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Location Choices of Swedish Independent Schools: How Does Allowing for Private Provision Affect the Geography of the Education Market?

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Location choices of Swedish independent schools

– How does allowing for private provision affect the geography of the education market?

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Abstract:

This paper studies the location decisions of Swedish start-up independent schools. It makes use of the great expansion of independent schools following a reform implemented in 1992 to test what local market characteristics are correlated with independent school entry.

The results suggest that independent schools are more likely to choose locations with a higher share of students with high-educated parents; a higher student population density; and a lower share of students with Swedish-born parents. There is also some evidence that independent schools are less likely to locate in municipalities with a left-wing political majority.

These results are robust to various alternative and flexible definitions of local school markets, which were employed in order to alleviate the Modifiable Areal Unit Problem. For some of the included variables, the definition of the local market however had a large impact on the results, suggesting that the issue of how to define regions in spatial analyses can be important.

Keywords: Private provision, Mixed markets, Education sector, Modifiable Areal Unit Problem

JEL-codes: H44, I28, L19, R32

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1 Introduction

This paper studies the location decisions of the independent schools[2] that emerged in the wake of the Swedish independent school reform of 1992. In particular it tests what characteristics of the local school market are correlated with independent primary level school entry[3], with respect to aspects such as the family background of the local student population, the local political majority and the quality and density of schools in the neighborhood.

The Swedish independent school reform provides an excellent opportunity to study the location decisions of private providers for several reasons: First, the reform introduced practically free entry[4], including for schools run by for-profit companies, thus introducing strong market incentives into the education sector. The fact that for profit provision was allowed makes Sweden an interesting case to compare to countries with more restrictive regulation in this respect, such as the UK and some of the US states.[5] Second, the number of independent schools expanded rapidly, from 60 to 400, in the decade following the reform[6], which means that there is a lot of variation in terms of independent school entry to study. Third, the independent school reform brings with it the nice feature that local characteristics can be measured just before the reform. This reduces the risk for endogeneity bias, which may otherwise arise if local characteristics are affected by the actual or expected entry of an independent school, for example through effects on the demographic composition. Fourth, detailed register data are available for the period around the reform, which allows for flexible modelling of schools' location decisions. In particular, this study makes use of precise geographical information to generate a set of alternative definitions of local school markets. This is an improvement compared to most of the previous literature in the field, which has generally used some pre-defined administrative regional unit, such as school districts or census tracts, to

[2] The Swedish term for these schools is friskolor, or fristående skolor.

[3] I choose to focus on the primary schools, and not the secondary schools, for the following reasons: First, primary schools are likely to have a stronger connection to the local neighborhood, as students in the lower grades are less prone to travel far to school. This means that factors related to the characteristics of the local student population are potentially more strongly related to the location choices of schools for the lower than for the higher grade schools. Second, there were more primary than lower secondary schools opening up during the time period under study, which gives more predictive power. Furthermore, I limit the study to school units offering grades 1–3, i.e. I exclude schools that offer only grades 4–6. The reason is that two grade 1–3 and 4–6 schools that are reported as two separate school units in the school register, may in fact be part of the same school structure. Limiting the analysis to the 1–3 grade schools avoids double counting such cases.

[4] There is no cap on the total number of independent schools, and while the municipalities may under limited circumstances veto entry of an independent school in the municipality, vetoes were very rare for the compulsory level schools in the time period of this study (see section 2.3 for details).

[5] Whether or not for-profit companies are allowed to run schools of similar type as the Swedish independent schools, varies between countries. In the UK, the academies are run by not-for profit charitable trusts (https://www.gov.uk/government/news/10-facts-you-need-to-know-about-academies), and the free schools can be run by businesses, but on a not-for-profit basis (https://www.gov.uk/types-of-school/free-schools). In the US, the legislation differs between states. An interesting example is California, where for profit companies were previously allowed to run and manage the states' charter schools, but will be prohibited from July 1st 2019 according to a recently passed bill (https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180AB406).

[6] This number is for primary level independent primary schools offering grades 1-3, which are the focus of this paper

measure local markets. By comparing the results from several alternative definitions, including both measures that were tailor made for this study and a couple of pre-defined units that are frequently used to measure neighborhoods in Swedish research (municipalities and SAMS[7]), this study addresses the Modifiable Areal Unit Problem (MAUP, see e.g. Fotheringham and Wong, 1991). In other words, it investigates whether or not the results are robust to gradual changes in the definition of local school markets.

The main results from this study suggest that the likelihood for independent school entry in the years following the independent school reform was correlated with the local student population density as well as with the local student family background. In particular, the independent school entry probability was higher in locations where students were of high educated family background, and was lower in locations where a large share of students had at least one Swedish-born parent. There was also some indication of a lower likelihood for independent school entry in municipalities with a local left-wing political majority, although this result was not robust to changes in the outcome time period.

The above mentioned results were robust to the various alternative and flexible definitions of local school markets. For some of the included variables, such as the local income dispersion, average GPA, and the local voucher level, the definition of the local market however had a substantial impact on the results. This can be viewed as an indication that the Modifiable Areal Unit Problem was to some extent present in the current setting.

The remaining sections of this paper are organized as follows: section 2 gives an overview of previous literature on private school location decision, section 3 describes the Swedish voucher school reform and shows the expansion of primary level voucher schools following the reform. Section 4 provides an informal theoretical framework for the location decisions of voucher schools, section 5 describes the data material and the construction of variables, and section 6 defines the spatial measurements. Section 7 presents the empirical model and the regression results, and section 8 concludes.

2 Previous literature

The previous literature on the entry location choices of privately provided schools is, to my knowledge, limited to a set of US studies and a couple of Swedish reports. This section discusses their findings and how they relate to the present study.

[7] SAMS stands for Small Area Market Statistics, and is a regional unit generated by Statistics Sweden. See Amcoff (2012) for references to literature using the SAMS-areas for neighborhood analyses.

Starting with the US studies, there is a number of studies on charter school location patterns using slightly different methods and data. Bifulco and Burger (2015) test whether New York State charter schools respond in their choice of location to school district level differences in the accountability and financing regulation. They find that charter schools more often start in school districts with cheaper and more vacant premises, lower teacher wages, higher per student payments and higher adult education levels. Glomm et al (2005) also study charter schools' location choices between school districts, but using data on Michigan. They find that the schools are more often choosing to enter school districts with a more diverse population in terms of race and adult education levels, and in districts with less efficient public schools. Burdick-Wills et al (2013) study Chicago charter schools. They define neighborhoods as 1 square mile quadrants, and find that charter schools are more likely to open in neighborhoods with declining shares of white population and increasing minority (black and Hispanic) shares. Henig and MacDonald (2002) estimate the likelihood for charter schools location in census tracts in the District of Columbia, and find that charter schools are more likely to locate in census tracts with middle incomes and high home ownership, and with higher proportions of African-American and Hispanic residents. Koller and Welsch (2017) take a slightly different angle and studies how the number of charter schools locating near an already existing public school varies with school, district and area characteristics. The outcome variable is given by the number of charter schools that locate within a certain travel distance from a public school, set of alternative distance cutoffs are used (5, 10, 15 and 20 miles). The results suggest that Michigan charter schools are more likely to locate in higher income areas, as well as in areas with more racial diversity and a larger proportion of black students.

There are also two US studies that focus on private schools prior to the charter school regulation, and hence treat the entry of schools that are both privately operated and privately funded. Downes and Greenstein (1996) study private schools in Californian school districts, and find that the public school teacher-pupil ratio, and the educational attainment of adults in Californian school districts in 1970/71, are related to the number of private schools in the districts in school year 1978/79. Barrow (2006) studies private school entry in Illinois between 1980 and 1990, using geographical data at the level of zip codes. She finds that private school entry correlates with public school class size, adult education levels, income levels, and racial concentration.

To summarize, the US literature on charter or private school location choices often finds that voucher/private schools tend to locate in neighborhoods that have a larger presence of minority student, and sometimes also where the education or income levels are higher. There is also some evidence that charter/private school entry is more common if the local public schools are underperforming.

In addition to the above literature on school location, there are a few more recent studies that take a comprehensive approach and model both schools' location decisions and students' school choices. Ferreyra and Kosenok (2018) estimate an ambitious structural model which simultaneously estimates charter school entry and household school choices using data on the large urban school district of Washington, DC. Their measures of neighborhoods are based on clusters of Census tracts. As a complementary measure they also use the larger Washington DC wards. Their analysis suggests that charter schools have generated substantial social welfare gains, in particular for middle-school and low-income, non-white students, who would in the absence of charters have less access to specialized curricula, longer travel distance to school, and lower accessible school quality. Mehta (2017) also estimates positive welfare gains when applying a structural model for school entry, student sorting and school inputs on data from North Carolina.

A more indirectly related reference to this paper is Rincke (2007), who studies how the charter school policy taken on by Californian school districts interacts with the policy of surrounding school districts. The results suggest a positive spatial correlation in the policies adopted by neighboring districts.

Finally, two Swedish reports are relevant to this paper. The first is a report to the The Expert Group on Public Economics under the Ministry of Finance, by Angelov and Edmark (2016), which analyses the location patterns of Swedish lower secondary (grade 7–9) independent schools. The report provides an analysis in the spirit of Koller and Welsch (2017), and regresses independent school entry on the characteristics of the public school nearest the entry point and on municipality characteristics. In addition, the report analyses school entry into neighborhoods measured using SAMS-units, a local unit generated by Statistics Sweden. The second is a report from the Institute for Evaluation of Labour Market and Education Policy by Holmlund et al (2014), which studies the correlation between local characteristics and the prevalence of independent schools at a given point in time, also using SAMS to define local areas. Both reports find that independent schools are more often present in areas where a larger share of the population has high education, or is born abroad. The first report also finds independent school entry to be less common if the local political majority is left-wing.[8] [9]

[8] The second report does not study municipality characteristics explicitly, but rather controls for municipality dummies and thus studies variation in independent school presence between SAMS within municipalities.

[9] It is useful to note the difference in the studied school population between this and the previous Swedish studies: I study only schools offering lower primary education, whereas Holmlund et. al. (2014) studies all independent schools, and Angelov and Edmark (2016) focuses only on lower secondary schools. Focusing on the lower primary schools, compared to the lower secondary schools, has the advantage of giving more data points, as there are more lower primary than lower secondary schools. It also avoids the risk that the measure for new higher level schools capture schools that are mere extensions of previously existing lower level schools.

The present study differs from the above in that detailed geographical information is used to more flexibly generate measures of local school markets. The idea is that using various alternative measures will indicate how sensitive the results are to gradual changes in the school market definition. The geographical literature has long recognized that the level of spatial aggregation has implications for e.g. segregation indices, and there are studies demonstrating that seemingly small changes in the neighborhood definitions can have significant impact on the results.[10] These concerns are relevant for studies on schools' location choices, as it is not self-evident how local school markets shall be defined (more on this in section 6).[11]

Finally, it can be noted that, in contrast to the previous Swedish reports but in line with some of the US studies, this study will measure school market characteristics prior to the independent school reform in order to avoid endogeneity bias.

3 The Swedish independent school reform[12]

This section contains an overview of the independent school reform, followed by a description of the application procedure for a start-up independent school, and finally gives a short summary of the independent school expansion that took place after the reform.

3.1 The 1992 independent school reform

Prior to the independent school reform of 1992, the vast majority of Swedish children were educated in a municipal school. Schooling could also take place in an independent school, but these were limited to certain types of schools[13] and received little public funding, and hence remained few.[14] In year 1991, there were 61 independent compulsory level schools.

In the fall of 1991, a tight parliamentary election brought a right-wing coalition government to power, after nine years of Social Democratic rule. In the spring of 1992, the new government

[10] See e.g. Wong (2004), Hennerdal and Meinild Nielsen (2017), and Östh et. al. (2015). See also Mitra and Builung (2012) for a study on how the MAUP affects the analysis of active school transportation in Toronto. Andersson and Musterd (2010) is another related study, which uses a set of alternative Swedish neighborhood measures, including SAMS.

[11] As a further motivation for this exercise, it can be mentioned that the SAMS-units have been criticized as measures for neighborhoods by Amcoff (2012), who has pointed out that the SAMS-regions differ greatly in size between municipalities, for reasons that are unrelated to population density or other neighborhood related issues. The size differences rather stem from variation across municipalities in what type of local spatial indicators were available and could be used to generate the SAMS when the measure was created in the 1990s. As a result, the SAMS-areas in the center of the second largest city of Sweden, Gothenburg, are for example dramatically smaller than the SAMS-areas in the center of the capital, Stockholm. As it is well known that the level of e.g. segregation measured in a neighborhood often depends on the geographical scale of the data, the widespread use of SAMS in Swedish research is thus potentially problematic.

[12] This section builds largely on information in Angelov and Edmark (2016).

[13] Independent school status was restricted to boarding schools, serving children from remote rural areas and children whose parents worked abroad; international schools, serving children from foreign countries, who resided temporarily in Sweden and who wished to be educated in their mother tongue; or schools that used alternative teaching methods and structures, and whose experience could thus be of value for the public school system.

[14] More detailed information on the pre-reform period can be found in Angelov and Edmark (2016).

proclaimed that the independent schools were to be given the right to operate under basically similar conditions as the public schools[15], and by July the same year it had implemented a reform which would significantly facilitate entry and operation of the new independent schools.

First, the reform abolished the previous restrictions for which types of independent schools were eligible for public grants.[16] This meant that independent schools were eligible for public funding as long as they fulfilled the requirements of providing education that was equivalent, in character, scope and general orientation, to that of the public school system. Additionally, the schools should be open to all students, which meant that the selection criteria in case of excess demand were limited to: application date, geographical proximity, having a sibling in the school, or being a student in a lower-grade school operated by the provider.

Second, the reform significantly improved the economic situation for the independent schools, by setting the per student annual grant to at least 85% of the average per student cost in the public schools in the municipality where the school was located.[17] Student tuition fees were simultaneously banned.[18] The per-student grant, or "voucher", would be paid out monthly by the municipality where the student resided.[19][20]

The development of the regulation for the independent schools after the 1992 reform can be characterized by keeping the fundamental freedom for independent schools to start up business and receive funding at similar level as the public schools, but moving towards more, and more detailed, regulation and control (see Angelov and Edmark, 2016, for an overview of the changes made during the time period studied in this paper). This has been achieved in part through extending the rules that already applied to the publicly operated schools to the independent schools, and in part by generally increasing the control and regulation of the education system. This applies also to the application procedure to start an independent school, which will be described in the following section.

