School Competition

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Abstract

This paper considers the influence of spatial competition on education and its effect on students' school choice and educational achievement by explicitly modeling educational production and the students' participation decision. Education at school is a function of teacher effort and class size. Students decide which school to attend on the basis of an assessment of the associated costs and prospective benefits from doing so. We analyze how competition between schools affects equilibrium resource spending and school diversity as well as the level and distribution of student attainment and welfare. The consideration of spatial aspects of school choice without recourse to vertical differentiation is a unique contribution of this paper.

We argue that schools in metropolitan areas with short ways to school and many potential students face fiercer competition which increases school productivity and student performance. This result confirms the findings in Hoxby (2000). Overall learning time in school is constant in the probability that students behave well if students are segregated by type. However, better behaved students have a higher achievement due to higher optimum resource spending.

Finally, we support our argument by an empirical analysis of student performance in various matura schools in Switzerland.

1 Introduction

Competition between schools is one of the most hotly debated approaches to providing incentives in order to improve education. The first step towards a competitive environment for schools is the introduction of *school choice*. In such a system, public schools have to compete at least against other public schools. A second step is the introduction of *vouchers* to enable students to attend any school – public or private – they (or their parents) like. The best-known proponent of this idea is Friedman (1997). Distinguishing between the financing and the provision of education, it is possible to assess whether private schools perform better than public schools. Vouchers create a market in education by establishing an exchange mechanism and the price is the nominal value of the voucher. As an entitlement to an amount of schooling, such vouchers may allow students to choose their education, where – because of government funding – the inequalities which potentially arise with choice are ameliorated. Potential consequences of voucher programs include changes in who enters the teaching profession, how teachers and students allocate time and effort to various tasks, and how students sort themselves into schools, classrooms, and neighborhoods (cf. Neal, 2002).

Evidence concerning the market for education suggests that there are beneficial effects from vouchers and school choice, but up to now, research can not give clear answers to the basic questions whether and how competition leads to better school performance. In this paper, we focus on the implications of school district properties and schooling policy measures for student attainment and achievement.

Most of the empirical literature on school competition and student performance considers the U.S. education sector where competition takes place between private and public schools. As will be discussed in section 2 below, empirical evidence suggests that competition between schools indeed leads to better student performance in public schools. The question addressed in the application of the model is whether students in the Swiss education system, where the role of private schools is minuscule and therefore competition concentrates on public schools, also profit from free school choice via the introduction of a voucher-like system. The analysis of horizontally differentiated schools with homogeneous school quality in equilibrium distinguishes our approach from the existing literature on school competition. It is most appropriate in school systems where public schools dominate and student selection on the basis of other criteria than

performance is prohibited. In the empirical application of the model we concentrate on the upper secondary level of education since this is the one on which students are most mobile and the establishment of free school choice and competition is explicitly intended to provide schools incentives to improve. Geographical restrictions for attending certain schools being very diverse throughout the country, an important focus of the paper is on the impact of the geographical dimension on school competition and student attainment.

We first present an overview of the literature on school competition. Then, we provide a theoretical framework for the analysis of the effects of school district properties and policy measures on student attainment and achievement. Finally, we discuss the actual competitive environment for matura schools in Switzerland and assess parts of our theoretical findings with data from the Program for International Student Assessment (PISA) in the context of the Swiss school system.

2   Related Literature

A large body of theoretical research examines the effects of competition on school quality and sorting across schools, cf. eg. Epple and Romano (1998, 2002), Hoyt and Lee (1998), Nechyba (1996, 1999, 2000), Caucutt (2002), and McMillan (2004). In this research, schools are often treated as passive technologies converting resources into educational achievement, thus abstracting from institutional characteristics of the school system and potential incentive effects of vouchers that influence school efficiency. Empirical findings on the effectiveness of competition between schools are controversial. Among the proponents of school choice are West (1997), Hoxby (2000, 2003), Holmes, DeSimone, and Rupp (2003); rather critical is Carnoy (1997). The potential problem of decreased equity in competitive school systems, where private schools tend to privilege certain student types, is addressed in Ambler (1994) and Ladd (2002).

Overall, evidence concerning the market for education suggests that there are beneficial effects from competition, but up to now, research cannot give clear answers to the basic questions whether vouchers and school choice will lead to market-like competition and whether this will lead to better school performance (cf. Levin, 2002). Potential disadvantages of voucher schemes include significant financial resources and teachers' time diverted to marketing and more weight

given to quantifiable examination results than to what is important. Thus, the costs of a voucher system may outweigh the expected benefits of introducing competitive pressure to schools and greater freedom into the provision of education.
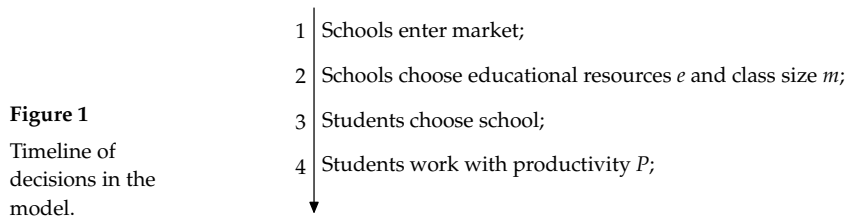
3 The Model

3.1 Model Outline

We develop a theoretical model which focuses on the effect of vouchers with respect to a school's choice of spending on schooling resources and class size and students' participation decision if education is compulsory. The main difference to the literature lies in the use of a more elaborate educational production function and the explicit modeling of students' participation decision. Also, the spatial dimension of school competition is explicitly taken into account. However, we abstract from peer-group effects such that higher school quality due to increased competition is a natural result. The model discussed in the following is similar to the approach taken by De Fraja and Landeras (2004). They model the interaction between schools and students in a framework where a student's educational attainment depends on her effort, her peer group and the quality of teaching. They find that teacher incentives as well as competition may have perverse effects on outcome. This is due to strategic interaction between students and teachers.

