cost of school enrolment $\left(B^j + \tau H_i\right)$ and the benefit provided by the presence of n^j children from educated families (i.e. type H_A parents). The benefit can be higher or lower according to whether family backgrounds are technical substitutes or complements in producing

[16] The elasticity of substitution in equation (4.7) is equal to $-\frac{1}{\sigma - 1}$, which is positive for $\sigma < 1$. It is also easy to check that $L(1) = H_A$ and $L(0) = H_B$.

[17] In Benabou 1996a (see also Benabou 1996b) it is shown that when we endogenise the decision over the optimal level of taxation, richer communities vote for lower tax rates, and nevertheless local schools obtain more funds in absolute terms.

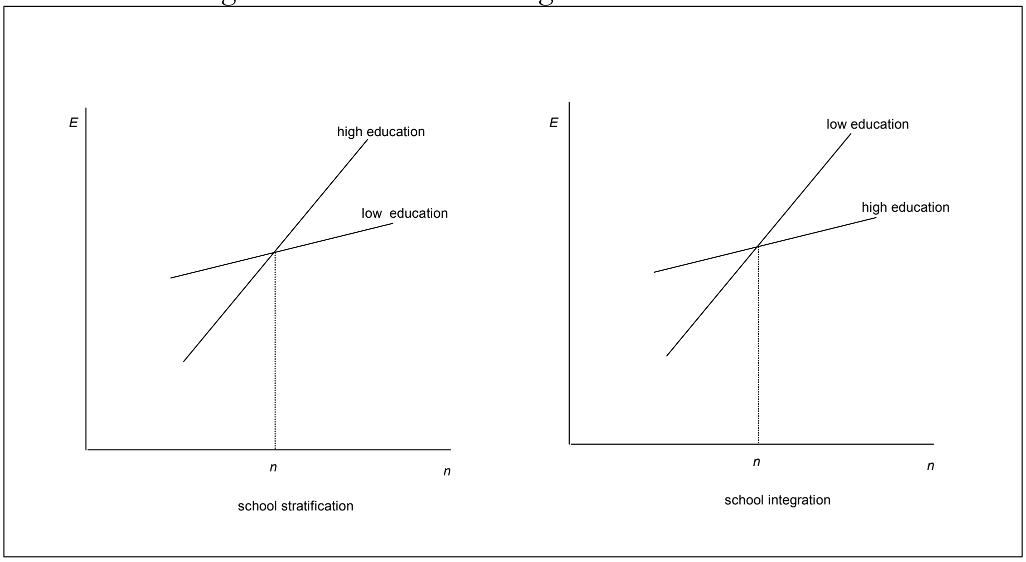
the social capital (as made clear by equation (4.7)). In addition, having classmates from richer families increases local funds available for the school (in accordance to equation (4.8)). Each agent will choose the combination $\left(E^j, n^j\right), j = 1,2$ granting her the highest utility level.

In order to study this choice, let us consider the slope of indifference curves in the (E, n) space, given the optimal choice described by equation (4.10). By means of the implicit function theorem,[18] it is possible to show that such a curve will slope as

$$\frac{dE}{dn} = -\frac{\frac{\partial U}{\partial H_{t+1}}\left(f_L \frac{dL}{dn} + f_E \frac{dE}{dn}\right)}{-\frac{\partial U}{\partial C_t^t}} = \frac{C_{t+1}^t}{H_{t+1}} \cdot \frac{\left(f_L \frac{dL}{dn} + f_E \frac{dE}{dn}\right)}{\left(1 + R(D_t, H_t) + D_t \frac{\partial R}{\partial D_t}\right)} \tag{4.11}$$

Equation (4.11) represents a marginal rate of substitution between costs (the denominator) and benefits (the numerator) of attending a given school. If this rate of substitution is increasing in the parent's human capital, this implies that educated parents (type H_A) exhibit steeper iso-utility curves (left panel of figure 1) than less educated parents. In such a case a stratified equilibrium will take place, because more educated (and richer) parents obtain greater benefit from school quality, are more willing to spend and therefore outspend poorer parents. Similarly, reducing the quality of social capital implies a reduced harm for low education parents when compared to high education ones, and therefore they are less inclined to pay for better school environment. The symmetric equilibrium (where $n^1 = n^2 = n$, that is the two schools have identical composition) is unstable, because it is sufficient for just one rich family expressing their greater availability to pay to fuel a cumulative rise of admission fees for the better school, up to the point where all highly educated parents would like to send their children there.

Figure 1 – Alternative configurations of iso-utilities



[18] In deriving equation (4.11), we have replaced the tuition cost B_j with the average resources obtained by each student E_j, disregarding the redistributive implication of changing composition of school bodies (i.e. the derivative $\frac{dE_j}{dn_j}$).