3.2 Application process to start an independent school

For the period under study in this paper, the application process for start-up independent schools was handled by The Swedish National Agency for Education. According to the regulation,

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[15] See Proposition 1991/92:95.
[16] See Proposition 1991/92:95.
[17] This was later, in 1995, lowered to 75%, and then again, in 1997, it was stated that the voucher should reflect the average per student cost in the municipality.
[18] Small fees for special purposes were initially allowed, but in 1997 fees were completely abolished.
[19] During the first year of the reform, school year 1992/93, the voucher was to be paid out by the municipality where the school was located, but this was changed to the current rule, the municipality of residence, starting from July 1993.
[20] That the new voucher meant a significant improvement of the financial situation of the independent schools is underlined by The Swedish National Agency for Education (1996). This article reports that the average annual per student voucher during the first school year after the reform was SEK 49 100, which can be compared to the per student grant of SEK 13 000 in 1991.

approval should be granted if the provider was deemed competent to provide education according to the goals and (since 1997) the value system of the Swedish education system, and had a credible economic plan. Whether this was the case or not, was assessed based on the information in the application form, which was to be handed in before April 1st the year before the planned starting year.[21] In the early days of the reform, it seems to have sufficed with very rudimentary information in order to be approved as an independent school.[22] The application forms have since then grown much more extensive and detailed, which reflects that the application process has become stricter over time.[23]

In processing the application, The Swedish National Agency for Education routinely contacted the municipality where the applicant school was to be located, for referral.[24] In 1997, this procedure gained in importance when it was written into the school law that the views of the municipality was to be taken into account in the application procedure. More precisely, eligibility for public grants could be denied if the entering school was deemed to have significant negative consequences for the public school system in the municipality of location. This was, however, for the municipalities to prove, and this type of municipal veto against independent school entry seems to have been granted very rarely during the period under study here.[25]

If approved for receiving public grants, the independent school could start operating the school year the year after the application was sent in, and would then receive per student grants from its students' home municipalities, paid out monthly to the school.

3.3 Descriptive statistics of the independent school expansion

As stated above, the 1992 school reform in Sweden significantly improved the conditions for independent schools, in particular through providing funding at a level that was on par with the public schools. The dramatic improvement in the economic conditions for independent schools, together with the fact that school aged cohorts grew in size during the 1990s, suggest that there was scope for an increase in the number of independent schools following the 1992 reform.

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21 This held from 1995 and until at least 2001 (see Proposition 1995/96:200 and The Swedish National Agency for Education (2001a), and The Swedish National Agency for Education (1996): Report 108). In 1993-94 the last application date was August 1 the year before the start of operation, following the proposal in Proposition 1992/93:230. Under the current rules, the last application date is January 31 the year before the start of operation.

22 This is based on a set of application forms that were approved during the early years of the reform. These forms were gathered from the Archives of The Swedish National Agency for Education and were originally used in Edmark and Angelov (2016).

23 Report 108 from The Swedish National Agency for Education (1996) contains information on the early years of the independent school reform.

24 According to Report 108 from The Swedish National Agency for Education (1996) the opinions of the municipalities were also seen as a way to obtain local information which could be of relevance for the application of the independent school.

25 See The Swedish National Agency for Education (2001b).

Figure 1 shows that this was indeed what happened: Just before the reform in 1991 there were 61 independent schools offering grade 1–3.[26] After the reform this number grew to 210 in 1995, 379 in 2000 and 473 in 2005. The share of students attending independent schools follow a similar trend, as can be seen in Figure 2, going from 1% in 1991, to 2.5% in 1995, 4.3% in 2000, and 7.2% in 2005. Figure 1 also shows a decline in the number of public schools between approximately year 2000 and 2005. This is this probably due that the cohort sizes started to shrink around year 2000, following a decade of increasing cohort sizes, as can be seen in Figure 2.

Figure 1: Number of independent and public schools offering grade 1-3 in 1988-2005.

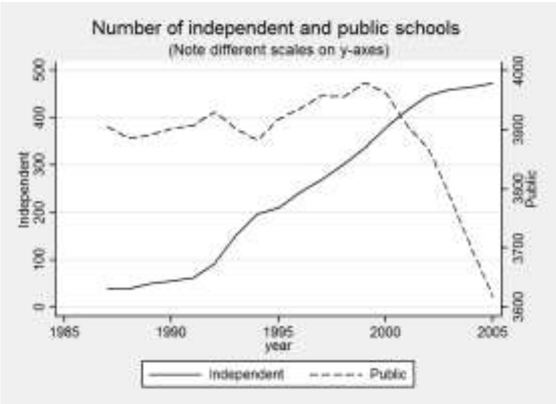
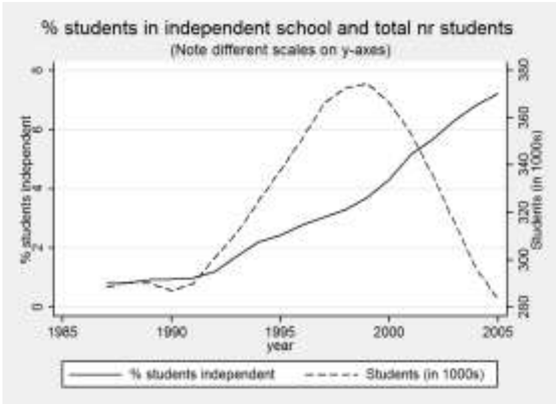


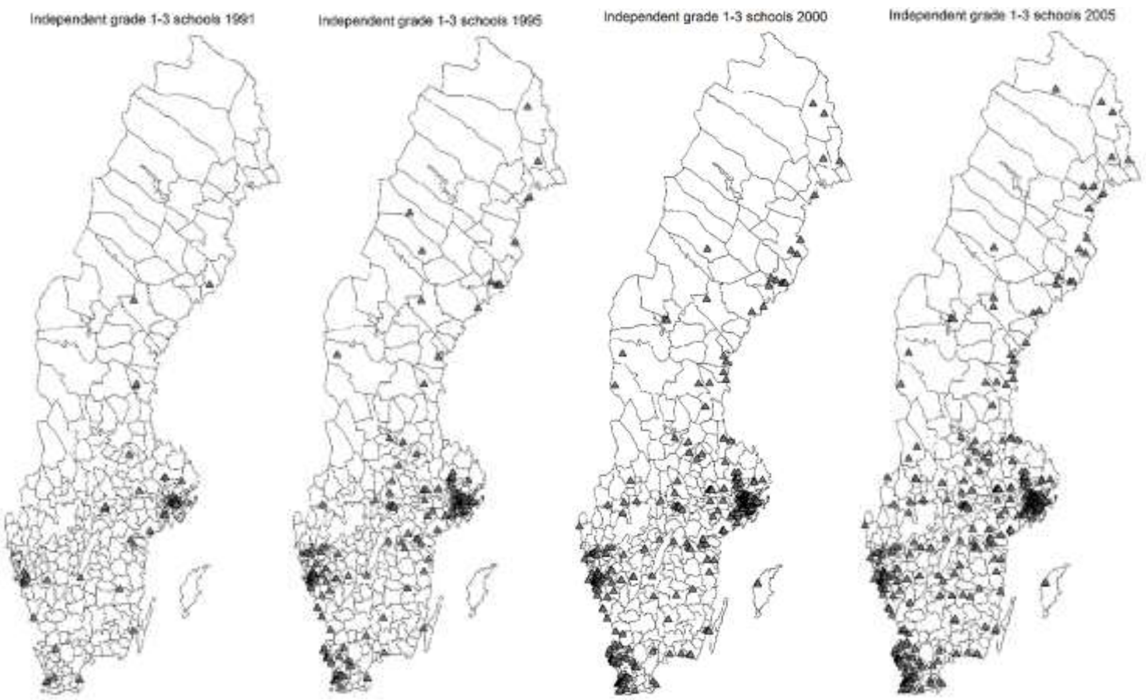
Figure 2: Share of grade 1-3 students in independent schools, and total number of grade 1-3 students.



The rapid expansion of the independent schools is also visible in the maps of Figure 3. The left hand side map shows the location of the lower primary level independent schools that existed just before the reform in 1991, and maps further to the right show the corresponding school locations in the subsequent years of 1995, 2000 and 2005.

[26] It can be noted that these schools often offer also higher grades, e.g. grade 4–6. However, as the grade structure differs between schools, I focus here on schools offering grade 1–3 and on the number of students attending these grades.

Figure 3: Maps over the location of independent schools offering grades 1-3 in 1991, 1995, 2000 and 2005.



4 A simple theoretical model of independent school location

Before moving to the empirical model, this section will clarify what assumptions are made regarding the location decision problem of the independent schools by outlining a simple theoretical framework. The framework is simplified by assuming that all schools are of equal capacity, and can admit a maximum number of students equal to S^*. This is done in order to focus the model on the location choice, and not on the potential choices of how many grades, and how many classrooms within each grade, to offer.[27]

I start out by considering only the monetary aspect and assume that the school provider's objective is to maximize profits (non-monetary aspects will be added further below). Starting out with this monetary objective makes sense given that all independent school providers – also those organized as not-for-profit enterprises – need to secure the financial viability of their organization. I thus assume that an independent school provider's utility is given by the economic profit, π, and I assume that the profit level varies depending on the chosen location *g*:

$$U_g = U(\pi_g) \qquad (1)$$

[27] Another simplification – in the theoretical as well as in the empirical analysis – is that all schools are treated as independent units, even though many of the independent schools are part of a larger organizations or corporation. As these larger structures are unobserved in the data available to the project, this cannot be taken into account in the present project. Analyzing the structure and decision making within independent school chains would however be an interesting extension for future studies.

$$\delta U/\delta \pi_g > 0 \qquad (2)$$

The profit level is given by total revenue minus total cost, $\pi_g = TR_g - TC_g$, and the total revenue is defined by the number of students the school admits if it chooses location *g*, S_g, times the local per student voucher, V_g, such that $TR_g = S_g \cdot V_g$. The total revenue thus increases linearly in S_g but reaches its maximum at $S^* \cdot V_g$, as each school's capacity is assumed to be capped at S^*. The total cost if choosing location *g*, TC_g, is made up by total fixed costs (*TFC*) and total variable costs (*TVC*). The former, *TFC*, consists primarily of location specific costs for premises, denoted H_g. The total variable cost (*TVC*) consists of costs that increase with the number of students in the school, primarily wage costs for teachers and teaching assistants. The cost function thus reflects that the main cost items for Swedish schools are expenditures for teaching/instruction and for facilities.[28] It thus depends positively on the number of students admitted to the school if location *g* is chosen: $\delta TVC/\delta S_g > 0$ and is capped at $TVC(S^*)$ (recall that $S^*$is defined as the maximum capacity of schools). It also increases in the level of teacher wages, W_g, such that $\delta TVC/\delta W_g > 0$.

I also add a political factor, P_g, to the fixed cost function, which measures whether the local political majority is in favor of independent schools or not. I thus take into account that the Swedish local (municipal) councils are relevant not only as they decide on the local voucher levels, but also potentially through the local policies on issues such as school transports, school choice policies and the granting of construction permits.[29]

The profit function for a representative independent school choosing location *g* can thus be written as:

$$\pi_g = S_g \cdot V_g - \left(TFC\left(H_g, P_g\right) + TVC\left(S_g, W_g\right)\right) \qquad (3)$$

We now have the basic setup of the model, and can start analyzing the location decision of the profit maximizing school.

First, we note that a profit-maximizing school will, all else given, prefer a location *g* where the voucher level, V_g, is higher. This follows from the fact that $\frac{\delta \pi_g}{\delta V_g} = S_g > 0$.

Second, by differentiating the profit equation with respect to the number of students, $\frac{\delta \pi_g}{\delta S_g} = V_g + \frac{\delta TVC}{\delta S_g}$, it becomes clear that admitting more students increases profits as long as the voucher

[28] Information on education expenditures is available from The Swedish National Agency for Education, and can be downloaded from the webpage siris.skolverket.se.
[29] The political component can also be motivated on the grounds that the municipalities' opinions are taken into account in the process of granting permission for an independent school to start operating in a municipality, although there are, as mentioned in section 3.3, indications that this was of little practical importance during the period under study.

level V_g is larger than the marginal cost $\frac{\delta TVC}{\delta S_g}$. The marginal cost of admitting a student to a not yet full classroom (i.e. a school operating below maximum capacity) is likely to be lower than the voucher level, as the latter is set to cover the average per student cost, including average fixed costs. The profit-maximizing school will therefore prefer locations where there is sufficient demand for it to have a better chance of filling the classrooms, i.e. where $S_g = S^*$.[30] (Section 5 will discuss what local factors may affect student demand.)

Third, equation (3) predicts that the school will prefer locations with lower costs, i.e. lower costs for facilities, H_g, and lower teacher wages, W_g, and where the local political majority, P_g, is not adverse to independent schools.

Thus far I have implicitly assumed that all students are homogenous. Let us now relax this, by instead assuming that students can be divided into two groups, where one is more costly to teach than the other. This can be due either to differences in behavioral problems, in parental involvement in the education process, or any other student specific component. In order to account for this in the model, I rewrite variable costs as a function of the number of low cost (*l*) and high cost (*h*) students: $TVC(\boldsymbol{S_g^c})$, where $\boldsymbol{S_g^c} = (S_g^l, S_g^h)$ and $\delta TVC/\delta S_g^l < \delta TVC/\delta S_g^h$. One way to view this is that accepting a high cost student to the school incurs some additional cost in the form of additional teachers or teaching assistants.

Talking the above into account, equation (3) can now be rewritten as:

$$\pi_g = S \cdot V_g - \left(TFC(H_g, P_g) + TVC(\boldsymbol{S_g^c}, W_g)\right) \qquad (4)$$

Equation (4) implies that a purely profit-maximizing school will prefer a location *g* where it has better odds to fill its school with low-cost students, as the low cost students give rise to a lower marginal cost but bring the same voucher to the school.[31]

[30] Note that in the model S_g equals the number of students the school will *admit* in location *g*. Cases where S_g=S^* thus reflect that *demand for* the school is either just equal to or larger than S^*.

[31] Note however that this holds only if the voucher level, V_g, is the same for the two student types. If a higher voucher is given for the high-cost students, then what type of students is preferred depends on the relation between the voucher level and the marginal cost. I abstain from modelling differentiated vouchers, for the following reason: There is very scarce information on the municipalities' policies on voucher differentiation for the data period studied in this paper, but the little information that does exist suggests that it was probably not widely used. The earliest comprehensive information is, to my knowledge, based on a survey carried out by The Swedish National Agency for Education in 2007. The survey indicated that the majority of students at that date resided in municipalities where the level of socioeconomic compensation (based on student background characteristics) to the municipality-operated schools was either non-existent or low (see p. 39-51 in The Swedish National Agency for Education, 2009), but gives no explicit information on the policies for the independent school vouchers. Based on the fact that socioeconomic compensation was rare even among the municipality schools, and as late as 2007, I deem it likely that it was even more rarely used for the vouchers for the independent schools in the 1990s, which is the period under study here. It can also be noted that that the national regulation up until 1997 instructed the municipalities to set the voucher to at minimum 75% of the per student cost in the municipality schools (85% in the earlier years), with no explicit mentioning of socioeconomic differentiation. In 1997 this was changed to stating that the voucher shall be based on the same criteria as the resource allocation to the municipalities' own schools, still with no explicit mentioning of socioeconomic differentiation.