Our model considers a competitive educational sector in the sense that students are free to choose the school they (or their parents) like. Students receive an education voucher in the form of free entry to any school they like, which equalizes them with respect to their endowment; schools are not allowed to accept payment other than the publicly provided voucher. The necessity of the physical attendance by students and teachers qualifies education as a local good. We therefore assume competition between schools to be spatial in the sense of Salop (1979). The exact location of students and schools is discussed in section 3.3 below. The Salop-model, on which our approach is based, has not yet been applied to competition among schools in the literature. In our model, the inefficiency of schools occurs not within schools due to the extraction of rents: Even with low competitive pressure, all schools make zero profit due to free entry into the

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market. The inefficiency arises from excess entry into the market. Hence, in the analysis below, tougher competition will lead to larger schools and thereby to a more productive *educational system*.[1]

We assume that there are N students per school district. Educational production consists of providing students with educational achievement of size H. Student success as a result of educational production is a very abstract concept deserving detailed appraisal of its own. In the context of this paper, we simply assume that schooling success is measurable as for example in external tests. Then, the passing of these tests may be either a prerequisite to move on to higher education or enable students to find highly qualified jobs. We are, however, well aware that such tests are limited to only a few dimensions of educational outcomes. Hence, a comprehensive analysis would have to include an in-depth discussion of the very goals of education in schools (productivity, literacy, citizenship), and the multi-dimensionality of inputs in educational production (cf. e.g. Holmstrom and Milgrom, 1991 and Holmstrom, 1982). For the sake of simplicity and focus on the goal of this paper, we abstract from these issues.

1	Schools enter market;
2	Schools choose educational resources e and class size m;
3	Students choose school;
4	Students work with productivity P;

Figure 1

Timeline of decisions in the model.

We assume free entry of schools which compete in resources and class size – given the students' participation constraint. The sequence of decisions is depicted in figure 1. To solve backwards for the equilibrium, we must (4) define an education production (student success) function, (3) determine the students' participation constraint, (2) determine the Nash equilibrium in educational resources and class size for any number of schools and calculate the reduced-form profit function and (1) determine the Nash equilibrium in the entry game of schools.

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[1]This result is driven by the effect of business stealing among schools. Teacher teamwork is easier encouraged in small schools, such that our result will not necessarily hold in a more general setting.

3.2 Educational Production Technology

In analyzing total educational production H, we discern between school production and home production of education:[2]

$$H_{i,j} = P_j + Q_i,$$

where subscripts i and j refer to individual students and schools, respectively. Educational production at school, P_j, is a (positive linear) function of educational inputs per class and class size in the sense of Lazear (2001): When one student disrupts classwork, the entire class suffers; the teacher's and the other students' concentration is diverted from studying. Let π be the probability that a student is not misbehaving at any moment in time. We assume that students are homogeneous with respect to π. Then, the probability that all students in a class of size m are behaving is π^m which is also equal to the proportion of schooling time during which students are effectively studying. Thus, a student's education P in school j is given by the following educational production function:

$$P_j = e_j \pi^{m_j}, \qquad \pi \in [0, 1[, \tag{1}$$

where e denotes educational inputs per class, m is class size, and π is the individual probability of non-disruption. For simplicity, we assume a cost function for resources $\eta(e)$ of the form

$$\eta(e) = \varepsilon e. \tag{2}$$

The term *resources* is not confined to physical resources at schools, such as the size of the classroom, whether there are computers, etc., but contains also teachers' education and motivation.[3] The home production part of education is

$$Q_i = q(\xi_i),$$

where ξ is a vector of student characteristics, such as her family background and her motivation. The home production part of eduction is student-specific and exogenous to schools. It will be needed in the emiprical application of the model in section 4.

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[2]Cf. Wössmann (2004) for a discussion of the school production vs. the home production part of education.

[3]Figlio (1999) finds that higher student-teacher ratios are associated with lower student performance and that higher teacher salaries are positively related to increased student performance. Cf. Pritchett and Filmer (1998) for a theory on the role of the relative strength of parents vs. teachers in the allocation of education expenditures.

3.3 Spatial Aspects of Student School Choice

Competition between schools is operationalized through free school choice by students and free teacher/school entry in the educational sector. Students incur transport costs by travelling to the school they attend. The term *transport costs* can be understood literally or as an expression for preferences toward a specific school type. Given this latter interpretation, the government can control transport costs by allowing free school choice or force parents to move to another district if they want their children to attend the school specific to that district. Generally, in metropolitan areas, there are several schools, each relatively close to where students live and with a large variety of elective courses, such that transport costs are low compared to rural areas, where the next school may be far away.