Rather the opposite, if the marginal rate of substitution $\frac{dE}{dn}$ is negatively correlated with family education (income), then the only stable equilibrium will be the perfect integration in both schools (right panel of figure 1).[19] It is thus clear that whenever stratification conditions apply, all H_A-type parents will spontaneously opt for the better school 1, whereas all H_B-type parents will prefer the worse school 2.[20]

School stratification has intergenerational implications, because all children from good family backgrounds obtain a better social capital from their school environment, attend schools with more financial resources and get H_A units of human capital. School stratification converts into social stratification. Vice versa, when school integration prevails, all human capital levels (incomes) converge to the same level, and an egalitarian society should emerge.

While integration may seem socially desirable, nevertheless the spontaneous allocation of students could go in the opposite direction. In such a case only a public intervention forcing the integration (a typical example being desegregation policies in United States) can lead to more efficient outcomes in terms of human capital formation. This may provide a rationale for a widely diffused practice of reserving quotas to various minorities.[21]

4. Class size

A final aspect related to class formation is the problem of optimal class size. If the educational outcome of a school can be easily identified and priced, then profit maximisation could identify the optimal class size. Going back to the educational production function (4.1) and amending it by taking into account that per capita resources E_{it} are increasing in the number of teachers m, while peer effect H_{it} dissipates with an increase in class size, we can formalise this problem for a given number of student n as follows

$$\max_m \left[\sum_{i=1}^{n} \beta \Delta H_{it} - wm \right] = \max_m \left[\sum_{i=1}^{n} \beta f\left(A_i, S_{it}, E\left(\underset{+}{m}\right), H\left(\underset{-}{\frac{n}{m}}\right)\right) - wm \right] \tag{4.12}$$

where β is the market price of an additional unit of human capital and w is the salary of a teacher. Maximisation (4.12) can be simplified by considering that S_{it} is endogenously selected by students on

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19 By taking specific functional forms for utility and financial market imperfections, Benabou 1996a is able to show that three conditions can disjointly be responsible for the emergence of stratification: technical complementarity between family background and social capital (that is $\frac{\partial f_L}{\partial H_t} > 0$); strong financial markets imperfections rendering the borrowing rate a negative function of family income (that is $\frac{\partial R}{\partial H} + D\frac{\partial^2 R}{\partial H \partial D} < 0$); wealth effects in the intertemporal distribution of resources.

20 If $n < 1/2$ some H_B-type parents will be forced to send their children to school 1 because they do not get admission to school 2, since all available positions were already taken. The opposite applies for H_A-type parents in the case where $n > 1/2$. We assume random selection of these families who do not get their first choice accommodation.

21 DeFraja 2002, provides an alternative justification of quotas on efficiency grounds where he models a situation of positive discrimination, favouring disadvantaged groups (i.e. groups with very few high potential individuals).

the basis of their individual ability, family background and expected return in the labour market (the β coefficient). By taking the first order condition associated with this problem, we obtain

$$\beta\sum_{i=1}^{n} f_E\left(A_i, E, H\right) - \beta\left(\frac{n}{m^2}\right)\sum_{i=1}^{n} f_H\left(A_i, E, H\right) - w = 0 \tag{4.13}$$

or rearranging terms

$$\frac{n}{m} = \sqrt{\frac{n\left(\frac{w}{\beta} - \sum_{i=1}^{n} f_E\right)}{-\sum_{i=1}^{n} f_H}} \quad \Leftrightarrow \quad m = \sqrt{\frac{n\left(-\sum_{i=1}^{n} f_H\right)}{\frac{w}{\beta} - \sum_{i=1}^{n} f_E}} \tag{4.14}$$

Equation (4.14) suggests that a profit maximising school (i.e. a private school) will optimally choose greater class sizes the bigger the student pool, the higher the teacher salary, the lower is the average effect of school resources (or peer effect) on individual human capital formation. Symmetrically, a private school will hire more teachers the bigger student pool, the lower the teacher salary and the higher the average effect of school resources (or peer effect) on individual human capital formation. Notice that a higher return to education (a bigger β) would suggest smaller classes and/or more teachers, because families would be available to pay the monetary cost of additional resources on the expectation of greater rewards in the labour market.

In order to derive optimal size prescription, it is necessary for the educational production function to be really affected by class size in empirical data, as predicted in equation (4.12). However in this respect the empirical evidence is mixed. Krueger (1999) analyses the available evidence on the STAR (Student/Teacher Achievement Ratio) experiment run in Tennessee in the period 1985-89, where 11.600 students in their first four years of school were randomly assigned to classes of different sizes.[22] Krueger (1999) found that after controlling for observable characteristics of the student and his/her family background, "…in all grades, the average student in small classes performed better on this summary [the achieved percentile in the distribution of test scores] than did those in regular and regular/aide classes". In a subsequent paper, Krueger and Whitmore (2001) merge the experiment sample with the records of college-entrance exams (SAT and ACT tests), and they are able to show that students assigned to smaller classes were more likely to apply for college; this effect was more pronounced among Afro-Americans than among white students. In addition, students from small classes outperformed those in regular classes by a small amount in test scores.[23]

Instead of reviewing a randomised experiment, Minter-Hoxby 2000a exploits natural variations in population size of a long panel of Connecticut elementary schools, finding that class size variation (due to age cohort size) does not have a statistically significant effect on student achievements (as measured by test scores in grade 4-6-8). Similarly Woessman and West (2002) analyse a larger sample from the TIMSS (Third International Mathematics and Science Study) conducted during the academic year 1994-95 by IEA (International Association for the Evaluation of Educational Achievement) across 40

[22] There were three types of classes: small classes (13-17 students), regular classes (22-25 students) and regular classes with teacher aide. At the end of the four-year experiment all participating students were returned to regular-size classes.