The above model builds on the assumption that the school providers are solely motivated by pecuniary incentives and an aim to maximize profits. However, even if making profits – or at least breaking even – is likely to be an important incentive for all schools, non-monetary incentives, such as the intrinsic drive to provide good education, are also likely to play a role. In order to incorporate such incentives into the model, I add a location specific non-monetary component, denoted NM_g, to the objective function of equation (1):

$$U_g = U(\pi_g, NM_g) \qquad (5)$$

I let this factor represent all potential non-pecuniary incentives that are relevant to the school provider and that vary due to the chosen location *g*. As an example, a school provider who is motivated by a social mission to provide good education for disadvantaged students will get a higher utility if more such students are admitted to the school, and is thus likely to prefer a location with a higher share of disadvantaged students. The same type of argument can be made for providers with other types of profiles or motives, for example religious schools or schools with a special profile, such as Waldorff schools. Generally speaking, if the provider of the school gets higher utility the more students of a certain type attend the school, then the provider will prefer locations where the likelihood to attract many such students is higher. I will leave the further discussion on what types of student characteristics are relevant to section 5, and here merely define the non-monetary utility component as a function of the matrix $\boldsymbol{S_g^T}$ which describes student characteristics that are relevant for the school's decision on whether or not to choose location *g*. This gives the following utility function:

$$U_g = U\left(S_g \cdot V_g - \left(TFC(H_g, P_g) + TVC(\boldsymbol{S_g^c}, W_g)\right), NM(\boldsymbol{S_g^T})\right) \qquad (6)$$

The above simple model framework can be summarized by the following predictions for the location choice of a start-up independent school:

All else equal, an independent school provider will prefer choose a location g where:

- …the total revenue is higher, i.e. where the voucher level is higher and the likelihood of filling the classrooms is higher.
- …the fixed and variable cost is lower. This has two types of implications: First, the school will prefer locations with lower costs for facilities, lower teacher wages and where the local political majority is not adverse to independent schools. Second, the school will locate where there is a higher likelihood of attracting students who entail a lower marginal cost.
- …the local prospective students to a larger extent corresponds to the profile or mission of the provider.

The above predictions will guide what explanatory variables are be added to the model. This will be explained in the next section, which describes the data sources and data variables.

5 Data variables

This section describes the variables that are included in the regression model, based on the theoretical framework of the previous section. We start by noting that the utility function of equation (6) implies that the indirect utility function of the entering independent school provider depends on the following location specific factors: number of students, S_g; student type/background, $\boldsymbol{S_g^c}$ and $\boldsymbol{S_g^T}$; voucher level, V_g; costs for facilities, H_g; the teacher wage level, W_g; and local political majority, P_g:

$$V\left(S_g, \boldsymbol{S_g^c}, \boldsymbol{S_g^T}, V_g, H_g, W_g, P_g\right) \qquad (7).$$

The below sections will explain how these variables are measured and included in the regression analysis, using the data at hand. The data set available to the study is based on the registers at Statistics Sweden and covers all students born in 1972–1990, their parents, and all compulsory level schools. It also includes a set of municipality level indicators. (For more detailed information on the data sources, see section 10.1 in the appendix.)

5.1 Variables for local demand S_g, and student type S_g^c and S_g^T

The theoretical model suggested that the school provider should, all else equal, prefer local markets with higher demand for the startup independent schools. Student demand cannot be observed directly. Instead, I assume that it is a function of the location specific student population density and the quality and density of the existing schools. In particular, I expect that the number of students the school can admit if choosing location *g* is positively correlated with the population density, and negatively correlated with the quality and density of existing schools.

The first of these factors, the local student population density, is in the regression analysis defined as the number of students aged 7–9 (the age of students in lower primary education) in the local market.[32] The school density is furthermore defined as the number of schools in the local market. I use separate measures for public (municipality-operated) and independent school density, as these may be regarded as different types of competitors by the entering independent school.[33] The school and population density measures will be denoted by the matrix $\mathbf{D_g}$ in the regression analysis.

[32] Lower primary schools often also offer grades for students up until age 12, and sometimes even until age 15. I however choose to base the variables on students age 7-9, as this is the age group that is common to all the schools in the regression sample.

[33] It can be noted however that the overall number of existing independent schools will be very small, as these will in the baseline regression be measured in 1991 – the year prior to the 1992 school reform – when the independent school status was limited to schools with specific profiles (see section 3).

The quality of the existing local schools is a more difficult variable to measure. I will, as a proxy variable, use the grade point average (GPA) among students graduating from grade 9. Students normally graduate from grade 9 the year they turn 16, and this is the earliest education attainment measure available in the comprehensive Swedish education registers for the studied time period. This proxy variable for school quality, denoted Q_g in the regression analysis, will thus have the drawback of reflecting the cumulative education that the students received up to age 16 – not only the quality of the grade 1-3 schools which are the focus of this study. Another caveat is that grading standards can differ between schools, in which case it is an imperfect measure of student attainment even for age 16. Finally, GPA tends to be correlated with student background characteristics, such as parental education and country of birth. It can be argued that GPA becomes a better measure of quality if the systematic variation due to differences in student background are eliminated. One the other hand, the raw GPA is often what is observed by parents and may thus be what is important for demand. I choose to include the variable in its raw form. It can however be noted that the baseline location model will include variables for local student background, and will thereby to some extent control for student composition effects.

I furthermore acknowledge that the demand for independent schools may be correlated with family characteristics, for example due to ideological preferences that are correlated with family background. It is also possible that demand for independent schools is higher in more disperse neighborhoods, for example where a larger share of students have foreign background, or where income distribution is more disperse. If parents prefer students to be surrounded by similar peers, then an entering independent school may offer a chance to "self-segregate". In order to capture such aspects, I include a set of local student background variables for: i) the share of students with at least one parent with post-secondary education; ii) the share of students with at least one Swedish born parent; and iii) the average and standard deviation of the disposable household income. All these variables, denoted by $\mathbf{X_g}$ in the regression equation, are measured among the local population aged 7–9, i.e. among the lower primary education cohorts.

Potential differences in the demand for independent schools is however not the only motivator for including these student background variables – they can also be viewed as indicators for the variables $\mathbf{S_g^c}$ and $\mathbf{S_g^T}$ from the theoretical model, i.e. whether students are low- or high-cost to teach, and whether students are of a background that is for some reason intrinsically (for non-monetary reasons) valued by the provider. Parental education and Swedish background are relevant in these aspects are they are strong predictors of students' educational achievement[34] – providers of education who are looking for "easy students" may for example want to avoid low education or

[34] See e.g Chapter 7.1.2.2 in Holmlund et. al. (2014) for evidence on Sweden.

high immigrant dense neighborhoods. On the other hand, education providers with a social motive may be more inclined to enter neighborhoods where the general education level is low, or low-income neighborhoods. The monetary and non-monetary motivations of the school provider can thus be related to the characteristics of the local student population in various ways. The empirical analysis will shed light on what family background characteristics are correlated with the location decision, but will not inform us on which of the potential mechanisms are at work.

5.2 Variables for reimbursement for independent schools, vouchers V_g

As was described in section 3.2, the level of reimbursement to independent schools is in Sweden determined by the municipalities, given the guidelines in the national regulation. Unfortunately, there is no comprehensive information available on the municipalities' voucher levels. Instead, I use the per student cost among the municipality operated schools as a proxy variable for the voucher level.[35] This is motivated on the grounds that the voucher regulation states that the municipalities' voucher levels shall be based on the per student reimbursement to the local public schools.[36] The current notation for this variable, V_g, will be kept in the regression equation.

5.3 Variables for fixed and variable costs, H_g, W_g, and local political majority, P_g

A straightforward prediction of the theoretical model is that an entering independent school will, all else equal, prefer a location where the fixed and variable costs are lower. Ideally, the model should include local school market information on the expected cost for facilities for an entering independent school, as well as the expected wage level for teachers (and other staff). Precise local level information is however lacking for these variables, and I thus use the following strategy: First, local expected costs for facilities will be approximated by the municipality level per student cost for school premises measured among the public (municipality-operated) schools. This variable is denoted H_m in the regression equation. Second, Labour market region dummy variables will be added to the regression in a robustness analysis to account for the fact that teacher wages may vary regionally. The Labour market region indicators are generated by Statistics Sweden based on local commuting patterns. As will be seen in section 7, the main results will remain unaltered when these dummy variables are included; however, they will induce a substantial share of the geographical units of analysis to be dropped due to multicollinearity since several of the Labour market regions are small and perfectly predict the outcome variable. Therefore, I have chosen to include this

[35] Using the reimbursement per student to the independent schools is not an option, as some municipalities have no independent schools.

[36] As was seen in section 2.2 the precise formulation of the regulation has changed over time, but has always indicated that the voucher level shall be based on the reimbursement to the publicly operated schools.

specification only as a robustness test, and not as the main specification, which means that local teacher wages, W_g, are omitted from the baseline regression equation.

Finally, the local political majority will be added to the regression equation in the form of a dummy variable indicating if the municipality is run by a left wing political majority, denoted L_m.[37] The left-wing parties were opposed to the independent school reform, and have remained more skeptical to independent schools than the right-wing parties. The hypothesis is thus that the independent schools may seek to avoid left-wing municipalities.

5.4 Time of measurement of the explanatory variables

All the explanatory variables are measured in 1991, i.e. in the year prior to the independent school reform. As was mentioned in the introduction, this is done in order to reduce the risk that the results are biased due to endogenous school market characteristics. Such endogeneity can arise if actual or anticipated entry of an independent school affects the characteristics of the school market, for example if plans for opening an independent school in a neighborhood affects moving patterns. The independent school reform was implemented in 1992, after a tight victory of a center-right coalition in the election of September 1991. As the election was tight, the independent school reform was probably not expected with any greater certainty among the population. It thus seems far-fetched to believe that local moving patterns would have adjusted in advance to expectations of local independent school entry following a school reform should the right-wing coalition win the election. Local characteristics measured in 1991, prior to the reform year, are thus likely to be exogenous to the entry of independent schools in the following years.

5.5 Outcome variable

The outcome variable of the regression model is measured as a binary indicator of independent school entry, and is denoted y_{gm}. In the baseline specification it takes the value one if at least one independent school opened in local school market *g* in municipality *m* at any point in time between 1992, the first year of the independent school reform, and year 2000.[38] [39] This means that I will study the location decisions of the independent school start-ups during the first 9 years of the independent school reform. As a sensitivity test, I will also estimate the regressions when the outcome is based on year 1992-1995, and year 1992-2005, respectively. I will also, as a further alternative specification which ignores the potential endogeneity bias, estimate the independent

[37] Left wing refers to the Social Democratic Party and the Left Party.

[38] When generating the outcome variable, I exclude all cases where an entering independent school shares geographical coordinate information with a school (independent or public) that existed already in 1991. This is done as I cannot rule out that these schools are transformations or extensions of previously existing schools, rather than new start-ups.

[39] This means that all start-ups between year 1992 and year 2000 are included in the analysis, including also schools that did not remain in business until year 2000. This is feasible as it is the schools' location choices – not their success rate – that is analyzed.

school locations in 1996-2000 as a function of location specific characteristics measured in year 1995. The timing of these measurements will be further discussed in section 7, in relation to the regression model.

The binary definition of the outcome variable does not take into account the intensity of the outcome variable, i.e. whether one or more independent schools choose a specific location. As will become clear in the following section, I will for most of the regression analysis define the geographical units of the analysis based on very small geographical entities, such that there will rarely be more than one independent school per unit. However, for the regressions using the larger SAMS and municipalities as spatial units, I will complement the binary outcome with a continuous outcome variable in the form of the number of start-up independent schools.

6 Spatial definition of potential school locations and school market characteristics

An important aspect in the analysis of independent schools' location decisions is how to measure "locations", or more specifically, how to measure the geographical areas that are relevant for the location choices.

In contrast to most of the previous literature on this subject, this study will *not* rely on pre-existing administrative geographical unit (school districts, zip codes, etc.) to define local geographical areas within which to measure school entry. The reason is that such areas – which were not generated for the particular research question at hand – may not be feasible as measures of local characteristics when studying the location choices of schools. For example, school districts, which are used in several previous US studies, may be too large – or too small, or merely of the wrong shape, to reflect the geographical units that are relevant for the location decisions of the entering schools.[40] It could for example be that a school that chooses to locate near the border of a school district (or zip code or any other administrative division), does so with the aim to serve students in parts of all districts near that border, instead of serving only the students in the district of location. If so, using the school district as unit of analysis means measuring the relevant variables with error. The issue is furthermore complicated by the fact that what is the relevant unit of measurement may vary across the regression variables.

It shall be acknowledged that this is not the first school location paper to deviate from using (only) administrative neighborhood measures: Burdick-Will et. al. (2013) use a project-specific generated grid consisting of approximately 1 square mile quadrats to measure neighborhoods in

[40] The issues relating to the size and shape of geographical areas are in the geographical literature known as the scale and zoning problems of the Modifiable Areal Unit Problem (MAUP), see for ex Wong (2004) and Fotheringham and Wong (1991).

their study on Chicago charter school openings and closings, and Ferreyra and Kosenok (2018) use measures of 39 neighborhood clusters on Washington DC that were originally generated by Filardo et. al. (2008). Additionally, Glomm et. al. (2005)[41] and Downes and Greenstein (1996), who both use school districts, provide discussions of potential problems related to these measures, and the latter authors take it into account in the analysis by taking account not only of the characteristics of each school district but also of its neighbors in the analysis. Finally, Edmark and Angelov (2016) and Koller and Welsch (2017) use the characteristics of the already existing local school to measure for example local student background.

Compared to the previous studies, however, I argue that this paper goes a step further by using a set of alternative measures of geographical school markets that are tailor made for the analysis. The extent to which I am able to do so is somewhat restricted by the data access – for one of the variables, costs for premises, data is only available at an aggregate regional level. But for many of the variables, I can use several alternative definitions for school markets, and thus evaluate how sensitive the results are to changes in the measures. In terms of the Modifiable Areal Unit Problem, I show how the results are affected by changes in the scale and zoning parameters.

So, then, what measures will I be using? As a starting point, I note that in principle, every "spot on the map" – or every coordinate point – constitutes a potential location for an entering independent school. This suggests that detailed geographical data are feasible for generating location measures. Furthermore, some of the potential local factors, such as the background characteristics of students residing nearby a location, change gradually as one moves over the coordinate points on the map. Other local characteristics, such as the municipal political majority, change discontinuously at the municipal border. The relevant spatial measurements of the local characteristics may thus look very different for different variables. Taking these issues into account, below I will first explain how the measures for the schools' location points, i.e. the outcome variable, are generated, and will then turn to the spatial measurements for the right hand side regression variables.