The following characterization of competition between schools is similar to the spatial competition model in a circular city by Salop (1979). Students are located on a circle with a perimeter equal to 1. Density is unitary around this circle such that the total mass of students is 1. Schools are also located around the circle, and all travel occurs along the perimeter.[4] Schools do not choose their location, but are exogenously located equidistant from one another on the circle as in figure 2. Thus, maximum differentiation is exogenously imposed.[5]
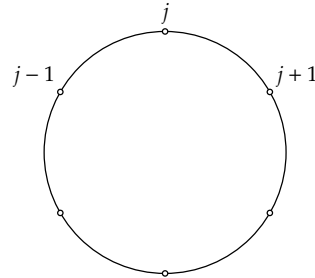

Figure 2

Uniform location of students and schools around a circle.

In principle, any school j competes against any other school on the circle. However, since schools are symmetric, we can abstract from the competition against

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[4]Apart from its spatial interpretation, the schools' location can also be taken as differentiated school profiles with respect to their curricula.

[5]The uniform location around the circle is optimal if also students are located uniformly around the circle and if transport costs are increasing and convex. With linear costs, there are multiple equilibria, one of which is the uniform allocation assumed here (cf. Economides, 1989, and Tirole, 1988).

schools which are not immediate neighbors. Students expect utility V which is separable over the private value of the school part of their education and the transport cost to school: $V = P - \delta x$, where x is the distance to the chosen school. In compulsory education, the local student participation constraint can be expressed by the student's indifference between attending school j and attending any other school. Thus, the local participation constraint writes as

$$\text{PC:}_j \qquad P_j - \delta \tilde{x} = P - \delta \left(\frac{1}{J} - \tilde{x} \right), \tag{3}$$

where J denotes the total number of schools in the district and $\tilde{x}$ is the farthest distance to a student attending school j. The number of students s attending school j, s_j, results from the area around the circle from which students are attracted: This area stretches in both directions up to a distance x. Solving (3) for x gives half the mass of students attracted. Denoting by N the total number of potential students in a district, s_j is computed as

$$s_j = 2\tilde{x}N = N \frac{P_j - P + \frac{\delta}{J}}{\delta}. \tag{4}$$

In symmetric equilibrium, school enrollment is simply $s_j = s = N/J$, such that travel costs δ have no influence on s. From the perspective of an individual school, however, higher transport costs make it more difficult to attract more students (business stealing from oter schools). On the other hand, with high transport costs, a school will lose fewer students to its neighbors if it offers lower quality. We thus have computed the number of students in school j given the number of schools, success probability in school j and in its neighboring schools. The next step backwards is the computation of the success probability in each school as a function of class size and resource spending.

3.4 Class Size and Resource Optimization

Schools receive a per-student contribution (voucher value) of g from the government and incur fixed costs f which include infrastructure costs et cetera. Any school j maximizes its profit W_j over resources and class size subject to the potential students' local participation constraint. The maximization problem writes as

$$\Pi_j^* : \qquad W_j^* = \max_{e_j, m_j \in \mathbb{R}_+} \left\{ g s_j - \frac{1}{m_j} \eta \left(e_j \right) s_j - f \right\},$$

where s_j is given by (4), g is the student voucher value and $\eta(e)$ is effort cost, as in (2). The first-order condition defining the optimum level of resource spending is

$$e_j: \qquad g\frac{ds_j}{de_j} \overset{!}{=} \frac{1}{m_j}\eta'\left(e_j\right)s_j + \frac{1}{m_j}\eta\left(e_j\right)\frac{ds_j}{de_j}. \tag{5}$$

The marginal benefit of increasing resources on the left hand side of (5) is just the per-student transfer g multiplied by the marginal reaction of enrollment s_j. The total marginal cost on the right hand side of (5) consists of the direct marginal cost plus the cost per additional student times the marginal enrollment reaction. The first-order condition with respect to class size m_j is

$$m_j: \qquad g\frac{ds_j}{dm_j} \overset{!}{=} -\frac{1}{m_j^2}\eta\left(e_j\right)s_j + \frac{1}{m_j}\eta\left(e_j\right)\frac{ds_j}{dm_j}. \tag{6}$$

Again, the marginal (negative) benefit of increasing class size is the per-student transfer times the change in enrollment. The marginal cost consists of the reduction of direct cost and the adjustment of student participation.

The two first-order conditions (5) and (6) can be merged to yield result 1.

Result 1 *With student achievement defined by (1), the resource cost function given by $\eta(e) = \varepsilon e$, and respecting the local student participation constraint (4), the optimum values of m and e are*

$$m^* = -\frac{1}{\ln\pi}, \tag{7}$$

$$e^* = \max\left\{0, \frac{m^*g}{\varepsilon} - \frac{\delta}{J\pi^{m^*}}\right\}. \tag{8}$$

Proof. The proof is given in appendix 6.1. ∎

Since e is restricted to be nonnegative, we have to distinguish between internal and corner solutions.[6]

If the number of schools is exogenously fixed (i.e. in the short-run) and education is compulsory, educational achievement can be improved by an increase in the voucher value:

$$\frac{dP^*}{dg} = -\frac{1}{\varepsilon\ln\pi}\pi^{-\frac{1}{\ln\pi}} > 0.$$

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[6]Of course, the corner solution $e = 0$ results in a shutdown of the school system.