[23] In a European context, using the NCDS (National Child Development Survey, a longitudinal analysis following a single cohort born in 1958) Dustmann, Rajah and van Soest 2002 found that pupils/teacher ratio affects negatively and significantly both test scores and the probability of proceeding further in the educational career at the age of 16. On the same dataset, Dearden, Ferri and Meghir 1998 show that the explanatory power of school resources variables declines with the introduction of family and social capital related regressors.

countries. Their paper discusses in detail the problem of self-sorting of students in smaller classes, either for school policies (as in case of remedial programmes for poor background children) or for parents effort (in order to secure better learning environments for their children). By taking differences between adjacent classes they eliminate the self-sorting within schools, and then control for endogeneity of class size by using an instrumental variable estimator, where the school average class size is used as the instrument. They find evidence of a negative effect of class size on 13-year old students in 4 cases out of 36 cases, leading to the conclusion that "…in the vast majority of cases, however, the estimated coefficient is not statistically significantly different from zero".

Therefore, while in principle we could identify an optimal class size by equating marginal costs to marginal benefits, in practice the benefit can be hardly detected, given the high variability of estimated impact of class size on student performance.

5. Resource effectiveness

The case of uncertain effects of class size on student performance is not exceptional. Many other indicators of school resources (like student/teacher ratio, teacher salary, teacher education, school size, availability of books and/or libraries) have been found with ambiguous effects while trying to estimate educational production function in the vein of equation (4.1). Eric Hanushek has repeatedly provided reviews of this literature.[24] The general puzzle to be addressed is that "…the constantly rising cost and 'quality' of the inputs of schools appear to be unmatched by improvement in the performance of students".[25] Family and neighbourhood are generally found to exert a greater impact on school achievement than aggregate indicators of school resources. While early studies directly tested the potential impact of school resources on test score achievements, more recent ones focussed on the acquisition of cognitive abilities as the main output of the educational production function. While the effect of school resources are uncertain with respect to student achievement, stronger effects are found through continuation in school.[26]

There are two main issues in measuring the effect of school resources on educational achievements:
i) sample selection
ii) data aggregation.

The first problem is given by the potential endogeneity of school resources, that could be correlated with unobservable abilities of students through self-sorting of students. If we take a linearised version of equation (4.1)

$$T_{it} = \eta_0 + \eta_1 A_i + \eta_2 E_{it} + \eta_3 H_{it} + \varepsilon_{it} \qquad (4.15)$$

where T_{it} is a generic measure of educational attainment (be it test scores, cognitive ability or years of education). Any ordinary least square estimation of η_2 will be biased if $Cov(A_i, E_{it}) \neq 0$, which can occur either because better students choose schools endowed with better resources (or even the

24 See for example Hanushek 1986, 1996 and 2002. For another review see Burtless in Burtless 1996.

25 Hanushek 1986, p.1148. Making reference to US data, Hanushek 1996 put forward that spending per student has steadily increased by 3.5% a year (due to decline in pupil/teacher ratio and increasing teacher stipends) whereas student performance has remained constant if not declining.

26 "An additional part of the return to school quality comes through continuation in school. There is substantial evidence that student who do better in school (either through grades or scores on standardised achievement tests) tend to go further in school" (Hanushek 2002, p.13).

opposite, better teachers want to teach in schools where students are better - $Cov(A_i, E_{it}) > 0)$[27], or because schools devote extra resources to less brilliant students ($Cov(A_i, E_{it}) < 0$). To minimise the problem, it is possible to resort to first differences (value added formulation)

$$\Delta T_{it} = \eta_2 \Delta E_{it} + \eta_3 \Delta H_{it} + (\varepsilon_{it+1} - \varepsilon_{it}) \tag{4.16}$$

The formulation (4.16) is possible only when panel information on students is available, and when school resources vary from one year to another. If for example E_{it} refers to a teacher input characteristics (like stipend, education or hours of work), it is not likely to change over the years and it cannot therefore be identified. In principle it would be possible to identify the relative contribution of each single teacher, using a two-step procedure. Possessing information on a wide sample of students that have changed teachers in their school careers, the contribution of each single teacher could be identified by a specific dummy (as long as there have been students changing classes and teachers). In the second step, individual teacher dummies can be regressed on observable characteristics of teacher in order to identify which variables could account for relative contribution to students' achievements. However the amount of data required is enormous, and this explains why similar procedures have been rarely attempted. Quite the opposite, the same strategy has been implemented by using aggregate data based on schools or district areas. This reduces the amount of information required (because individual level data on resources are replaced with school or area averages) but may introduce aggregation biases that may create more problems than those that they are able to solve.