That said, although each and every spot on the map is in principle a potential location point, letting each coordinate point constitute a separate location unit is not a feasible option for the regression analysis, as it would result in low statistical power due to too many (too small) location spots.[42] I therefore aggregate the coordinate points to a larger grid, consisting of 1km*1km

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[41] See the working paper version of the paper http://www.indiana.edu/~workshop/papers/glomm022601.pdf.

[42] The reason is that the location spots that an entering school is in practice choosing among are likely to be much larger in size than geographical coordinate points. Defining school markets based on all geographical coordinate points would hence give the statistical analysis too low power. Intuitively, this follows from the fact that spots that are very close to a chosen location would count as not chosen locations (zeroes in the binary outcome variable) even though they would in fact belong to the category of spots that were chosen by an entering independent school (ones in the binary outcome variable).

squares.[43] The choice of exactly 1 km*1 km sized grid cells is arbitrary, and as an alternative, I will also provide results from using a smaller, 0.5 km*0.5 km sized, grid, thus changing the scale of the spatial units, in the terminology of the MAUP. The generated grid cells constitute the locations that can be chosen by the entering independent school. The outcome variable of the regression analysis will thus be defined as a dummy variable which takes the value one if at least one independent school has started up in the grid cell during the period of study, and zero otherwise.[44][45]

Many of the grid cells will however be located in completely deserted areas, as vast areas of Sweden are virtually unpopulated. In order to drop such irrelevant locations I limit the regression sample to cells with at least 30 students residing within a 3 km radius. The resulting regression sample of grid cells for the 1km*1km specification is shown in the left hand side map in Figure 4. The middle and right hand side maps show the location of independent schools in year 2000, and the age 7–9 population density measured in 1991, respectively. As can be seen in the maps, the regression sample grid cells correspond to the more populated areas of Sweden and cover the vast majority of the actual location choices of the independent schools.[46]

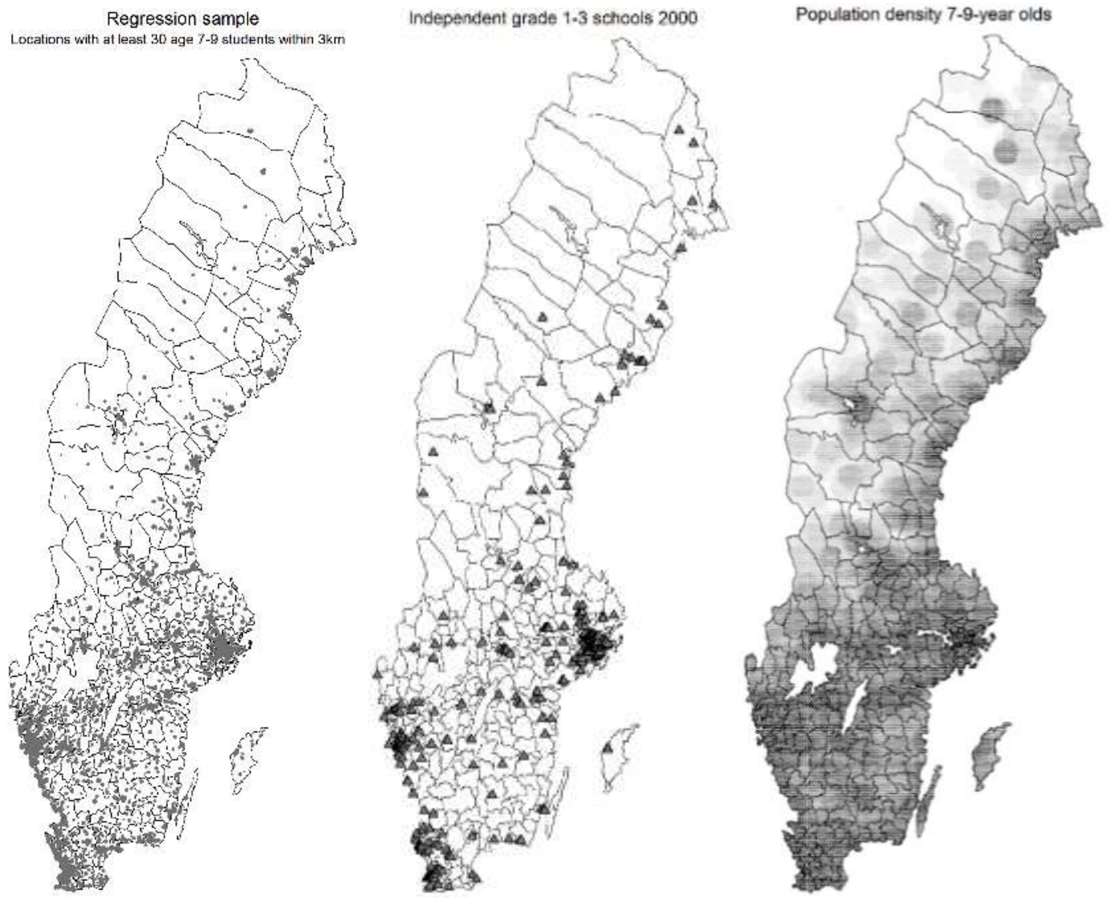
Figure 4: Maps over the regression sample grid cells for the 1km*1km grid, the location of independent schools offering grades 1–3 in 2000, and the population density of 7-9 year olds in 1991.

[43] This was done using the command spmap in Stata. All data work and analysis was done using Stata and the Stata matrix based program Mata.

[44] The outcome variable is generated based on geographical information on schools in the form of 100m*100m squares for the geographical coordinates of the school addresses.

[45] As the grid cells are small, there is rarely more than one independent school starting up within a cell. Out of all the start-up independent schools during 1992-2000, there were 332 grid cells with only one entering school, 30 grid cells with 2 entering schools, 2 grid cells with 3 entering schools, and one grid cell with 4 entering schools. This holds for the 1km*1km grid cell location units that are used in the baseline estimations.

[46] The unrestricted sample has, for the outcome period 1992-2000, 429 cases where the outcome dummy variable takes value one and 236 290 cases where it takes value zero. The restricted the regression sample (excluding low populated areas) has 400 outcome observations taking value one, and 50 308 cases where it takes value zero. 29 cases of independent school locations are thus lost due to the regression sample restriction.



For the explanatory regression variables, the spatial aggregation will vary depending on what is suitable for the specific variable, and depending on the restrictions posed by the data at hand.

First, as was noted above, for the variable municipal political majority the relevant geographical area is naturally the municipality, so each grid cell will be assigned the value of political majority corresponding to its municipality. In addition, the proxy variable for costs for school premises is also measured at the level of the municipality, although in this case due to lack of more detailed information.

Second, the regression variables for student background, i.e. parental education level, immigrant background, disposable income and GPA, and for the voucher level[47], shall be generated such that they reflect the characteristics of the pool of students that an entering school can be expected to attract if it chooses a certain location. Taking this into account, I define the following four alternative variables for measuring the family background and voucher level of the local student population:

[47] The level of the voucher depends on the student's home municipality, and the vouchers available to a school thus depends on the home municipality of the students it attracts. An alternative would be to simply measure the voucher level in the municipality of location, but this would ignore the fact that an independent school that locates near a municipality border may very well attract students from the bordering municipality.

i) Students residing within a 3 km radius from a grid cell midpoint.

ii) Students residing within 1.5 km radius from a grid cell midpoint.

iii) The 50 students residing nearest the grid cell midpoint, and

iv) The 100 students residing nearest the grid cell midpoint.[48]

The two first measures are based on the notion that primary school students are likely to prefer schools located near their home, and use fixed cutoffs in order to measure proximity.[49][50] Alternatives iii) and iv) instead take into account the fact that what is viewed as an acceptable travel distance is likely to differ across regions, for example depending on access to public transport. They thus assume that it is the students residing nearest the school that are likely to be more interested in the school, without explicitly taking into account the travel distance. [51]

Third, the variable for population density will be measured using the same cutoff values as in the two first student-based measures above (note that the nearest-student type alternatives iii) and iv) are not useful for this variable). That is, population density is in the regression analysis defined as the number of age 7-9 individuals residing within 3 km from a grid cell midpoint, or alternatively, within 1.5 km from a grid cell midpoint.

Fourth, the variables for school density will be measured using double the cutoff distances used for the population density measure, namely 6 km and 3 km from a grid cell midpoint, respectively. This is based on the notion that if schools are assumed to attract students within a given radius (3 km and 1.5 km above), then they are expected to compete with schools within twice that distance.

The analysis will thus be carried out on a set of alternative regression variables, based on slightly different spatial assumptions. The aim is, as stated above, to evaluate if the results change when the different measures are used, thus indicating if the Modifiable Areal Unit Problem is present in the current setting.

In addition, the results from the above described measures will be compared to the SAMS and municipality level specifications. These will use outcome and explanatory variables aggregated at the level of the SAMS, and the municipality, respectively. As was commented in section 2, a comparison with the SAMS level specification is particularly interesting as SAMS has frequently

[48] In order to speed up the calculations of the nearest neighbor-measures, which were calculated using Stata's Mata program, I imposed the restriction that onley students residing within 100km from the gridcell midpoint were included.

[49] All distance-based variables are based on data on coordinate pairs for residential addresses, in the form of 100m*100m squares. The distances are measured as the crow flies. Actual travel distances for different modes of transport could not be computed due to lack of access to the necessary software.

[50] I lack data on the school of attendance for students of this age, but data on year 2000 for age 16 students attending grade 9, suggest that the median distance to school even in grade 9 was 1.6 km, while the average was 7.2 km. For the lower grade students in this analysis, the distances to school of attendance are not observable, but the distance to the nearest school was for 7-year old students in 1991 1.4 km and the median value was 0.63 km.

[51] K nearest neighbors measures have been used to define neighborhoods in several studies, for example Östh et. al. (2015) and Hennerdahl and Meinild Nielsen (2017). The program Equipop has been developed to calculate measures of K nearest neighbors, see http://equipop.kultgeog.uu.se/. The measures used in this study were however calculated using Stata (Mata).

been employed to measure neighborhoods in the Swedish research literature. If the results vary a lot between the generated measures and the SAMS based measures, this can be viewed as an indication that SAMS is potentially problematic to use as a measure of neighborhood.

Table 1 summarizes descriptive statistics for the alternative variables based on the 1km*1km grid cells, and for the SAMS and municipality level measures. (Descriptive statistics for the variables when using 0.5km*0.5km grid cells are available in Table A1 in the Appendix.). The table uses the following abbreviations for the variable names: *dS2000* denotes the binary outcome variable defined based on the period 1992-2000, whereas *d1995* and *d2005* denotes the corresponding for periods 1991-1995 and 1991-2005. *NrS2000*, *NrS1995* and *NrS2005* denote the continuous outcome measures (for number of start-up schools) for the same periods. *GPA* denotes the grade point average, *High educ parent* denotes the variable for parental education level, *Fam disp inc* is the family disposable income measure, and *Std Fam disp inc* gives the standard deviation for the same measure. *Sw parent* denotes the variable for Swedish born parent, *School age pop* is the density among the school age population, and *Voucher proxy* denotes the proxy variable for the voucher level. *Left* denotes the local political majority variable, and *Costs premises* gives the proxy variable for costs for premises. Finally, *Mun sch density* and *Indep sch density* denote the density variables for municipal and independent schools, respectively.

Table 1: Descriptive statistics for all generated regression variables for the 1km*1km grid, and for the Municipality and SAMS level specifications.

Outcome variables:		*1km*1km grid cell location units*				*Municipality*	*SAMS*
Mean of:	dS2000	0.0079				0.4161	0.0551
dS2000:	Nr of ones	400				119	192
dS2000:	Nr of zeroes	50308				167	3293
Mean of:	nrS2000					1.3531	0.0666
Sd of:	nrS2000					3.4809	0.2995
Mean of:	dS1995	0.0035				0.2587	0.0255
dS1995:	Nr ones	179				74	89
dS1995:	Nr zeroes	50529				212	3396
Mean of:	dS2005	0.0110				0.5070	0.0735
dS2005:	Nr ones	559				145	256
dS2005:	Nr zeroes	50149				141	3229
Student background variables:		*≤ 3km*	*≤ 1.5km*	*50 nearest*	*100 nearest*		
Mean of:	GPA9	3.19	3.19	3.20	3.20	3.19	3.20
Sd of:	GPA9	0.18	0.41	0.14	0.11	0.09	0.25
Mean of:	High educ parent	0.34	0.34	0.35	0.35	0.33	0.38
Sd of:	High educ parent	0.13	0.24	0.15	0.13	0.10	0.18
Mean of:	Fam disp inc	260844	260071	262325	261121	254534	262080
Sd of:	Fam disp inc	31643	95053	38652	33047	23881	51464
Mean of:	Std Fam disp inc	105280	90660	97822	104790	121401	105213
Sd of:	Std Fam disp inc	116305	124291	120516	118883	101683	140776
Mean of:	Sw parent	0.93	0.93	0.93	0.93	0.92	0.90
Sd of:	Sw parent	0.07	0.11	0.07	0.06	0.06	0.10
Mean of:	Voucher proxy	46852	46707	46848	46846	48050	47634
Sd of:	Voucher proxy	4555	4414	4557	4511	5866	4692
Municipality level variables:							
Mean of:	Left	0.23				0.25	0.21
Sd of:	Left	0.42				0.44	0.41
Mean of:	Costs premises	11029				11347	11527
Sd of:	Costs premises	2592				2911	2743
School and population density:		*≤3km*		*≤1.5km*			
Mean of:	School-age Pop	171		43		1003	65
Sd of:	School-age Pop	299		95		1478	47
		≤6km		*≤3km*			
Mean of:	Nr mun schools	5.60		1.87		13.76	0.69
Sd of:	Nr mun schools	8.86		2.84		14.22	0.71
Mean of:	Nr priv schools	0.15		0.04		0.21	0.01
Sd of:	Nr priv schools	0.93		0.35		1.20	0.11
Number of observations:		*≤3km*	*≤1.5km*	*50 nearest*	*100 nearest*		
Mean of:	Nr of obs age 7-9[a]	170.52	43.20	50.00	100.00	1002.96	64.93
Sd of:	Nr of obs age 7-9	298.66	95.27	0.00	0.00	1478.16	47.26
Mean of:	Nr of obs GPA9[b]	61.45	15.59	50.00	99.97	360.47	22.33
Sd of:	Nr of obs GPA9	96.92	32.44	0.00	1.19	464.89	17.27
Nr of:	Grid cells/Municip/SAMS	50708	50708	50708	50708	286	3485[c]

[a] The number of observations per unit refers to the number of observations used for the calculations of the student background variables, in the alternative specifications. The information in the table for age 7-9 refers to the variables using information on age 7-9 children, and is based on the number of non-missing observations for the variable parental education level. For the other variables based on 7-9 year olds, the number of non-missing observations can differ slightly, due to missing information.