This incentivizes schools to increase resource spending, while optimum class size remains unchanged. Higher transport costs decrease performance through a diminishing competitive pressure on schools,

$$\frac{dP^*}{d\delta} = -\frac{1}{J} < 0.$$

while the number of students in a district does not affect achievement. Neither does the value of the fixed costs f which just determines the schools' rents in the absence of free entry. The optimum value of resource spending e is a positive function of J, the equilibrium number of schools per district, hence

$$\frac{dP^*}{dJ} = \frac{1}{J^2} > 0.$$

The equilibrium number of schools will be determined in the next step backwards.

3.5 School Entry

The number of schools is endogenous in our model.[7] It is given by the zero-profit condition for the existing schools in the market:

$$\left(g - \frac{1}{m^*}\eta\left(e^*\right)\right)s_j - f \stackrel{!}{=} 0. \tag{9}$$

Combining (8) and (9), we see that a school's gross profit $\left(g - \frac{\varepsilon e^*}{m^*}\right)s_j$ is decreasing in the total number of schools. Hence, additional schools will enter the market as long as gross profit exceeds fixed costs f. The equilibrium number of schools per district is given in result 2.

Result 2 *The equilibrium number of schools is*

$$J^* = \sqrt{\frac{N\delta\varepsilon}{m^*\pi^{m^*}f}}. \tag{10}$$

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[7]In the present model setting, the entry of an additional school results in a rearrangement of incumbent schools. Hence, the model is ill-suited to analyze actual entry of additional schools. However, comparative static effects are sensibly interpretable even in this simple model.

Proof. The proof is given in appendix 6.2. ∎

The number of schools in a district increases with the number of students N and decreases with fixed cost f. Also, the higher transport costs are, the more schools exist in equilibrium. This is due to the effect that higher transport costs decrease the competitive pressure on schools which allows more schools to operate with non-negative profit.

Note that the equilibrium number of schools does not depend on the voucher value. This is due to the mutual cancellation of the direct positive effect on the school profit function and the indirect effect via optimum resource spending in (9). An increase in the voucher value just inflates the level of spending in all schools, but does not actually alter their competition. Hence, the structure of the school system is not altered by changes in student-based school funding. The equilibrium number of schools can now be used in the computation of optimum resources and class size in order to determine the equilibrium student success probability.

3.6 Equilibrium

Assuming positive resource spending and merging the partial results yields an equilibrium student success probability $P^* = e^* \pi^{m^*}$ with $m^* = -\frac{1}{\ln \pi}$ and $e^* = \frac{m^* g}{\varepsilon} - \sqrt{m^* f \delta / \varepsilon N \pi^{m^*}}$. Variables which are potentially influenceable by policy interventions are voucher value g, fixed costs which have to be borne by schools f and transport cost δ. A concrete measure to influence f would be the lump-sum subsidization of schools, while δ can be influenced by changing the bureaucratic cost of choosing a certain school or the installation of a school bus system. Comparative statics yield

$$
\frac{dP^*}{dg} = -\frac{1}{\varepsilon \ln \pi} \pi^{-\frac{1}{\ln \pi}} > 0,
$$

$$
\frac{dP^*}{df} = -\frac{1}{2} \sqrt{-\frac{\delta}{fN} \frac{1}{\varepsilon \ln \pi} \pi^{-\frac{1}{\ln \pi}}} < 0,
$$

$$
\frac{dP^*}{d\delta} = -\frac{1}{2} \sqrt{-\frac{f}{\delta N} \frac{1}{\varepsilon \ln \pi} \pi^{-\frac{1}{\ln \pi}}} < 0. \tag{11}
$$

Thus, a student's educational achievement increases in government spending per student, while it decreases in fixed school costs and transport costs. An increase

in per-student government spending incentivizes schools to compete harder for additional students, hence increasing their educational production. An increase in fixed costs decreases the number of schools, thereby reducing competitive pressure and inducing schools to lower their resource spending. The effect of higher transport costs on educational achievement works via two channels: On the one hand, higher transport costs c.p. decrease resource spending by reduced competition. On the other hand, higher transportation costs increase the equilibrium number of schools which intensifies competition, cf. (8) and (10).

Another interesting comparative static result is the impact of the district size N on student success:

$$\frac{dP^*}{dN} = \frac{1}{2}\sqrt{-\frac{\delta f}{N^3}\frac{1}{\varepsilon \ln \pi}\pi^{-\frac{1}{\ln \pi}}} > 0. \tag{12}$$

Students have c.p. a higher achievement in areas with more students than in areas with fewer students. This is also due to a higher number of schools in a more densely populated district which induces fiercer competition.

The comparative static results can be interpreted along the line of argument of Hoxby (2000). She argues that Tiebout choice[8] among school districts serves as a powerful market force in American public education. Consequently, her empirical investigations suggest that metropolitan areas with greater Tiebout choice have more productive public schools and less private schooling. In our model setting, the character of a district – whether it is metropolitan or rural – is determined by the two parameters N and δ for the population size and transport cost, respectively. Metropolitan areas have a large number of students while transport costs in their spatial interpretation are smaller than in rural areas. Considering equations (11) and (12) we can see that Hoxby's argument is confirmed by our analysis. The reason for higher achievement in metropolitan areas in our model is the same as in hers: A densely populated area with many schools shows fiercer competition than an area where students have no school choice due to too far distances. If students have good alternatives, they make high demands to schools.

3.7   The Role of Student Characteristics

Result 3 presents the impact of student characteristic π on class size, total studying time in class, optimum resource spending and student success.