The aggregation procedure is correct under the assumption of independent disturbances across the group structure, otherwise it leads to downward biased least square estimates of standard errors (Moulton 1990). But schools or districts can share observable and unobservable characteristics, which should be controlled for (either by imposing a clustered structure for the errors distribution or by using two stage procedures). Still, even in the case of aggregate data, the effect of local school resources is only identifiable by students changing location, because otherwise group averages would be observable.[28]

If only group averages are used (as in cross country analysis), then typically positive and significant effects are found in the literature. Lee and Barro (1997) take test scores on internationally comparable tests (taken at the age of 9 and 14) as measures of educational achievement and regress them on proxies for family resources (output per capita and average years of education) and for school resources (pupils per teacher, average expenditure per student, average salary per teacher and average length of academic year). Using information for 58 countries over the period 1960-90 they find significantly positive effects of school resources variables.

Completely different results are obtained when school effectiveness is tested with respect to labour market outcomes. Card and Krueger in different papers (1992, 1996 and in Burtless 1996) have argued that abundance of school resources reflect in longer stay at school and higher return to education. The

[27] "If a researcher does not control for family background, then when analysing a data set in which children from wealthier families attend schools with smaller class sizes and better-paid teachers, the researcher will find a positive correlation between student outcomes and school resources. But that correlation may simply mean that students from wealthier families are primed to do better in school. Conversely, to the extent that students from poor families are more likely to be assigned to remedial classes with higher resources per student, an incautious researcher who does not control for family background would conclude that greater school resources reduce school outcomes." (Blau 1996, p.6). In addition, self-selected samples (like those constituted by student taking the SAT tests) provide estimates of school resources that are biased when referred to the entire population (see Hedges and Grenwald in Burtless 1996).

[28] But this makes it impossible to control for social environment, which is a crucial determinant of educational attainment. When samples are restricted to "immobile" students (i.e. children from non-moving families), most of the resource effects are found negative (Hanushek 2002).

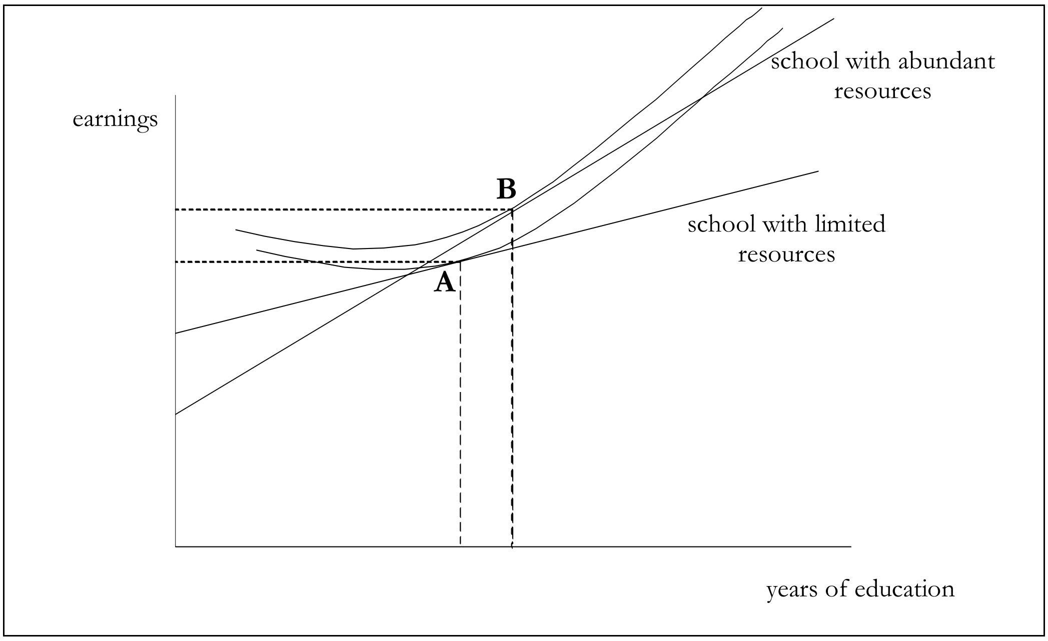
basic idea is described by figure 2. Individuals differ in terms of ability, whereas schools differ in terms of resource endowments. If school resources are inputs in the educational production function, then student self sorting gathers better students in schools with more abundant resources (because they have a lower cost of school attendance and/or expect a higher return per invested unit of school resources). This corresponds to point **B** in figure 2. The remaining low ability students will choose less education and will experience lower earnings (point **A**). By estimating a regression line for each sub sample, a researcher would expect two different slopes, the "high resource" schedule being characterised by lower intercept (a high talent individual choosing not to acquire education will be penalised in the labour market) and higher slope (student attending better schools will experience higher returns to education). Thus this model yields three theoretical predictions: greater school resources are positively correlated with longer stays at school, higher returns to education and lower intercepts in the earning-education function.[29] Card and Krueger (1992) test this approach by using census data for US population born between 1920 and 1949 and by attributing to each individual the school quality information associated to the area where the person was born, finding significant effect of student/teacher ratios experienced in the birth area and the subsequent labour market experience (even when controlling for birth region, residence region and cohort effects).[30] Card and Krueger (1996) follow a natural experiment approach by comparing individuals born (and supposedly educated) in North Carolina (where race segregated schools were absent) and in South Carolina (where school desegregation took place more recently). They find evidence of a persistent difference in wages for Afro-Americans born in North Carolina and white people born in South Carolina,[31] and they attribute this permanent difference to the difference in educational systems (different class sizes being a crucial aspect of it). Finally Card and Krueger in Burtless (1996) review related literature (24 articles), confirming that on average a 10% increase in educational expenditure per student is associated with 1-2% increase in student's subsequent annual earning.