[b] It can be noted that the average number of observations for the 100 nearest students is slightly lower than 100. This is due both to the occurrence of missing observations, and to the fact that the calculations for the nearest neighbor specifications was limited to students residing within 100 km from the grid cell, in order to facilitate the computation.

[c] Note that only SAMS-areas with at least 30 age 7-9 students, measured in 1991, are included in the regression data. This explains why the number of included SAMS-areas falls far short of the total number of approximately 9000 SAMS-areas.

7 Regression model and results

The below sections first describe the regression model that will be used in the empirical analysis and discusses some estimation issues, then presents the main results, and finally reports the results from a set of sensitivity tests.

7.1 Regression model and estimation issues

As was explained in section 5.2, the likelihood that an independent school chooses location *g* in municipality *m*, $P(y_{gm})$, is modelled as a function of the following local variables: school and student density, $\boldsymbol{D}_g$; student grade point average (proxy for existing school quality), Q_g; student background in terms of parental education, Swedish background and household disposable income, $\boldsymbol{X}_g$; the voucher level V_g; costs for premises in the municipality H_m; and a dummy for left-wing majority in the municipal council L_m. The probability is assumed to follow the logistic function, which implies the following regression equation:

$$P(y_{gm}|\boldsymbol{D}_g, Q_g, \boldsymbol{X}_g, V_g, H_m, L_m) = \frac{e^{\alpha+\boldsymbol{D}_g{'}\tau+\theta Q_g+X_g{'}\beta+\gamma V_g+\delta H_m+\varphi L_m+\varepsilon_{gm}}}{1+e^{\alpha+\boldsymbol{D}_g{'}\tau+\theta Q_g+X_g{'}\beta+\gamma V_g+\delta H_m+\varphi L_m+\varepsilon_{gm}}} \quad (8),$$

As was also mentioned in the previous sections, the outcome variable is in the baseline specification based on independent school start-ups in 1992-2000, and the explanatory variables are measured in 1991 in order to avoid endogeneity bias. The downside of measuring local characteristics in 1991, however, is that they will be imperfect measures for the local characteristics in later years, and likely more so the further we move in time from the starting year. The correlation between the variables over time is however quite strong, which suggests that this is not a major issue.[52] One can also note that the potential measurement problem is likely to be smaller for the shorter alternative outcome period of 1992-1995, than for the longer outcome period 1992-2000. Comparing the results from these specifications hence gives a hint on whether or not measurement error affects the results. It is thus reassuring that the results are generally very stable across specifications for different time periods.[53]

Before we turn to the presentation of the results of the model, there are a couple of estimation issues that need to be dealt with. First, and as could be seen in the summary statistics in Table 1, the outcome variable relatively rarely takes the value one; the vast majority of the observations take value zero. In order to test if the results from the logit specification suffers from bias due to the

[52] Table A2 in the appendix shows the correlation between the explanatory variables measured in 1991 and 1995.
[53] See Table A5 in the Appendix.

fact that the outcome one is a relatively rare event, I also present results from using the firthlogit-estimator, which uses penalized maximum likelihood to estimate the logit odds ratios.[54] As can be seen in Table A4a-A4d in the Appendix, this yields estimates that are very close to the ordinary logit. Small sample bias thus does not seem to be a problem in the present case, and I will therefore use the ordinary logit for the baseline estimations, as it is faster and easier to compute.[55]

A second issue regards the estimation of the standard errors, which should take into account that the data is likely to exhibit spatial correlation. I will in the baseline analysis present standard errors that allow for arbitrary spatial correlation within the municipality.[56] In addition, I estimate standard errors based on Conley (1999)[57], which models the spatial component of the standard errors based on the correlation within a predefined geographical distance around each grid cell.[58] As can be seen in the appendix (Table A4a-A4d), the resulting standard errors (and p-values) are very similar to the standard errors that are obtained when instead clustering on municipality, and yield the same qualitative results.[59] I thus choose to proceed using the option of clustering on municipality, as this facilitates the estimation.

7.2 Main results

Table 2 shows the regression results for the outcome period 1992-2000, and for the set of alternative local school market specifications. The results in Table 2 are presented in the form of elasticities, in order to facilitate comparison between the specifications. Note that all columns show the results of logit estimations for the binary outcome variable for independent school locations, except for columns (6) and (8) which show the results from poisson regression models using the continuous outcome variables measuring the number of independent schools opening up in SAMS (column 6) and municipalities (column 8). These estimations are shown as a complement to the binary specifications for the SAMS and municipality regressions, and are in particular relevant for the municipalities which often have several independent schools.

[54] See https://www3.nd.edu/~rwilliam/stats3/RareEvents.pdf for a note on this estimator.
[55] Note also, as pointed out by Allison (https://statisticalhorizons.com/logistic-regression-for-rare-events), that the rare events problem is due not to the *relative* but the *absolute* rarity of the event that the outcome takes on value 1. In other words, even though the share of outcomes equaling one in the regression data is very low, the absolute number is still quite large (400 observations in the baseline specification) and may therefore not cause small sample bias.
[56] These were estimated using the Stata command cluster.
[57] The estimation was made using the code downloadable from: http://economics.uwo.ca/people/conley_docs/code_to_download_gmm.html.
[58] The estimations presented in Tables A4a-A4d use a cutoff of a couple of km.
[59] The tables in the appendix also show that the non-clustered standard errors were in general a bit smaller.

Table 2: Average marginal effects: Elasticities, Outcome period 1992-2000. Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Outcome variable:	dS2000	dS2000	dS2000	dS2000	dS2000	nrS2000	dS2000	nrS2000
Specification student variables:	≤ 3km	≤ 1.5km	50 nearest	100 nearest	SAMS	SAMS	Municip	Municip
GPA	-3.184**	-0.0217	-0.270	0.241	-2.771**	-2.689**	-8.303**	-11.37***
	(1.402)	(0.378)	(1.624)	(2.598)	(1.131)	(1.146)	(3.922)	(3.661)
High educ parent	1.779***	0.719***	1.457***	1.531***	1.105***	1.035***	1.007*	1.740***
	(0.182)	(0.0645)	(0.166)	(0.203)	(0.183)	(0.177)	(0.537)	(0.476)
Fam disp inc	-0.398	-0.230	-1.850*	-1.064	-0.255	-0.205	3.586*	0.798
	(1.036)	(0.276)	(0.953)	(0.954)	(0.591)	(0.575)	(1.908)	(0.889)
Std Fam disp inc	0.131**	0.0978**	0.140**	0.0851	-0.0190	0.00718	-0.0771	0.0304
	(0.0572)	(0.0446)	(0.0686)	(0.0557)	(0.0657)	(0.0716)	(0.109)	(0.0914)
Sw parent	-4.171***	-2.182***	-3.032***	-3.834***	-2.459***	-1.973***	-3.084*	-6.232***
	(0.877)	(0.339)	(0.950)	(0.843)	(0.650)	(0.656)	(1.733)	(1.137)
School-age Pop	0.275***	0.297***	0.256***	0.256***	0.284***	0.201***	0.422*	0.298
	(0.0657)	(0.0664)	(0.0558)	(0.0596)	(0.0853)	(0.0746)	(0.226)	(0.193)
Voucher proxy	-0.873	-0.608	-0.604	-0.640	-3.322**	-2.978**	0.255	-2.809*
	(1.737)	(1.721)	(1.793)	(1.791)	(1.504)	(1.431)	(1.822)	(1.573)
Left	-0.194***	-0.211***	-0.227***	-0.212***	-0.233***	-0.254***	-0.210**	-0.272***
	(0.0653)	(0.0610)	(0.0665)	(0.0656)	(0.0703)	(0.0715)	(0.0898)	(0.0603)
Costs premises	-0.0661	0.107	0.0397	-0.0328	1.234**	1.129**	-0.208	0.613
	(0.692)	(0.712)	(0.713)	(0.687)	(0.546)	(0.563)	(0.689)	(0.595)
Mun sch density	-0.0801	-0.0269	-0.0278	-0.0481	0.135*	0.125	0.0315	0.205
	(0.0729)	(0.0664)	(0.0668)	(0.0706)	(0.0742)	(0.0765)	(0.269)	(0.163)
Indep sch density	-0.00733*	-0.00581	-0.00754	-0.00552	-0.000234	0.000668	-2.76e-05	-0.0613***
	(0.00445)	(0.00683)	(0.00484)	(0.00467)	(0.00400)	(0.00410)	(0.0141)	(0.0216)
Observations	50,325	37,875	50,292	50,304	3,361	3,361	283	283
Specification	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies
Estimator	Logit	Logit	Logit	Logit	Logit	Poisson	Logit	Poisson
Log-likelihood	-1806	-1771	-1822	-1820	-657.9	-789.2	-132.7	-331.1

Standard errors are clustered on municipality in parentheses, except for the SAMS level regressions, where standard errors are clustered on the SAMS level.
*** p<0.01, ** p<0.05, * p<0.1

The results in Table 2 suggest that the probability for independent school location in the local area (grid cell, SAMS or municipality, depending on specification) is higher in locations where a larger share of the student population has high educated parents, and lower where a larger share of the student population has Swedish-born parents. It is furthermore positively correlated with the local student population density, and is negatively correlated with a left-wing municipal political majority. In terms of estimate sizes, the estimated elasticities are the largest for the share of students with Swedish-born parents: a one percent increase in this variable is estimated to be correlated with a 2 to 4 percent lower probability of independent school location, depending on the specification. The second largest elasticity, of 0.7-1.8 percent, is estimated for the share of students with high educated parents.

For the variable left wing political majority it is however more intuitive to express the estimate size in terms of a 0–1-change than in terms of the elasticities given in the table. Expressed in this manner, the results suggest that locations in municipalities with a left wing political majority are on average 0.6–1 percent[60] less likely to experience independent school location over the studied period than locations in municipalities with another political majority.

The above results are consistent over all of the alternative school market definitions (except for a statistically insignificant estimate on population density in the municipality level regression in column 8). Some of the other estimated elasticities however differ markedly depending on the level of spatial aggregation. For example, the elasticities in columns (1)-(3) of Table 2 suggest that a one percent higher standard deviation in household income is correlated with an approximately 0.1 percent increase in the likelihood that an independent school opens up. However, this relation turns insignificant when measured among the 100 nearest students in column (4), and is insignificant, and sometimes even changes sign, in the SAMS and municipality level specifications in columns (5)-(8). The local student grade point average (GPA) is furthermore estimated to be strongly and statistically significantly correlated with the likelihood for independent school location for the specifications using a 3 km cutoff in column (1) and the SAMS-based specifications in columns (5)-(6), and even more so when using the municipality level in columns (7)-(8). The elasticity is however small and statistically insignificant for the other specifications in columns (2)-(4). Finally, statistically significant and positive elasticities were estimated for the proxy variable for costs for premises in the SAMS-based specifications in columns (5)-(6), but that was insignificant and of much smaller magnitude, and sometimes of negative sign, for the other specifications. This results is in addition of the opposite sign to what we expect from the theoretical model. It is plausible that these estimates are the result of some omitted variable which correlates with the

[60] The precise estimate varies between -0.62% and -1.07%, depending on specification. Estimates are available upon request.

independent school entry variable at the SAMS level. The above variations in the estimated elasticities between the alternative spatial specifications furthermore indicate that these estimates suffer from the Modifiable Areal Problem, and shall thus be interpreted with caution.

As was commented in section 4, local information on teacher wages is missing from the empirical model, and as a robustness check the specifications of Table 2 are rerun, but adding dummy variables for Labor market regions as proxy variables for local differences in wage levels. These regions are defined by Statistics Sweden based on observed commuting patterns, and I use the values for year 1991. These regressions are not estimated for the municipality level, as the 111 Labor market regions would capture a substantial amount of the variation among the 286 municipalities in the regression sample.

As can be seen in Table 3, adding the Labor market regions substantially decreases the sample sizes of the grid cell specifications. This is due to the fact that some of the included Labor market regions (some of which are quite small) perfectly predict the outcome variable, and are hence dropped from the regression. Table 3 therefore also repeats the baseline specification from Table 2 but using the sample of the Labor market dummy specifications (see columns 7-12). The results in columns (1)-(6) in Table 3 indicate that adding Labor market dummy variables overall makes very little difference to the estimates for the grid cell specifications. The most striking differences are that the estimated positive elasticity for the standard deviation of household income comes out as statistically significant in all grid cell based specifications, and in addition the positive estimate for the elasticity for the average disposable income level is statistically significantly different from zero in all specifications. The dummy variable for left wing political majority in the municipality is no longer statistically significant – this is however not surprising given that the Labor market regions are (as commented above) likely to capture a lot of the municipality level variation. The SAMS level estimates are a bit more sensitive to the inclusion of Labor market region dummies than the grid cell-based estimates[61]: the elasticities for the share of Swedish born parents and the cost for premises are no longer statistically significantly different from zero. In addition, a negative and statistically significant elasticity is estimated for the average disposable income, while the dummy variable for left wing political majority becomes insignificant, similarly to the grid cell based specifications.

[61] This is not surprising, as the number of SAMS is much lower than the number of grid-cells, meaning that the Labor market region dummies capture relatively more of the variation among observations for the SAMS specification.