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[8]By the expression *Tiebout choice* we refer to households choosing the school district that meets best their educational needs.

Result 3 *If students are segregated by type,*

(a) optimum class size is increasing in the probability π that students behave well;

(b) total studying time in class, π^m is constant in π;

(c) optimum resource spending increases in π;

(d) student achievement increases in π;

(e) the equilibrium number of schools decreases in π.

Proof. The proof is given in appendix 6.3. ∎

Result 3b can be explained intuitively: Schools raise class size until the optimal *noise level* in the class room is reached. This is the same for every class because in any case, potential productivity is multiplied by the factor that determines the noise level π^m. The cost and benefit of changing class size m do not depend on how productivity is generated (i.e. on the level of physical resource spending). Results 3c and 3d are driven by result 3b: An increase in π increases class size with no adverse effect on overall learning time which is constant. More students profiting from extended resources improves schools' incentives to spend more on them. The decrease in the number of schools as a result of more attentive students is due to larger classes. Since schools cannot charge the remaining classes with an increased fraction of fixed costs, the number of schools must decline.

Next, we discuss the optimum level of government spending from a welfare point of view.

3.8 Welfare Considerations

In this section, we examine the equilibrium allocation from a normative point of view. There are three endogenous variables defining an equilibrium: spent resources e^*, class size m^*, and total number of schools J^*. Since m^* is not dependent on the two other endogenous variables, we can analyze it independently. Given m^*, we can evaluate the welfare properties of e^* and J^*.

Result 4 *If education takes place,*

(a) in the decentralized equilibrium, class size m^* is chosen too large by schools;

(b) equilibrium resource spending e^* is too low;

(c) in the decentralized allocation, the total number of schools, J, is too low or too high, depending on the values of π: $J^* \gtreqqless J^{**} \Leftrightarrow m\pi^m \lesseqqgtr 4\varepsilon$, where J^{**} denotes a benevolent social planner's choice of J.

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Proof. The proof is given in appendix 6.4. ∎

In the decentralized equilibrium, schools equal marginal costs and benefits of an increase in resource spending and find interior solutions even though the cost function and educational production are linear in resources. This is due to the regressive students' enrollment reaction. In the centralized optimization problem, the total benefit of an increase in resource spending is linear, such that there is no finite interior solution. Hence, in the decentralized equilibrium, too little educational resources are spent. The non-existence of an interior solution to the centralized problem results in too large classes since in the centralized solution, beneficial extra spending per student is diverted to smaller classes. Regarding the optimality of the number of schools, under reasonable parameter values, there are too many schools in the decentralized equilibrium. This is due to the *business stealing* effect outweighing the *profit creation effect*: Additional schools entering the market steal other schools' market share while adding to the spending of total fixed costs. This is not fully compensated for by the reduction of total transport costs due to being closer to the students' home.

Since educational production and resource costs are both linear in resource spending e, there is no internal solution to the social planner's choice of e and hence no policy measure which would assure an optimum class size and resource spending: Depending on the parameter constellation, there is a systematic under- or overprovision of education. However, the optimum number of schools is obtained iff schools perceive fixed costs $\tilde{f} = (1 + \tau)f = 4\varepsilon f / (m^* \pi^{m^*})$. This can be induced by taxing/subsidizing the schools' spending on fixed costs at a rate $\tau = 4\varepsilon / (m^* \pi^{m^*}) - 1$.

An increase in the voucher value g results in a linear increase of student achievement. Total net welfare is the total of private values of education minus transport costs minus the cost of government spending:

$$
\Omega = NP^* - N\delta \left(2J^* \int_0^{\frac{1}{2J^*}} x\,dx \right) - Ng(1 + \lambda)
$$

$$
= NP^* - \frac{N\delta}{4J^*} - Ng(1 + \lambda),
$$

where λ denotes the net marginal cost of raising government funds.

Result 5 *Increased government spending per student increases welfare as long as the total cost of government spending* $1 + \lambda < -\frac{1}{\varepsilon \ln \pi} \pi^{-\frac{1}{\ln \pi}}$.

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Proof. The proof is given in appendix 6.5. ∎

Assuming increasing costs of government resources, e.g. through an excess burden in taxation, result 5 implies an optimum level of government spending g such that the marginal cost of government resources just equals the social benefit of government spending through higher student achievement.

4 Empirical Assessment

We now turn to a discussion of the secondary education system in Switzerland and test some of the implications of our model empirically. In Switzerland students are tracked by ability after 6th grade. After compulsory schooling, i.e. after 9th grade, adolescents transfer to the upper secondary level which is divided into general education and vocational education. The general education schools are the matura schools and the intermediate diploma schools. Apprenticeships as well as full-time vocational schools are a part of vocational education. In the following, we concentrate our study on matura schools in three Swiss cantons since these meet the assumptions on educational production closest: (1) students are homogeneous with respect to their behavior in class, (2) students have free school choice and (3) there are financial incentives to schools to attract students.

4.1 The Swiss School System

4.1.1 Vocational Training

Vocational education with training in an enterprise and vocational school was developed in the 19th century. After the secondary I level, about three-fifths of the adolescents in Switzerland complete vocational training (apprenticeship). An apprenticeship takes between two and four years, but the majority takes three or four years. The practical training takes place in an enterprise (3.5 to 4 days per week), the theoretical training in a vocational school (1 to 1.5 days). The division between *enterprise training* and *vocational schools* on the one hand and *matura schools* on the other hand constitutes the *dual system* of education in Switzerland.