Figure 2 – Educational choice under different endowments of school resources

[29] We cannot take these correlations as causal, as Card and Krueger 1996 make clear with the following example: let us suppose that students from wealthier families tend to stay in school longer; in addition, the very same persons will earn more because of social networking of their families. In addition suppose that wealthier families demand smaller class size, even though class size is uninfluential on learning. We would observe positive correlations between school resources and both educational attainments and earnings, but both correlations would be spurious, merely reflecting the failure to account for the independent effect of family wealth.

[30] Heckman, Layne-Ferrar and Todd 1997 have repeated the same type of analysis extending the sample to younger cohorts, controlling for the potential endogeneity of migration and allowing for non-linearity of the relationship between education and log-earnings, but they find even stronger effects (see also Heckman, Layne-Ferrar and Todd in Burtless 1996).

[31] "For blacks, the estimated payoff to a year of education in 1980 was 2.1 for those born in South Carolina and 4.0 per cent for those born in North Carolina; while for the whites the order of the returns was reversed: 6.6 per cent for South Carolina and 6.0 for North Carolina." (Card and Krueger in Burtless 1996).



How do we reconcile these two sets of contradictory results ? On one side, we find that educational resources are scarcely related to school performance (as measured by test scores and/or literacy tests), nor do test scores have any impact on subsequent earnings.[32] On the other side we find that district-average educational resources per student affect educational attainments and subsequent labour market earnings. These results cannot be easily reconciled in a human capital perspective, where earnings mirror acquired competences. However, schools perform screening activity as one of their by-products, and test scores are crucial in this prospect. They implicitly indicate the likelihood that teachers place on the prosecution of studies beyond a specific level. In an earning function, when we already control for educational attainment, these scores are rather likely to play a limited effect (the so-called *sheep-skin effect*, since people with identical educational credentials look similar to potential employers).

But school resources can still be effective in extending school attendance. If mass scholarisation takes "low quality" students in schools (i.e. students with poor background, who require increasing inputs for identical outputs), we would observe constant (or even declining) school productivity (as measured by test scores), but increased educational attainment in the population. Extended attendance can explain the positive correlation between school resources and earnings, but we still lack a convincing (and testable) explanation for the correlation with marginal return rates of education.

6. Resource efficiency

A recurrent explanation for the finding of absent effectiveness of educational resources when estimating educational production functions makes reference to inefficient use of the same resources (Hanushek 1986, Pritchett and Filmer 1999, Gundlach, Woessman and Gmelin 2001). The basic idea is simple: with decreasing marginal productivity of inputs, an intensive use of one input can lower its productivity down to having a negligible impact (statistically indistinguishable from zero). The extensive use is not justifiable under cost minimisation. In fact, defining a cost function linked to an aggregate educational production function (equivalent to the sum across individuals of equation (4.1)) as

[32] See for example Altonji and Dunn 1996 or Murnane, Willet and Levy 1995.

$$\min_{\bar{E}} \sum_{j=1}^{m} p_j E_j \quad \textit{subject to } \Delta H = f\left(E_1, E_2, ..., E_m\right) \tag{4.17}$$

where E_j represents a generic input (say teachers, books, libraries, and so on) linked to a market price p_j. Considering first order conditions associated with problem (4.17) and taking their ratio we get

$$\frac{p_j}{p_k} = \frac{f_{E_j}\left(E_1, E_2, ..., E_m\right)}{f_{E_k}\left(E_1, E_2, ..., E_m\right)} \tag{4.18}$$

which can also be re-expressed as

$$\frac{f_{E_j}\left(E_1, E_2, ..., E_m\right)}{p_j} = \frac{f_{E_k}\left(E_1, E_2, ..., E_m\right)}{p_k} \tag{4.19}$$