Table 3: Specifications with and without including Labour market region dummy variables, for the grid cell and SAMS based regressions, when using the Labour market region regression sample for all specifications. Average marginal effects: Elasticities, Outcome period 1992-2000, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome variable:	dS2000	dS2000	dS2000	dS2000	dS2000	nrS2000	dS2000	dS2000	dS2000	dS2000	dS2000	nrS2000
Specification student variables:	≤ 3km	≤ 1.5km	50 nearest	100 nearest	SAMS	SAMS	≤ 3km	≤ 1.5km	50 nearest	100 nearest	SAMS	SAMS
GPA	-3.004**	0.0303	-0.0726	0.351	-2.529**	-2.445**	-2.817**	-0.00186	-0.0882	0.508	-2.365**	-2.689**
	(1.482)	(0.395)	(1.471)	(2.384)	(1.119)	(1.119)	(1.419)	(0.393)	(1.616)	(2.560)	(1.109)	(1.146)
High educ parent	2.084***	0.724***	1.658***	1.821***	1.265***	1.151***	1.663***	0.680***	1.401***	1.446***	1.010***	1.035***
	(0.269)	(0.0743)	(0.226)	(0.272)	(0.228)	(0.212)	(0.186)	(0.0674)	(0.171)	(0.209)	(0.197)	(0.177)
Fam disp inc	-2.511*	-0.616*	-3.161***	-2.730***	-1.681**	-1.682**	-0.553	-0.295	-1.921**	-1.133	-0.654	-0.205
	(1.398)	(0.363)	(0.958)	(0.997)	(0.695)	(0.666)	(1.058)	(0.305)	(0.964)	(0.970)	(0.612)	(0.575)
Std Fam disp inc	0.258***	0.128**	0.225***	0.189***	0.0581	0.0927	0.158**	0.108**	0.150**	0.0950	0.0151	0.00718
	(0.0812)	(0.0569)	(0.0713)	(0.0586)	(0.0774)	(0.0769)	(0.0648)	(0.0517)	(0.0723)	(0.0589)	(0.0693)	(0.0716)
Sw parent	-2.416*	-1.614***	-1.812*	-2.447***	-0.782	-0.357	-3.828***	-2.010***	-2.782***	-3.518***	-1.455**	-1.973***
	(1.250)	(0.388)	(1.051)	(0.947)	(0.853)	(0.880)	(0.860)	(0.324)	(0.928)	(0.821)	(0.657)	(0.656)
School-age Pop	0.311***	0.331***	0.293***	0.293***	0.246***	0.181**	0.301***	0.324***	0.281***	0.281***	0.284***	0.201***
	(0.0717)	(0.0744)	(0.0597)	(0.0631)	(0.0903)	(0.0716)	(0.0691)	(0.0701)	(0.0587)	(0.0627)	(0.0870)	(0.0746)
Voucher proxy	-0.617	-0.957	-0.446	-0.478	-4.136**	-3.748**	-0.330	0.0444	0.0774	0.0146	-2.274	-2.978**
	(1.994)	(1.934)	(1.991)	(2.035)	(1.826)	(1.805)	(1.733)	(1.692)	(1.781)	(1.793)	(1.457)	(1.431)
Left	-0.0495	-0.0806	-0.0630	-0.0550	-0.143	-0.169	-0.114***	-0.129***	-0.139***	-0.127***	-0.0811*	-0.254***
	(0.0603)	(0.0626)	(0.0602)	(0.0601)	(0.0991)	(0.154)	(0.0441)	(0.0404)	(0.0453)	(0.0443)	(0.0420)	(0.0715)
Costs premises	-0.228	-0.0534	-0.285	-0.274	0.838	0.621	-0.189	-0.0636	-0.131	-0.187	0.768	1.129**
	(0.614)	(0.654)	(0.623)	(0.616)	(0.636)	(0.676)	(0.643)	(0.653)	(0.661)	(0.641)	(0.517)	(0.563)
Mun sch density	-0.121	-0.0789	-0.0876	-0.1000	0.161**	0.156**	-0.102	-0.0540	-0.0477	-0.0679	0.155**	0.125
	(0.0783)	(0.0770)	(0.0708)	(0.0733)	(0.0720)	(0.0731)	(0.0781)	(0.0718)	(0.0715)	(0.0756)	(0.0700)	(0.0765)
Indep sch density	-0.0153**	-0.00562	-0.0109*	-0.00972	-0.00218	-0.000964	-0.00732	-0.00464	-0.00740	-0.00500	-0.000981	0.000668
	(0.00676)	(0.00831)	(0.00639)	(0.00617)	(0.00517)	(0.00408)	(0.00540)	(0.00788)	(0.00576)	(0.00557)	(0.00500)	(0.00410)
Observations[a]	39,549	30,333	39,516	39,528	2,423	3,361	39,549	30,333	39,516	39,528	2,423	3,361
Specification	LAregion dummies	LAregion dummies	LAregion dummies	LAregion dummies	LAreg dummies	LAreg dummies	No additional dummies	No additional dummies	No additional dummies	No additional dummies	No additional dummies	No additional dummies
Estimator	Logit	Logit	Logit	Logit	Logit	Poisson	Logit	Logit	Logit	Logit	Logit	Poisson
Log-likelihood	-1732	-1699	-1740	-1742	-583.7	-706.4	-1774	-1734	-1785	-1785	-621.5	-789.2

Standard errors are clustered on municipality in parentheses, except for the SAMS level regressions, where standard errors are clustered on the SAMS level.
*** p<0.01, ** p<0.05, * p<0.1

7.3 Unconditional regression results

The analysis in the former section suggested what local factors were correlated with the location choices of independent schools *conditional on* the other right hand side variables. The relatively large, positive and statistically significant estimated elasticity for, say, high education background, implies that this factor stands out as strongly correlated with location choices even after holding constant for all other local variables. On the other hand, the estimated elasticity for local disposable income was often estimated as negative in sign, with the statistical significance varying a lot between specifications (often insignificant in the baseline Table 2, often statistically significantly different from zero when including labor market region dummies in Table 3). This does not mean that independent schools do not locate in high income neighborhoods – rather that, *conditional on* other local factors such as education background etc, the estimated correlation is negative/insignificant.

As can be seen in Tables A3a-A3f in the appendix, many of the included variables are correlated, in particular the local income and education level. It is thus reasonable to complement the "conditional on"-analysis with the unconditional counterpart, i.e. regressing the outcome variable on each local factor separately. Table 4 shows the results from such separate regressions for each variable.

As expected, more of the variables are estimated as being statistically significantly correlated with the likelihood of independent school entry when using separate regressions. This holds in particular for student GPA, household disposable income, voucher level, costs for premises, and for the two school density variables. All these are estimated as being positively correlated with independent school location in most of the specifications, although they were often estimated with negative and/or insignificant elasticities when conditioning on all other variables. Independent schools are thus actually more likely to enter locations with higher income level, but this correlation is no longer present if we hold constant for other local factors, such as the education level and Swedish/foreign background of prospective students' parents.

Table 4: Separate regressions for each covariate, Average marginal effects: Elasticities, Outcome period 1992-2000, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Outcome variable	dS2000	dS2000	dS2000	dS2000	dS2000	nrS2000	dS2000	nrS2000
Specification student variables:	≤ 3km	≤ 1.5km	50 nearest	100 nearest	SAMS	SAMS	Municip	Municip
GPA	5.379***	1.259***	8.324***	13.81***	0.168	0.248	5.527**	13.13***
	(1.623)	(0.382)	(2.544)	(3.484)	(0.888)	(0.956)	(2.525)	(2.903)
High educ parent	2.028***	0.705***	1.707***	1.945***	0.769***	0.754***	2.245***	2.100***
	(0.232)	(0.0904)	(0.205)	(0.223)	(0.127)	(0.136)	(0.346)	(0.307)
Fam disp inc	2.369***	0.108***	1.336***	2.151***	0.645**	0.711***	7.937***	3.262***
	(0.452)	(0.0410)	(0.278)	(0.283)	(0.253)	(0.248)	(1.351)	(0.676)
Std Fam disp inc	0.215***	0.121***	0.0916***	0.128***	0.0413	0.0541	0.283*	0.345***
	(0.0424)	(0.0205)	(0.0205)	(0.0266)	(0.0284)	(0.0336)	(0.163)	(0.0976)
Sw parent	-7.115***	-2.752***	-6.026***	-6.324***	-2.530***	-2.395***	-5.681***	-7.474***
	(0.825)	(0.245)	(0.503)	(0.584)	(0.433)	(0.417)	(1.407)	(1.357)
School-age Pop	0.298***	0.298***	0.298***	0.298***	0.492***	0.386***	0.623***	0.248***
	(0.0289)	(0.0289)	(0.0289)	(0.0289)	(0.0764)	(0.0460)	(0.0875)	(0.0242)
Voucher proxy	3.145***	3.510***	3.123***	3.187***	0.646	0.614	-1.320*	0.435
	(1.131)	(1.156)	(1.142)	(1.156)	(0.652)	(0.693)	(0.701)	(0.894)
Left	-0.377***	-0.377***	-0.377***	-0.377***	-0.328***	-0.340***	-0.228***	-0.462***
	(0.0790)	(0.0790)	(0.0790)	(0.0790)	(0.0683)	(0.0694)	(0.0755)	(0.0745)
Costs premises	2.036***	2.036***	2.036***	2.036***	1.116***	1.097***	0.0631	1.116**
	(0.647)	(0.647)	(0.647)	(0.647)	(0.263)	(0.282)	(0.274)	(0.527)
Mun sch density	0.340***	0.340***	0.340***	0.340***	0.271***	0.298***	0.629***	0.421***
	(0.0195)	(0.0195)	(0.0195)	(0.0195)	(0.0547)	(0.0507)	(0.0911)	(0.0239)
Indep sch density	0.0494***	0.0494***	0.0494***	0.0494***	0.00592*	0.00636	0.0367***	0.0494***
	(0.00218)	(0.00218)	(0.00218)	(0.00218)	(0.00349)	(0.00399)	(0.00417)	(0.00455)
Observations	50,388-50,682	42,681-50,682	50,388-50,682	50,682	3,391-3,485	3,391-3,485	284-286	284-286
Specification	No additional dummies	No additional dummies	No additional dummies	No additional dummies	No additional dummies	No additional dummies	No additional dummies	No additional dummies
Estimator	Logit	Logit	Logit	Logit	Logit	Poisson	Logit	Poisson
Log-likelihood	-1915 – -2333	-1915 – -2263	-1915 – -2327	-1915– -2323	-705.9 – -743.1	-849 – -891.4	-152.7 – -192.4	-470.6 – -710.6

Standard errors are clustered on municipality in parentheses, except for the SAMS level regressions, where standard errors are clustered on the SAMS level.
*** p<0.01, ** p<0.05, * p<0.1

7.4 Additional robustness tests

In addition to the above estimations, the independent school location choice was estimated after making the following alterations to the baseline specification that was presented in Table 2:

- Estimating the regression for alternative outcome years (1992-95, and 1992-2005, respectively), and estimating the regression for outcome years 1996-2000 and measuring explanatory variables in 1995. The overall pattern of results is similar across specifications. The main difference is that the variable for left-wing majority in the municipal council is not statistically significantly different from zero in all specifications: It is only weakly significant when the outcome period is 1991-1995, and not statistically significant when the outcome period 1996-2000 is regressed on local factors measured in 1995. (See results in Table A5 in the Appendix.)
- Using a smaller (500m*500m) grid (instead of the baseline 1km*1km size grid) to measure potential location points. This yields results that are very similar to the baseline specification. (See results in Table A6 in the Appendix.)
- Defining population density as number of students residing within 1.5 km from the grid cell (instead of the 3 km in the baseline specification) and measuring school density within 3 km (instead of 6 km). Most estimates are unaltered by this, however the standard deviation of income, which was statistically significant in most specifications in the baseline case, is now insignificant in most of the specifications. Municipality school density, which was previously insignificant, is on the contrary now positive and statistically significant in all 4 specifications. (See results in Table A7 in the Appendix.)
- Adding dummy variables for municipality type, based on the categories defined by the Swedish Association of Local Authorities and Regions[62], and estimating the regression only for the municipalities within the Stockholm County. The results are overall very similar to the baseline specification. The more prominent difference is that the estimated elasticities for the average and standard deviation in local disposable income are more often statistically significantly different from zero than in the baseline specifications. (See results in Table A8 in the Appendix.)

[62] These categories are: large cities, suburban, municipalities with many commuters, large towns, manufacturing towns, other municipalities with a population of more than 25 000, other municipalities with a population of 12 500-25 000, other municipalities with a population below 12 500, and rural municipalities.

8 Concluding discussion

The overall results of this study suggest that the likelihood for independent school entry during the studied period was higher in locations where a larger share of school age children had high educated parents and where the local population density among school age children was higher. The likelihood was furthermore lower in locations with a larger share of school age children with Swedish born parents. These results held both conditionally and unconditionally of the other local factors that were included in the regression model and were stable across the alternative spatial specifications and the alternative regression models that were estimated.

The results also showed that a left-wing political majority in the local council was negatively correlated with independent school entry in the baseline specification, although this correlation was only weakly, or not at all, statistically significant when the shorter outcome periods of 1992-1995 and 1996-2000 were used. The independent schools furthermore tended to locate in areas with a higher income dispersion, although this result was not stable across all spatial specifications.

When conducting an unconditional analysis, there was evidence that independent schools were more likely to locate in areas with higher income. However, when conditioning on the other local variables, this relation vanished, and the estimated elasticity instead turned negative, although often not statistically different from zero. The same held for the average GPA among local students: this was positively correlated with independent school entry unconditionally on the other local factors, but was often negative, and quite unstable across the alternative spatial aggregations, when all local factors were included in the regression model.

How do these results compare to the previous literature? The main results are well in line with previous results on the US and Sweden. Many of the US studies suggest that the likelihood for charter or private school location is positively correlated with the local adult education level and with a higher level of dispersion in terms of ethnicity or higher shares of students with foreign background. The previous Swedish reports, Angelov and Edmark (2016) and Holmlund et al (2014), also find that the probability of independent school entry is higher in locations with a larger share of students from high-educated or foreign family background. These results correspond to what is found in this study, namely a larger probability for independent school entry in locations with higher parental education background, and a *lower* probability in locations with a higher share of students with *Swedish born* parents. It can be noted that these results hold both conditional on other local characteristics (see Angelov and Edmark, 2016, and the baseline estimations of this study) and unconditionally (see Holmlund et al, 2014, and section 7.3 of this paper). It can also be noted that they hold across the various spatial definitions of school markets, and for the different grade levels of schools, that were employed in these respective reports and the current study. [63] Both of the above mentioned reports and the current study also estimated positive correlations between student population density, or student population size, and the likelihood for independent school entry, although this estimate was not always statistically significantly different from zero. The present study and Angelov and Edmark (2016) furthermore found indications of a negative correlation with a left-wing local majority.

The results however differed between Angelov and Edmark (2016) and the present study when it comes to the included proxy variables for local voucher levels and estimated costs for facilities. These variables were estimated as statistically significant and of the expected sign (positive correlation between school entry and voucher level, and negative for costs for facilities) in Angelov and Edmark (2016) when SAMS was used to measure local school markets. The current study however yielded estimates of the opposite sign, although they were only statistically significant in the SAMS-level specification, and not for the other spatial specifications. This suggests that the results for these variables shall be interpreted with caution.

The sometimes diverging results between different specifications also points to the general importance of testing the robustness of the results with respect to several alternative spatial measures, as was done in this paper. Although the results for many of the variables were, as described above, consistent across all the employed spatial measurements, others were not. This held for example for the average GPA among local students, for the level and standard deviation of local household income, and, again for the proxy variables for local voucher levels and estimated costs for facilities. Although the analysis was not a formal test of which spatial aggregation was the best, the results thus exemplify that the spatial unit of analysis can have significant impact on the estimated results.