In many professions, special training blocks in the form of introductory courses (triple system) are added. During the introductory courses basic skills of the respective profession are imparted at the training centers of the professional associations. Furthermore, there are full-time vocational training centers and full-time

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vocational schools (e.g., commercial middle schools, nursing schools), especially in western and southern Switzerland.

4.1.2 Matura Schools

The highest school type after elementary school is academic high school (matura school), which prepares students for entrance into any of the Swiss universities. It lasts six years, three of which belong to compulsory education. In 1995, a system of elective subjects with basic subjects, a main subject and a complementary subject has been accepted. An education authority assigns each school a main focus (ancient languages, modern languages, art, science, economics and law). Schools are allowed to further differentiate by offering complementary subjects. As to school choice, students are free to choose any school within their respective canton – provided they pass the centralized entry test. High schools are free for students; they are financed by the canton on a per-student basis.

There are matura schools in all of the cantons. The education lasts at least 12 years of school from the first primary class to matura. The actual matura school education really begins after the compulsory education period (short form of the matura school, duration three to four years), in some cantons, however, even earlier (long form of the matura school, duration six to seven years).

In the early 1980s 10% of young people attended matura schools every year; today it is 18% on average (between 9% and 32%, depending on the canton). 14'000 teachers teach at 195 matura schools; the number of students is more than 65'000.

Every canton determines admission criteria independently. In more than half of the cantons, transfer to a matura school occurs without admission examination, when there are excellent achievements at the lower secondary level (measured by grades and evaluations by lower secondary level teachers). In other cantons, a written and oral admission examination is conducted in addition. There are tests in at least a first national language (German, French, Italian, and Romanic, depending on the region), a second national language, and mathematics. The first semester at the matura school is considered a probationary period.

4.1.3 Competition between Matura Schools in the Cantons of Zürich, Bern, and Aargau

The model presented in this paper reproduces parts of the school system introduced in Switzerland by the regulation of the recognition of matura diplomas

Maturitätsanerkennungsreglement (MAR) in 1995. We study matura schools in the three Swiss cantons Zürich, Bern, and Aargau because these are the cantons in which there is at least one city with more than one matura school with no important geographical differentiation and some solitary schools in smaller cities. Thus, there is actual school choice in metropolitan areas, whereas in smaller communities, students typically choose the local matura school. Based on our model, we conjecture that schools in a competitive environment offer higher school quality, such that students who attend such schools perform c.p. better than students attending monopoly schools.

4.2 Data and Estimation Technique

We use student performance and school related data from the OECD-PISA survey in 2000 and individual student data from the accompanying Swiss national study (SIDOS, 2004). Our empirical analysis is restricted to the students' reading test score for which the largest sample size is available and which is usually a good measure for know-how abilities learned at school (cf. Fertig, 2003). In order to satisfy the assumptions of our model, we only use data from the cantons of Zürich, Bern, and Aargau. All observations with missing values are deleted; the remaining sample consists of 492 observations in 27 different schools (clusters). Appendix 6.6 gives a detailed description of the variables used in our estimation.

Total reading performance is estimated in the following way

$$S_{i,j} = P_j + \alpha D_j + \boldsymbol{\beta}' \boldsymbol{\xi}_i + \varphi_i + v_j, \tag{13}$$

where $S_{i,j}$ is the test score of student i attending school j, $\boldsymbol{\xi}_i$ is a vector of student characteristics, φ_i is a student-specific error term and v_j is a school-specific error term. We simplify the theoretical model insofar, as we assume only two different types of schools, $j \in \{c, r\}$ where c denotes a cityschool in a metropolitan area and r is a rural school. We hence create a dummy variable D_j for all schools in towns which have fewer than 15'000 residents and estimate (13) with schools in metropolitan areas as the baseline category:

$$D_j = \left\{ \begin{array}{ll} 0 & \text{if school } j \text{ is metropolitan,} \\ 1 & \text{if school } j \text{ is rural.} \end{array} \right.$$

Hence, α captures the difference in educational production at school, P_j, between metropolitan and rural schools. In our sample of schools, this is equivalent to

grouping schools into ones which are monopolists in their city and ones which face competition from at least one other school. The coefficient α and the coefficient vector β are to be estimated. In determining the effect of the school type on performance, we are especially interested in the value of α, which measures the difference in the performance measure for otherwise equal students attending a cityschool vs. a rural school. We control for individual and family background characteristics of the students.

The dependent variable is a difficulty-adjusted test score in reading. Table 1 reports the summary statistics of the score in our sample. We use OLS with standard errors of the coefficients corrected for heteroscedasticity and common factors to students in the same school by clustering (cf. for a justification of this correction Froot, 1989, and Moulton, 1986).

Table 1

Summary statistics of reading performance.

	Observations	Mean	Std. Dev.	Min	Max
Full sample	492	578.6	65.8	379.6	884.5
Landschool	289	565.3	64.6	379.6	884.5
Cityschool	203	597.5	63.0	387.0	812.9

Obseravble input factors in educational production, such as class size and teacher qualification do not differ significantly between schools in rural and metropolitan areas. Hence, observed differences in student achievement must be due to differences in teacher motivation and school organization, which possibly result from diverse competitive settings.