Equation (4.19) defines cost effectiveness, corresponding to the condition that achievement gains per dollar spent have to be equalised across inputs. As Pritchett and Filmer (1999) convincingly demonstrate, the vast majority of studies on educational production function are inconsistent with condition (4.19).[33] In a similar vein, using aggregate data on educational expenditure Gundlach, Woessman and Gmelin (2001) find that the educational sector in OECD countries has exhibited a productivity decline in the order of 2-4 percentage points a year over the period 1970-94.[34]

How can we account for this evidence of technical inefficiency ? Several explanations are at hand. The easiest one is that the educational production function is a multi-output technology. Schools aim to improve competences of students (often proxied by test scores), but they are also expected to raise civic attitudes, self control, aesthetic sense, ability to cooperate with fellows, and so on.[35] As long as educational resources are relevant in raising these aspects, we could not satisfy condition (4.19) and still be on the efficiency frontier. The problem is that these other outcomes are hardly measurable, and therefore this claim goes unchecked.

An alternative explanation invokes the lobbying activity of teachers and families.[36] If school resources are chosen under teachers' influence (i.e. in accordance with teachers' welfare), then we will observe an

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[33] Pritchett and Filmer 1999 openly recognise that educational production function estimation is blurred by the ignorance of the degree of utilisation of each factor: "…there is a crucial distinction between testing whether inputs have low productivity at their current rate of application versus testing whether they are 'inputs' at all." (p.224).

[34] Gundlach, Woessman and Gmelin 2001 consider a two-sector model, where educational service is stagnant, whereas the residual sector grows at a constant rate. Assuming price determined in competitive markets (which is a rather strong assumption for education, given the public sector nature in most of the countries in the sample), we should observe an increase of the relative price of education at the same growth rate of productivity in the residual sector. The difference between the two is taken as proxy of productivity decline in the educational sector.

[35] Edwards 1977 shows that test scores in schools (and wages in workplaces) are highly correlated with personal traits that teachers (and job supervisors) seem to appreciate: "Rule" (rule orientation), "Depend" (habit of predictability and dependability) and "Internalise" (personal identification with enterprise/school goals). As long as these traits can be induced in students, these are outputs of the educational system.

[36] "Class size reductions are enacted often because they are popular with nearly every constituency interested in schools. Parents like smaller classes because their personal experience suggests that they themselves give more to each child when they have fewer children to handle… Teachers may like smaller classes because they reduce the effort that they must expend in order to deliver instruction. Teachers' unions may like class size reductions because they increase the demand for teachers. Administrators may like class size reductions because they increase the size of their domain." (Minter-Hoxby 2000a, pp.1239-40).

excessive use of the resources that are more relevant in this utility function. Indirect evidence of this proposition exists. Minter-Hoxby (1996a) finds that unionisation of teachers[37] can account for greater use of educational inputs; this evidence is consistent with either teachers having better information about educational production function (*efficiency-enhancing*) or with teachers' unions being rent seekers. In addition to educational budget expansion, teachers' unions may also be able to change budget allocation in favour of inputs that reduce teachers' effort (like reducing class size and/or teaching load per teacher) or increase teachers' salaries. Pritchett and Filmer (1999) review several articles estimating educational production functions in less developed countries, and show that statistical significance is greater for inputs that are not a direct concern of teachers (like books, libraries, class homework), whereas other inputs (pupil/teacher ratios or teachers salaries) tend to prove insignificant. Additional evidence is obtained from the comparison between private and public schools, since the former is less under control of teachers.

An alternative interpretation has been proposed by Woessman (2003) reviewing the TIMMS survey over 39 countries. His starting point is that "…public schooling systems still differ substantially across countries in their institutional structure of educational decision-making processes. They give different amounts of decision-making power to the different agents involved in educational production, which creates different incentives for their behaviour. These differences in institutions and incentives will affect the agents' decisions on resource allocation and thereby the effectiveness of resource use in the education sector, which should impact on the educational performance of the students."[38] After controlling for family backgrounds and educational resources, he is able to prove that the degree of school autonomy has positive bearing on student performance; institutional features like external examinations and a competitive environment set by a large private schooling sector have statistically significant positive effects on student performance in mathematics and science. His interpretation is given in terms of agency problem: greater autonomy for schools implies more effective monitoring of teachers by parents concerned about students' learning, thereby being conducive to better student performance. Conversely, a larger influence of teacher unions in the education process leads to lower performance levels.[39]

The role of external competition is also stressed by Minter-Hoxby (2000c). In order to evaluate her contribution, we must refer to the concept of Tiebout choice. In his original paper, Tiebout (1956) argued that the under-provision of public goods when individual preferences are unobservable could be solved by decentralised expenditure (and taxation). By moving to the location closer to the preferred combination of tax rate and public supply, each individual reveals her true preferences: conditional on externalities being limited to community size, spatial mobility is a way to reveal hidden preferences and to levy taxes up to the desired amount. The idea of "voting with your feet" can be applied to the quasi-market for education. By increasing their opportunity set (i.e. by raising the number of alternatives in school choice), families can obtain the desired amount of education for their children, in terms of resources, peer effect and social capital. This increase in self-sorting according to preferences with regard to schooling raises *private allocative efficiency*, whereas the effect on *social allocative efficiency* depends on the shape of the educational production function (see section 3 above). Increased parental choice calls for better scrutiny of available alternatives, yielding stricter monitoring of existing schools. As in any agency problem, stricter monitoring leads to improved performance and/or to a more efficient use of existing resources, thus reducing the unitary cost of delivering education.