Finally, it can be underlined that the results in this paper provide descriptive evidence in the form of estimated correlations, but remains agnostic on what are the underlying mechanisms. As the theoretical framework in section 4 indicated, some of the local variables were includes based on several alternative hypotheses. This holds in particular for the student background variables. For example, the estimated negative correlation between the share of students with Swedish-born parents could on the one hand suggest that independent schools do not (on

[63] As was noted in the literature review in section 2, these differ from the current study in that they base the measures of school markets on SAMS and/or the school population in the current schools, whereas the present study employs both SAMS (and municipalities) and a set of spatial measures generated using geo-coded data. The studies also differ in the level of education studied (Angelov and Edmark: lower secondary schools, Holmlund et al: primary and lower secondary schools, and the current study: lower primary schools) and in whether or not the estimates are modelled conditional or unconditional on other local characteristics. (Holmlund et al condition on municipality fixed effects, whereas Angelov and Edmark include a relatively large set of local characteristics. The present study presents results from both the unconditional model, and conditioning on other local characteristics.)

average) shy away from locations where students have a more disadvantaged family background (in terms of expected study results). On the other hand, it could reflect a school provider choosing a more diverse neighborhood but with the aim to attract only a segment of the student population, such as those with some religious affiliation, the Swedish-born etc. Further studies are thus needed in order to dig more into the underlying mechanisms. Using structural models to simultaneously model the schools' location decisions, students' school choices and potential moving patterns can be one fruitful line of future research in this respect.

9 References

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10 Appendix

10.1 Information on the sources of data

The analysis is based on data from Statistics Sweden on all cohorts born in 1972-1990 and their parents, and on all lower primary level schools. The data includes links between parents and children, and covers individual register based information on disposable income, education and country region of birth. The data also includes detailed geographical information based on the addresses of all schools and students. The school level data includes information on grades offered and whether the school is publicly or independently operated. Municipality level information on educational resources was gathered from the webpage of The Swedish National Agency for Education, and information on local electoral outcomes was downloaded from the publicly available database of Statistics Sweden.

The variables that were used in the regression analyses are based on the below data:

Independent school location: The outcome variable for independent school locations is based on school level information on whether the school is independent or municipal, and geographical information based on the school address. The school level data comes from the School Register of Statistics Sweden. The geographical information is described further below in this section.

GPA: Grade point average among students graduating from grade 9 comes from the Grade 9 Graduation Register of Statistics Sweden. The variable measures the average grades of the students at a one decimal level, with a minimum value of 1.0 and a maximum of 5.0.

High educated parent: The education level of the parents is defined as a dummy variable indicating that at least one of the parents of a student has completed a post-secondary education degree. The variable is defined as missing if information on both parents is lacking (and is defined based on the observed parent in case only one parent has non-missing information). The data source is the SUN code for education level from Statistics Sweden.

Disposable family income: Disposable family income is measured in 1SEK, as defined in the register based income data of Statistics Sweden. This variable is based on the value observed by the mother of the child. That is, for children with divorced parents, the family income will differ between the mother and the father, and the information used in the regression analysis will then be based on the disposable family income recorded for the mother.

Swedish born parent: Swedish born parent is measured as a dummy variable which takes value one if at least one parent of the child is born in Sweden, and zero otherwise. The variable is defined as missing if information on both parents is lacking (and is defined based on the observed parent in case only one parent has non-missing information). The variable is based on the Statistics Sweden Country of Birth Register.

Voucher proxy: This variable is based on the information on the average cost (in 1SEK) for students in the municipality-operated compulsory level (grade 1-9) schools. It thus reflects the per student cost in the municipal schools, and is defined at the municipality level. The information was downloaded from the SIRIS database of The Swedish National Agency for Education (https://siris.skolverket.se/siris/f?p=Siris:1:0). Note that this information is only available from 1992 on. Year 1992 information was therefore used instead of year 1991 information for this variable.

Costs premises: This variable measures the average cost (in 1SEK) for facilities for students in the municipality-operated compulsory level (grade 1-9) schools. It thus reflects the per student cost for premises in the municipal schools, and is defined at the municipality level. The information was downloaded from the SIRIS database of The Swedish National Agency for Education (https://siris.skolverket.se/siris/f?p=Siris:1:0). Note that this information is only available from 1992 on. Year 1992 information was therefore used instead of year 1991 information for this variable.

Left: this variable takes the value one if the seat share of the Social Democratic and the Left parties in the municipal council is equal to or exceeds 50 percent, and the value zero otherwise. The information on municipal council seats can be downloaded from the webpage of Statistics Sweden (http://www.statistikdatabasen.scb.se/pxweb/sv/ssd/START__ME__ME0104__ME0104A/Kfmandat/?rxid=f45f90b6-7345-4877-ba25-9b43e6c6e299).

Geographical information: In addition to the above variables, geographical information on students' residential addresses and school addresses was used to generate various spatial measures. This information is in the form of 100m*100m squares for the geographical coordinates, and stems from the geographical data registers of Statistics Sweden.

Intergenerational link: Finally, the link between children and parents that was used to generate information on parental characteristics comes from the Multigenerational Register of Statistics Sweden and includes biological as well as adoptive parents.

10.2 Additional data information

For the schools, 3.2% of the observations over 1991–2000 have missing coordinate grid cell information. The number of missing values is larger for the earlier (5.7% in 1991) than for the later years (1.0% in 2000). The missing information can be due either to the school providers not submitting the address information to the School Register, or the information being inaccurate and thus not possible to link to geographical coordinates.

The missing coordinate grid cell information was in this paper handled by replacing missing information by future, or lagged, values for the same school. This will result in erroneous information for schools that change location over time, but as school moves tend to be uncommon, the risk for this should be small. After replacing missing values in this manner, the share of schools with missing geo-grid information had dropped to 2.7% for the public schools and to 1.3% for the independent schools.

For the students, there is a relatively large number of missing coordinate info for the early period of the data: 15% of all 7-9 year olds measured in 1991 lack geographical information. This means that for 15% of the student based sample, geographical coordinate grid cell, municipality and SAMS information is missing, and can thus not be used for computing the variables that are defined based on the local student population. (It can be noted that in contrast to the schools, for the students it does not make sense to replace missing information with lagged of future values, as students may well move between years.) These regression variables are thus measured with some error due to missing information.

10.3 Additional tables

Table A1: Descriptive statistics for all generated regression variables for the 0.5km*0.5km grid cell regression sample.

Outcome variables:		*0.km*0.km grid cell location units*			
Mean of:	dS2000	0.0020			
dS2000:	Nr of ones	408			
dS2000:	Nr of zeroes	203522			
Mean of:	dS1995	0.0008			
dS1995:	Nr ones	169			
dS1995:	Nr zeroes	203761			
Mean of:	dS2005	0.0029			
dS2005:	Nr ones	589			
dS2005:	Nr zeroes	203341			
Student background variables:		*≤ 3km*	*≤ 1.5km*	*50 nearest*	*100 nearest*
Mean of:	GPA9	3.19	3.19	3.20	3.20
Sd of:	GPA9	0.18	0.41	0.14	0.11
Mean of:	High educ parent	0.34	0.35	0.35	0.35
Sd of:	High educ parent	0.13	0.24	0.15	0.13
Mean of:	Fam disp inc	260798	259948	262223	261035
Sd of:	Fam disp inc	31743	96267	38758	33094
Mean of:	Std Fam disp inc	105139	91044	97615	104927
Sd of:	Std Fam disp inc	116383	127190	120147	120418
Mean of:	Sw parent	0.93	0.93	0.93	0.93
Sd of:	Sw parent	0.07	0.11	0.07	0.06
Mean of:	Voucher proxy	46845	46703	46841	46838
Sd of:	Voucher proxy	4545	4407	4546	4500
Municipality level variables:					
Mean of:	Left	0.23			
Sd of:	Left	0.42			
Mean of:	Costs premises	11026			
Sd of:	Costs premises	2587			
School and population density:		*≤3km*			
Mean of:	School-age Pop	170			
Sd of:	School-age Pop	299			
		≤6km			
Mean of:	Nr mun schools	5.59			
Sd of:	Nr mun schools	8.84			
Mean of:	Nr priv schools	0.15			
Sd of:	Nr priv schools	0.92			
Number of observations:		*≤3km*	*≤1.5km*	*50 nearest*	*100 nearest*
Mean of:	Nr of obs age 7-9[a]	170.23	43.33	50.00	100.00
Sd of:	Nr of obs age 7-9	298.52	95.89	0.00	0.00
Mean of:	Nr of obs GPA9[b]	61.36	15.63	50.00	99.97
Sd of:	Nr of obs GPA9	96.94	32.61	0.00	1.16
Nr of:	Grid cells	203930	203930	203930	203930

[a] The number of observations per unit refers to the number of observations used for the calculations of the student background variables, in the alternative specifications. The information in the table for age 7-9 refers to the variables using information on age 7-9 children, and is based on the number of non-missing observations for the variable parental education level. For the other variables based on 7-9 year olds, the number of non-missing observations can differ slightly, due to missing information.

[b] It can be noted that the average number of observations for the 100 nearest students is slightly lower than 100. This is due both to the occurrence of missing observations, and to the fact that the calculations for the nearest neighbor specifications was limited to students residing within 100 km from the grid cell, in order to facilitate the computation.

Table A2: Raw correlation between explanatory variables measured in 1991 and 1995, for the 1km*1km grid cell based specifications.

Student level variables	*≤ 3km*	*≤ 1.5km*	*50 nearest*	*100 nearest*
GPA	0.2943	0.1069	0.3439	0.3600
High educ parent	0.8388	0.4204	0.7563	0.7925
Fam disp inc	0.6973	0.2163	0.5857	0.6609
Std Fam disp inc	0.3088	0.2289	0.1873	0.2180
Sw parent	0.8038	0.3957	0.6626	0.7329
Voucher proxy	0.7201	0.7025	0.7190	0.7193
Municipality level variables				
Left	0.4924			
Costs premises	0.6389			

Variables based on fixed cutoffs	*≤ 3km*	*≤ 1.5km*
School-age Pop	0.9959	0.8633
	≤ 6km	*≤ 3km*
Mun school density	0.9935	0.8408
Priv school density	0.9104	0.6865

Table A3a: Correlation among right-hand side variables measured in 1991[a], Student variables: ≤ 3km, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

(obs=50,325)	GPA	High educ parent	Fam disp inc	Std Fam disp inc	Sw parent	School-age Pop	Voucher proxy	Left	Costs premises	Mun school density	Priv school density
GPA	1.0000										
High educ parent	0.3674	1.0000									
Fam disp inc	0.2836	0.5664	1.0000								
Std Fam disp inc	0.1429	0.2643	0.6998	1.0000							
Sw parent	0.0470	0.0486	0.0176	-0.0359	1.0000						
School-age Pop	0.0968	0.2877	0.1352	0.2123	-0.4391	1.0000					
Voucher proxy	0.0266	0.0770	0.0511	0.0472	-0.1459	0.1581	1.0000				
Left	-0.0484	-0.1111	-0.1090	-0.0674	0.0081	-0.0774	0.3532	1.0000			
Costs premises	0.0754	0.1805	0.1390	0.0849	-0.1536	0.2181	0.7756	0.1645	1.0000		
Mun sch density	0.1445	0.3671	0.2265	0.2598	-0.4155	0.8764	0.1983	-0.0717	0.2723	1.0000	
Indep sch density	0.0887	0.2406	0.1430	0.2143	-0.2168	0.6521	0.1351	-0.0901	0.1881	0.7341	1.0000

[a] Costs for premises and voucher level measured in 1992 due to lack of data for year 1991.

Table A3b: Correlation among right-hand side variables measured in 1991[a], Student variables: ≤ 1.5km, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

(obs=37,875)	GPA	High educ parent	Fam disp inc	Std Fam disp inc	Sw parent	School-age Pop	Voucher proxy	Left	Costs premises	Mun school density	Priv school density
GPA	1.0000										
High educ parent	0.1684	1.0000									
Fam disp inc	0.1091	0.3233	1.0000								
Std Fam disp inc	0.0627	0.1672	0.7388	1.0000							
Sw parent	0.0104	0.0294	0.0381	-0.0146	1.0000						
School-age Pop	0.0627	0.2212	0.1041	0.1759	-0.3264	1.0000					
Voucher proxy	0.0097	0.0631	0.0468	0.0471	-0.1117	0.1948	1.0000				
Left	-0.0373	-0.0840	-0.0579	-0.0586	0.0071	-0.0823	0.3368	1.0000			
Costs premises	0.0370	0.1290	0.0863	0.0746	-0.1154	0.2543	0.7744	0.1509	1.0000		
Mun sch density	0.0804	0.2586	0.1518	0.2024	-0.2894	0.8880	0.2336	-0.0779	0.3075	1.0000	
Indep sch density	0.0506	0.1743	0.0890	0.1586	-0.1687	0.6598	0.1597	-0.0967	0.2158	0.7480	1.0000

[a] Costs for premises and voucher level measured in 1992 due to lack of data for year 1991.

Table A3c: Correlation among right-hand side variables measured in 1991[a], Student variables: 50 nearest students, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

(obs=50,292)	GPA	High educ parent	Fam disp inc	Std Fam disp inc	Sw parent	School-age Pop	Voucher proxy	Left	Costs premises	Mun school density	Priv school density
GPA	1.0000										
High educ parent	0.4501	1.0000									
Fam disp inc	0.3654	0.5673	1.0000								
Std Fam disp inc	0.1415	0.1811	0.7162	1.0000							
Sw parent	0.1074	0.1114	0.0751	0.0176	1.0000						
School-age Pop	0.1304	0.2955	0.1575	0.0927	-0.3482	1.0000					
Voucher proxy	0.0398	0.0748	0.0509	0.0249	-0.1209	0.1558	1.0000				
Left	-0.0567	-0.1036	-0.0923	-0.0460	-0.0025	-0.0773	0.3538	1.0000			
Costs premises	0.0969	0.1716	0.1256	0.0500	-0.1261	0.2183	0.7757	0.1642	1.0000		
Mun sch density	0.1990	0.3668	0.2346	0.1263	-0.3203	0.8765	0.1956	-0.0716	0.2725	1.0000	
Indep sch density	0.1182	0.2276	0.1195	0.0821	-0.1830	0.6521	0.1326	-0.0902	0.1880	0.7342	1.0000

[a] Costs for premises and voucher level measured in 1992 due to lack of data for year 1991.