4.3 Empirical Results

Table 2 displays the OLS regression results of estimating equation (13). Since we study matura schools across cantons, controlling for cantonal characteristics seems appropriate. It turns out, however, that including cantonal dummies yields no significant canton-specific factors in educational production. We hence exclude cantonal dummies from our estimation equation.

As the model predicts, Landschool has a significantly negative coefficient implying that students attending matura school in rural areas perform c.p. worse by 29

Table 2

Reading performance equation estimation.

Variable	Coefficient	t-value	
Constant	525.00	32.53	**
Landschool	-29.24	-5.00	**
Personal characteristics			
High age	-29.63	-2.19	**
Low age	6.00	0.50	
On schedule	4.96	0.83	
Female	10.97	2.26	**
Native	11.22	1.08	
Foreign test language	-10.53	-1.35	
Family characteristics			
Parent income	0.13	0.56	
Siblings	0.67	0.19	
Books at home	7.18	3.39	**
No PC at home	-37.76	-1.82	*
Intact family	1.53	0.23	
Foreign parents	-0.15	-0.02	
Secondo	15.63	2.36	**
Parents medium	0.86	0.09	
Parents high	8.92	0.87	
Mother tertiary	-3.08	-0.25	
Father tertiary	3.56	0.40	
Discipline	-2.37	-0.39	

Notes: OLS regression, standard errors are corrected for clustering;
number of observations: 492; number of clusters: 27; R^2: 0.16;
** denotes significance at the 5% level;
* denotes significance at the 10% level.

points than students in schools which face direct competition. Personal characteristics significantly influencing test scores are a student's high age and gender. High age means that a student had repeated a class due to unsatisfactory grades before the test was taken. It seems plausible that reading skills are somewhat autoregressive, such that this result is not surprising. We also find that female students perform better, which is a common finding across OECD countries due to their higher maturity at that age.[9]

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[9]PISA shows a pattern of gender differences that is fairly consistent across countries: In every country, on average, females reach higher levels of performance in reading literacy than males. The better performance of females in reading is not only universal but also large. On average, it is 32 points, and generally greater than the typical difference in mean scores between countries (cf. OECD, 2001).

Concerning family characteristics, the number of books at home, whether a student has access to a PC at home, and whether one of her parents is born abroad determines her performance significantly. The number of books can be interpreted as an indicator of the parents' attitude towards reading which influences their children's reading capability. Whether a student has a PC at home also indicates her socioeconomic background which seems to be favorable if a student has the opportunity to use a computer. Interestingly, a student performs especially well if one of her parents was born abroad. One could argue that it is difficult for such children to attend matura school at all (because of a foreign first language, a different cultural background, etc.), so that they are particularly motivated to meet with success once they have this chance.

Besides the analysis of educational achievement (via test scores) as a function of regional characteristics, also educational attainment (via enrollment rates) could be analyzed in a similar setting. If school attendance is non-mandatory, students will choose to attend a certain school type only when their net-benefit from attending such a school is positive. As already laid out, attendance in matura school is voluntary, such that based on our model, one may expect that student participation in matura schools is higher in metropolitan areas than in rural areas.

Figure 3 shows the location of matura schools in the canton of Zürich as black dots. The ratio of students in matura schools and students in vocational school is indicated by the shading of the communities: The darker a community, the larger the fraction of matura students. The figure indeed suggests that children in communities farther away from matura schools tend not to attend matura school.
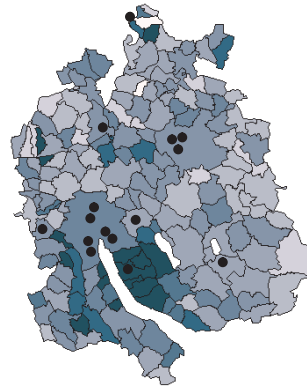

Figure 3

Education in the canton of Zürich.
Source: Statistisches Amt des Kantons
Zürich

In the city of Zürich, there are many schools close to each other, hence competing fiercely against each other and keeping their quality high, while schools in the rest of the canton face almost no competition with according performance of their students. Since more students participate in better schools, the metropolitan area around the city of Zürich tends to show higher student attainment. Of course, in a more serious analysis of student attainment, one would also have to control for student characteristics, which would at least partly explain the high participation rates on the north-east bank of the lake (indicated by the white stripe in the south of the map).

5   Conclusion

We have modelled school organization and -finance in a framework where entry into the educational sector is free and where schools are heterogenous from a student's perspective. The students' success depends both on class size and spending on schooling resources. Abstracting from incentive issues within schools, we have analyzed the effect of competition between schools on student attainment. Higher government spending and fiercer competition – measured by the number of schools in a district and lower transport cost – lead to an increase in the students' educational achievement. This result confirms the findings in Hoxby (2000). Overall learning time in school is constant in the probability that students behave well if students are segregated by type. However, better behaving students profit more from schooling due to higher optimum resource spending for their classes.

We support our theoretical findings by an empirical assessment of student reading performance in matura schools in Switzerland. It turns out that among individual factors and a student's socioeconomic background, the location of the school she attends is an important determinant of her achievement. This backs our conclusion that indeed competition between schools in the form of free school choice increases school quality and student performance and that the geographical characteristics of a school district are important determinants of educational success.