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37 A school district is defined "unionised" if three conditions are contemporaneously met: presence of collective bargaining; existence of a collective agreement; presence of a union claiming more than 50% of district teachers among its members.

38 Woessman 2003, p.119.

39 However this papers suffer from different degree of variable aggregation, since the dependent variable (individual student performance) is regressed onto family characteristics, class or teacher information and country variables.

Using data on 6.523 US metropolitan districts, Minter-Hoxby (2000c) measures the extent of available parental choice with concentration indices built on enrolment rates.[40] This measure exerts a positive impact on student achievement and a negative impact on both per-student spending and enrolment share in private schools. The author takes this evidence as confirming that increased competition among public schools (i.e. greater availability of choices) can be beneficial for both students and taxpayers. Her results are robust despite the increased sorting of households by districts, because increased homogeneity among district families has little net effect on achievement, on per-pupil spending and on productivity (constructed as the ratio between achievement and spending, as in equation (4.19)).

Analogous conclusions can be found in Fiske and Ladd (2000), where they review the large-scale school reform undertaken in New Zealand between 1989 (labour government) and 1991 (nationalist government). The state system of compulsory education was fully decentralised; administrative responsibility was passed to locally elected boards of trustees; charter schools (combining central funding and accountability with autonomy of management) were also introduced. Oversubscribed schools had the right to designate criteria of admission (thus shifting the system from "increased parental choice" to "increased school choice"). According to the evidence collected by the authors, better-educated parents mainly exploited the increased availability of choice. Five years after the reform, they noticed an increased polarisation of enrolment by ethnic and/or socio-economic groups. They also report an increased polarisation among schools: most popular schools attracted most of the students oriented to a university career, better teachers and wealthier families. A still unsolved question had to do with low performing schools, typically located in culturally (and economically) deprivated areas. The reform left this issue unsolved, leading the authors to suggest that the new mechanism did not provide any formal mechanism for balancing the narrow interest of a particular group of parents against the legitimate needs of broader communities: "The bottom line is that it is impossible to sustain a system in which all parents are completely free to select the school their child will attend. Some mechanism must be devised for rationing places in popular schools, and this inevitably involves constraints on choice. The challenge is to keep the constraints from falling disproportionately on students from disadvantaged families…".[41]

Summing up, while there is strong evidence that public schools do not behave according to profit maximisation, it is not yet clear why this occurs. It has been argued that this has to do with teachers' influence (including rent seeking); the implication would be that more competition between schools should reduce rents, improve both productive efficiency of resources (for given demand for education) and (private) allocative efficiency of students and teachers (for given supply of schools). However this discussion shows that it is rather different to increase the freedom of choice at the margin or on the whole.[42] The crucial fact that education is compulsory, at least at initial stages, requires that it has to be delivered sufficiently close to families in order to enact the legal or constitutional obligation. While in competitive markets unprofitable firms will be driven out of the market by the (prospective) losses incurred by their owners, in quasi-market for education less efficient schools need to be retained in order to supply a minimum of education to anyone. While in principle it would be possible to disentangle family background, unobservable ability, peer effect and (in)efficient use of resources in educational production function, in practice it becomes impossible to isolate cases of inefficient use of resources from cases of low quality inputs, since students self-sort in accordance with alternative features (parental status, parental education, family income and wealth, ethnicity, religious beliefs).

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[40] She computes Herfindhal indices on enrolment shares for each district within a metropolitan area, and takes it as proxy of choice availability. Since this variable is potentially endogenous, she instruments it with a variable measuring the extent of natural barriers created by existing rivers.

[41] Fiske and Ladd 2000, p.287.

[42] Even in the New Zealand case, parents' freedom to choose has been limited by reimposition of residential zoning as basis for enrolment policy.

7. Efficiency versus equity

Previous discussion on the legal obligation to provide at least some education to all citizens, irrespective of the attained level of efficiency, leads us to discuss the potential trade-off existing between efficiency and equity in education provision.

In modern societies, opening access to education has progressed hand in hand with the extension of voting rights.[43] Publicly funded education has also exerted redistributive effects.[44] In addition, free provision of equal amounts of education to all students should produce intertemporal equalising effects on income distribution.[45] On the whole, one may argue that educational expenditure has an intrinsic equalising content, which can be strengthened if one chooses to allocate these resources in a compensatory manner (namely by favouring individuals from poor backgrounds).