6 Appendix

6.1 Proof to Result 1

Use the local student participation constraint (4) to see that

$$\frac{ds_j}{dm_j} = \frac{Ne_j\pi^m \ln \pi}{\delta},$$

$$\frac{ds_j}{de_j} = \frac{N\pi^m}{\delta}.$$

We thus have

$$\frac{ds_j}{dm_j} = e_j \ln \pi \frac{ds_j}{de_j}.$$

Insert this into the first-order conditions (6) and (5) to find

$$m_j^* = m^* = -\frac{1}{\ln \pi},$$

where the first equality results from the symmetry of the schools. Note that by symmetry $s_j = \frac{N}{J}$, and solve (5) for e to get

$$e_j^* = e^* = \max\left\{0, \frac{m^* g}{\varepsilon} - \frac{\delta}{J\pi^{m^*}}\right\}$$

where again the first equation results from the symmetry of the schools. Obviously, the condition for an interior solution for e^* is $\frac{m^* g}{\varepsilon} > \frac{\delta}{J\pi^{m^*}}$.

6.2 Proof to Result 2

Insert m^* and e^* from (7) and (8) respectively into (9) and solve for J. Assuming an interior solution for e, we obtain (10).

6.3 Proof to Result 3

(a) Differentiate m^* with respect to π to find $\frac{dm^*}{d\pi} = \frac{1}{\pi(\ln \pi)^2} > 0$. (b) Studying time is given by π^m. Differentiate with respect to π to get $\frac{d\pi^m}{d\pi} = 0$. (c) Substitute m^* into (8), and differentiate with respect to π to get the result. (d) Substitute m^* and e^* into 1 and differentiate with respect to π. (e) Substitute m^* into (10), and differentiate with respect to π to get the result.

6.4 Proof to Result 4

(a)/(b) In order to find the optimum values of m and e, given the number of schools J, a benevolent planner solves the per-student problem

$$\Pi_{m,e}^{**}: \qquad W_{m,e}^{**} = \max_{e,m \in \mathbb{R}_+} \left\{ e\pi^m - \frac{1}{m}\varepsilon e \right\}.$$

The assumption that education takes place amounts to imposing $\pi^m > \frac{\varepsilon}{m}$. Exploiting the first-order condition with respect to m yields

$$m: \qquad (m^{**})^2 \, \pi^{m^{**}} = -\frac{\varepsilon}{\ln \pi} \Rightarrow m^{**} < m^*,$$

where the inequality results from a comparison with (6). The first-order condition with respect to e is

$$e: \qquad \frac{dW_{m,e}^{**}}{de} > 0.$$

(c) The efficient number of schools is determined by the social planner's solution to the problem

$$\Pi_J^{**}: \qquad W_J^{**} = \min_{J \in \mathbb{R}_+} \left\{ Jf + N\delta \left(2J \int_0^{\frac{1}{2J}} x\,dx \right) \right\}.$$

She minimizes the sum of fixed costs plus the total transportation costs. The term in parenthesis represents the average transportation costs per person, where $\frac{1}{2J}$ is the farthest distance a student has to travel. Therefore, we have

$$J^{**} = \frac{1}{2}\sqrt{\frac{N\delta}{f}}.$$

Thus, comparing with (10) yields

$$J^* \gtreqless J^{**} \Leftrightarrow m\pi^m \lesseqgtr 4\varepsilon.$$

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6.5 Proof to Result 5

The impact of increased government spending on welfare is

$$\frac{d\Omega}{dg} = N\frac{dP^*}{dg} + \frac{N\delta}{4\,(J^*)^2}\frac{dJ^*}{dg} - N\,(1+\lambda)$$

$$= -\frac{N}{\varepsilon\ln\pi}\pi^{-\frac{1}{\ln\pi}} + \frac{m^*\pi^{m^*}f}{4}\underbrace{\frac{dJ^*}{dg}}_{=0} - N\,(1+\lambda)$$

$$= -\frac{N}{\varepsilon\ln\pi}\pi^{-\frac{1}{\ln\pi}} - N\,(1+\lambda)\,.$$

Note that the middle term on the right hand side is zero by (6) and (10).

6.6 Description of Variables

Table 3

Description of variables.

Variable	Description
Read	Weighted likelihood estimate in reading; difficulty adjusted test score
Landschool	1 if school location is in a city with up to 15'000 inhabitants; in our sample, this also means that there is only one school in that city.
Parent income	Socio-economic index of parents' occupational status as a proxy for income
Siblings	Number of siblings
High age	1 if student is older than 204 months, 0 otherwise
Low age	1 if student is younger than 180 months, 0 otherwise
Books at home	Number of books at home
On schedule	1 if student claims never to have arrived late in school during the last two school weeks, 0 otherwise
No PC at home	1 if students has never accessed a PC at home, 0 otherwise
Female	1 if student is female, 0 otherwise
Intact family	1 if pupil lives together with father and mother, 0 otherwise
Native	1 if country of birth is Switzerland, 0 otherwise
Foreign Parents	1 if country of birth for both parents is not Switzerland, 0 otherwise
Secondo	1 if only one parent is born abroad, 0 otherwise
Foreign test language	1 if native language is not testlanguage, 0 otherwise
Parents medium	1 if parents' highest level of education is lower secondary
Parents high	1 if parents' highest level of education is upper secondary
Mother tertiary	1 if mother has tertiary education, 0 otherwise
Father tertiary	1 if father has tertiary education, 0 otherwise
No Discipline	1 if students feel disturbed by discipline problems at school

Note: Reference categories are metropolitan schools and parental education below secondary level.

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