On the other hand, in previous sections we have seen that compensatory allocation can prove ineffective and/or inefficient, depending on the configuration of the educational production function. In fact, there can be plausible cases where a society as a whole produces more human capital by concentrating resources on the best students; equality can be achieved by subsequent redistributive taxation of labour incomes. As in other spheres of public economics, public provision of education faces a trade-off between equity and efficiency, so that a society can improve in one dimension only at the expense of worsening in the other.[46]

Some authors have tried to escape from the trade-off. Minter-Hoxby (1996b) recasts the equity-efficiency trade-off in terms of centralised-decentralised school financing. In her view, local financing is able to achieve allocative efficiency (each individual invests her desired amount of resources in education) and productive efficiency (each unit of human capital is obtained at the lower cost of delivery) at the same time. The goal of equity is to apply this standard of optimality to everyone, regardless of family background or income. Since optimal investment can be prevented by an imperfect financial market, moral hazard behaviour and/or imperfect recognition of externalities, there is scope for public intervention to relieve inequality of opportunity. This can be done with means-tested school vouchers or with categorical aid,[47] but the former is more effective in strengthening competition among

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[43] Gradstein and Justman 1995 propose a model that replicates Kuznets' curve through the extension of franchise. During a process of growth, there is an increase in the population share with income beyond the threshold required to gain voting rights. As a consequence, the income of the median voter declines, and more resources are devoted to public education financing.

[44] It has been argued that education financing through general taxation can be regressive as long as the offspring of richer families have a higher propensity to proceed in the academic career. However other aspects have to be taken into account in making these types of calculation: most fiscal systems are progressive (i.e. the rich pay a higher percentage of taxes on their incomes), and the number of children may vary according to family income. With respect to a representative sample of Italian families surveyed in 1995, 53.0% of families in the lowest quartile of incomes had a child aged 6-25 cohabiting, while the same percentage was 68.8% in the top quartile. Even taking into account a potential bias due to the fact that poorer families give birth to children earlier, only 8.3% of families in the lowest quartile have a child enrolled at the university, whereas the same percentage is 22.5% for the top quartile: as a consequence, the bottom quartile receive only 10.6% of the benefit from public funding of Italian universities, while the top quartile receive 40.5%. However, according to fiscal law applying to the same year, the bottom quartile was only contributing 7.9% to the revenues from income and consumption taxation, while the top quartile was contributing 49.4%. In this respect, public funding of Italian universities still exerts a redistributive effect. For details see Flabbi in Checchi 1999, chpt.4.

[45] Checchi 2001 studies the relationship between income inequality and education inequality (measured by Gini indices obtained from years of education), finding evidence of a non-linear relationship between the twos.

[46] A famous book on the argument is Okun 1975.

[47] "…categorical aid should be financed by taxes, such as statewide income taxes, that have no marginal price effect on the spending decisions of individual school districts." (Minter-Hoxby 1996b, p.66).

schools. However these prescriptions ignore other aspects that prevent educational investment: culturally poor families value education less (especially when living in poor neighbourhoods, where role models seem to confirm their judgment); economically poor families are more risk adverse, at least with respect to educational investment; schools are not evenly distributed in the territory, and mobility costs can be high; educational systems can be based on early tracking (as in the case of Germany and Italy, for example), thus making past choices irreversible. Under these circumstances, efficient use of educational resources may conflict with equity goals taking the form of compensatory additional resources to be spent on disadvantaged individuals.

By focussing on higher education, Arrow (1993) also tries to avoid the notion of potential trade-off between equity and efficiency (to be understood as "excellence" in his framework). Since private returns to higher education are by far greater than social ones, students applying for university should pay (almost) the entire cost of their education: why should society subsidise individuals who by nature are destined to earn more ? In his perspective, the equity-efficiency trade-off is misplaced at the university level, given that existing demand for skilled labour covers only a fraction of the entire labour force. But this "natural" outcome can be revealed as inefficient, whenever the brightest children from poor families are excluded from the opportunity of entering university. Arrow's conclusion holds only under the condition of perfect screening of natural abilities by preceding levels of schooling and perfect information on families. Otherwise, subsidising university education to ensure greater equality of opportunities retains its meaning. But this somehow reduces the selectivity of access to the best universities, recreating the trade-off with efficient outcomes.

In my opinion, the trade-off between equity and efficiency keeps holds up in educational markets, since it is practically impossible to correct for all existing obstacles to educational investments. Improvements in efficient use of resources can certainly be achieved by means of appropriate incentive schemes for schools and teachers, but as long as parents' education remains one of the most significant predictors of children's schooling there is scope for compensatory action by public authorities, in order to improve on the equity side. This is especially true when families have incentives to differentiate through the educational investment, as is explained more fully in the next chapter.

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