Table A3d: Correlation among right-hand side variables measured in 1991[a], Student variables: 100 nearest students, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

(obs=50,304)	GPA	High educ parent	Fam disp inc	Std Fam disp inc	Sw parent	School-age Pop	Voucher proxy	Left	Costs premises	Mun school density	Priv school density
GPA	1.0000										
High educ parent	0.5183	1.0000									
Fam disp inc	0.4296	0.6414	1.0000								
Std Fam disp inc	0.1649	0.2022	0.6614	1.0000							
Sw parent	0.0844	0.0978	0.0770	0.0300	1.0000						
School-age Pop	0.1506	0.3021	0.1662	0.0910	-0.4049	1.0000					
Voucher proxy	0.0356	0.0707	0.0383	0.0079	-0.1317	0.1580	1.0000				
Left	-0.0782	-0.1245	-0.1203	-0.0662	-0.0047	-0.0773	0.3583	1.0000			
Costs premises	0.1199	0.1821	0.1206	0.0276	-0.1450	0.2183	0.7747	0.1643	1.0000		
Mun sch density	0.2348	0.3839	0.2583	0.1293	-0.3843	0.8764	0.1990	-0.0717	0.2724	1.0000	
Indep sch density	0.1449	0.2393	0.1355	0.0866	-0.2121	0.6521	0.1340	-0.0902	0.1880	0.7341	1.0000

[a] Costs for premises and voucher level measured in 1992 due to lack of data for year 1991.

Table A3e: Correlation among right-hand side variables measured in 1991[a], SAMS-level measures.

(obs=3,361)	GPA	High educ parent	Fam disp inc	Std Fam disp inc	Sw parent	School-age Pop	Voucher proxy	Left	Costs premises	Mun school density	Priv school density
GPA	1.0000										
High educ parent	0.5121	1.0000									
Fam disp inc	0.4439	0.6558	1.0000								
Std Fam disp inc	0.1660	0.2655	0.6939	1.0000							
Sw parent	0.2003	0.1901	0.2278	0.0462	1.0000						
School-age Pop	0.0079	0.0710	0.0376	0.0440	-0.2126	1.0000					
Voucher proxy	0.0646	0.1050	0.0648	0.0510	-0.2021	0.0682	1.0000				
Left	-0.0646	-0.1308	-0.1038	-0.0677	0.1087	-0.0977	0.2370	1.0000			
Costs premises	0.1067	0.2026	0.1091	0.0682	-0.1770	0.1646	0.8056	0.0771	1.0000		
Mun sch density	-0.0236	-0.0806	-0.0619	-0.0106	-0.0372	0.3988	0.0783	0.0433	0.1039	1.0000	
Indep sch density	0.0350	0.0558	0.0180	0.0190	-0.0334	0.0731	0.0509	-0.0410	0.0793	0.0417	1.0000

[a] Costs for premises and voucher level measured in 1992 due to lack of data for year 1991.

Table A3f: Correlation among right-hand side variables measured in 1991[a], Municipality-level measures.

(obs=283)	GPA	High educ parent	Fam disp inc	Std Fam disp inc	Sw parent	School-age Pop	Voucher proxy	Left	Costs premises	Mun school density	Priv school density
GPA	1.0000										
High educ parent	0.5385	1.0000									
Fam disp inc	0.4794	0.7434	1.0000								
Std Fam disp inc	0.1628	0.3512	0.6051	1.0000							
Sw parent	-0.0454	-0.1449	-0.1726	-0.0435	1.0000						
School-age Pop	0.1584	0.4118	0.2174	0.2491	-0.3385	1.0000					
Voucher proxy	0.1573	-0.0104	-0.0068	-0.0404	-0.0876	-0.0228	1.0000				
Left	-0.1311	-0.2020	-0.1677	-0.1507	-0.0049	-0.1115	0.3428	1.0000			
Costs premises	0.2333	0.1834	0.1170	0.0272	-0.1460	0.0924	0.8012	0.1862	1.0000		
Mun sch density	0.1277	0.4013	0.1673	0.2494	-0.2413	0.9551	0.0141	-0.0540	0.1139	1.0000	
Indep sch density	0.1001	0.2304	0.1265	0.2041	-0.2360	0.8635	0.0567	-0.0981	0.1227	0.7758	1.0000

[a] Costs for premises and voucher level measured in 1992 due to lack of data for year 1991.

Table A4a: Logit coefficients, Outcome period 1992-2000, Student variables: ≤ 3km, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

Variables	Odds ratios Logit	Odds ratios FirthLogit	St.Dev. Logit Non-clustered	St.Dev. FirthLogit Non-clustered	St.Dev. Logit Cluster municip	St.Dev. Conley Logit	P-value Logit Non-clustered	P-value FirthLogit Non-clustered	P-value Logit Cluster municip	P-value Conley Logit
GPA	-1.0133	-1.0215	0.4554	0.4564	0.4334	0.3832	0.0261	0.0252	0.0194	0.0082
High educ parent	5.2149	5.1960	0.6084	0.6096	0.5681	0.5187	0.0000	0.0000	0.0000	0.0000
Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4515	0.4693	0.6527	0.5564
Std Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0044	0.0035	0.0224	0.0118
Sw parent	-4.3966	-4.4261	0.8598	0.8576	0.7771	0.9797	0.0000	0.0000	0.0000	0.0000
School-age Pop	0.0015	0.0015	0.0002	0.0002	0.0004	0.0003	0.0000	0.0000	0.0000	0.0000
Voucher proxy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.8178	0.7773	0.8703	0.8593
Left	-1.1668	-1.1379	0.2875	0.2830	0.2417	0.3287	0.0000	0.0001	0.0000	0.0004
Costs premises	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.5902	0.5787	0.7014	0.7081
Mun sch density	-0.0125	-0.0124	0.0082	0.0082	0.0105	0.0119	0.1284	0.1282	0.2333	0.2957
Indep sch density	-0.0465	-0.0464	0.0323	0.0322	0.0336	0.0420	0.1498	0.1500	0.1663	0.2683
GPA	-1.0133	-1.0215	0.4554	0.4564	0.4334	0.3832	0.0261	0.0252	0.0194	0.0082

Table A4b: Logit coefficients, Outcome period 1992-2000, Student variables: ≤ 1.5km, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

Variables	Odds ratios Logit	Odds ratios FirthLogit	St.Dev. Logit Non-clustered	St.Dev. FirthLogit Non-clustered	St.Dev. Logit Cluster municip	St.Dev. Conley Logit	P-value Logit Non-clustered	P-value FirthLogit Non-clustered	P-value Logit Cluster municip	P-value Conley Logit
GPA	-0.0544	-0.0628	0.1886	0.1893	0.1155	0.1089	0.7731	0.7400	0.6377	0.6176
High educ parent	2.1308	2.1095	0.3155	0.3148	0.2092	0.2457	0.0000	0.0000	0.0000	0.0000
Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.4061	0.5437	0.2997	0.3018
Std Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0026	0.0027	0.0128	0.0043
Sw parent	-2.2239	-2.2871	0.5065	0.5035	0.3550	0.4514	0.0000	0.0000	0.0000	0.0000
School-age Pop	0.0014	0.0014	0.0002	0.0002	0.0003	0.0002	0.0000	0.0000	0.0000	0.0000
Voucher proxy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7345	0.7076	0.8168	0.7943
Left	-1.2612	-1.2307	0.2853	0.2809	0.2381	0.3260	0.0000	0.0000	0.0000	0.0001
Costs premises	0.0000	0.0000	0.0000	0.0000	0.0001	0.0000	0.9943	0.9840	0.9961	0.9960
Mun sch density	-0.0027	-0.0029	0.0077	0.0077	0.0085	0.0108	0.7219	0.7079	0.7473	0.7991
Indep sch density	-0.0271	-0.0257	0.0293	0.0291	0.0416	0.0390	0.3548	0.3784	0.5151	0.4865

Table A4c: Logit coefficients, Outcome period 1992-2000, Student variables: 50 nearest students, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

Variables	Odds ratios Logit	Odds ratios FirthLogit	St.Dev. Logit Non-clustered	St.Dev. FirthLogit Non-clustered	St.Dev. Logit Cluster municip	St.Dev. Conley Logit	P-value Logit Non-clustered	P-value FirthLogit Non-clustered	P-value Logit cluster municip	P-value Conley Logit
GPA	0.0189	0.0198	0.4412	0.4408	0.5294	0.5399	0.9658	0.9642	0.9715	0.9720
High educ parent	4.0680	4.0551	0.4730	0.4722	0.5077	0.5538	0.0000	0.0000	0.0000	0.0000
Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0053	0.0054	0.0880	0.0868
Std Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0236	0.0151	0.1239	0.1024
Sw parent	-3.2070	-3.2249	0.6524	0.6509	0.9284	0.8990	0.0000	0.0000	0.0006	0.0004
School-age Pop	0.0014	0.0014	0.0002	0.0002	0.0003	0.0002	0.0000	0.0000	0.0000	0.0000
Voucher proxy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6775	0.6414	0.7849	0.7569
Left	-1.2915	-1.2627	0.2858	0.2814	0.2471	0.3282	0.0000	0.0000	0.0000	0.0001
Costs premises	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001	0.7677	0.7570	0.8404	0.8386
Mun sch density	-0.0040	-0.0037	0.0081	0.0080	0.0099	0.0115	0.6216	0.6480	0.6889	0.7292
Indep sch density	-0.0413	-0.0415	0.0308	0.0307	0.0333	0.0411	0.1801	0.1754	0.2154	0.3158

Table A4d: Logit coefficients, Outcome period 1992-2000, Student variables: 100 nearest students, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

Variables	Odds ratios Logit	Odds ratios FirthLogit	St.Dev. Logit Non-clustered	St.Dev. FirthLogit Non-clustered	St.Dev. Logit Cluster municip	St.Dev. Conley Logit	P-value Logit Non-clustered	P-value FirthLogit Non-clustered	P-value Logit Cluster municip	P-value Conley Logit
GPA	-0.0155	-0.0153	0.5619	0.5613	0.7178	0.6760	0.9780	0.9782	0.9827	0.9817
High educ parent	4.4718	4.4628	0.5576	0.5566	0.5843	0.6698	0.0000	0.0000	0.0000	0.0000
Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1715	0.1738	0.3635	0.3539
Std Fam disp inc	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.1440	0.1173	0.1645	0.2359
Sw parent	-4.1176	-4.1391	0.6972	0.6954	0.8108	0.8883	0.0000	0.0000	0.0000	0.0000
School-age Pop	0.0014	0.0014	0.0002	0.0002	0.0003	0.0002	0.0000	0.0000	0.0000	0.0000
Voucher proxy	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.7029	0.6665	0.7956	0.7737
Left	-1.2209	-1.1922	0.2866	0.2822	0.2427	0.3284	0.0000	0.0000	0.0000	0.0002
Costs premises	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.6264	0.6177	0.7288	0.7342
Mun sch density	-0.0083	-0.0080	0.0082	0.0081	0.0105	0.0118	0.3107	0.3256	0.4324	0.4842
Indep sch density	-0.0283	-0.0285	0.0308	0.0306	0.0337	0.0412	0.3583	0.3526	0.4017	0.4929

Table A5: Different outcome periods. Average marginal effects: Elastiticites. Population density ≤ 3km, School density ≤ 6km. 1km*1km grid.

	Outcome 1992-95 (and base year=1991)				Outcome 1992-2005 (and base year=1991)				Outcome 1996-2000 and base year=1995			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Outcome variable:	dS2000	dS2000	dS2000	dS2000	dS2000	dS2000	dS2000	dS2000	dS2000	dS2000	dS2000	dS2000
Specification student variables:	≤ 3km	≤ 1.5km	50 nearest	100 nearest	≤ 3km	≤ 1.5km	50 nearest	100 nearest	≤ 3km	≤ 1.5km	50 nearest	100 nearest
GPA	-2.724	0.100	0.898	1.475	-2.662**	-0.142	-1.483	0.699	-2.379	-0.439	-1.783	-1.854
	(1.848)	(0.476)	(2.336)	(2.998)	(1.171)	(0.301)	(1.408)	(2.091)	(1.563)	(0.507)	(1.986)	(2.742)
High educ parent	2.016***	0.776***	1.589***	1.562***	1.658***	0.666***	1.373***	1.394***	1.666***	0.843***	1.454***	1.763***
	(0.245)	(0.0948)	(0.200)	(0.230)	(0.176)	(0.0599)	(0.128)	(0.161)	(0.269)	(0.103)	(0.231)	(0.289)
Fam disp inc	-0.558	-0.701*	-2.535**	-0.995	-0.455	-0.249	-1.572*	-1.005	-0.544	-0.727*	-1.162	-1.824**
	(1.299)	(0.421)	(1.002)	(0.949)	(1.029)	(0.290)	(0.828)	(0.865)	(1.137)	(0.417)	(0.939)	(0.901)
Std Fam disp inc	0.158*	0.163***	0.207***	0.104	0.134***	0.102**	0.152***	0.0992*	0.144*	0.160***	0.0996	0.171***
	(0.0882)	(0.0296)	(0.0763)	(0.0794)	(0.0510)	(0.0407)	(0.0578)	(0.0513)	(0.0737)	(0.0567)	(0.0666)	(0.0620)
Sw parent	-6.016***	-2.727***	-3.710***	-5.040***	-3.855***	-2.073***	-2.845***	-3.937***	-1.250	-1.430***	-1.835*	-1.714*
	(1.050)	(0.461)	(1.174)	(1.103)	(0.814)	(0.320)	(0.679)	(0.674)	(1.076)	(0.549)	(1.034)	(0.978)
School-age Pop	0.219***	0.243***	0.209***	0.206***	0.296***	0.315***	0.275***	0.275***	0.260***	0.269***	0.239***	0.243***
	(0.0704)	(0.0689)	(0.0580)	(0.0618)	(0.0676)	(0.0672)	(0.0596)	(0.0614)	(0.0488)	(0.0411)	(0.0353)	(0.0366)
Voucher proxy	-0.752	-0.262	-0.328	-0.529	-0.733	-0.305	-0.558	-0.592	-2.965	-2.714	-2.535	-2.697
	(2.347)	(2.365)	(2.408)	(2.337)	(1.606)	(1.596)	(1.674)	(1.657)	(1.978)	(1.913)	(1.856)	(1.931)
Left	-0.112	-0.137*	-0.153*	-0.133*	-0.154***	-0.173***	-0.184***	-0.170***	-0.0971	-0.138	-0.178	-0.159
	(0.0799)	(0.0771)	(0.0826)	(0.0807)	(0.0540)	(0.0511)	(0.0546)	(0.0533)	(0.141)	(0.142)	(0.138)	(0.139)
Costs premises	-0.541	-0.351	-0.382	-0.464	-0.215	-0.0996	-0.111	-0.180	0.196	0.392	0.230	0.196
	(1.032)	(1.099)	(1.098)	(1.038)	(0.652)	(0.649)	(0.657)	(0.635)	(0.610)	(0.627)	(0.609)	(0.623)
Mun sch density	-0.0584	0.0243	0.00363	-0.0219	-0.105	-0.0535	-0.0524	-0.0773	-0.000946	0.0172	-0.0129	-0.0128
	(0.100)	(0.0893)	(0.0910)	(0.0974)	(0.0681)	(0.0630)	(0.0625)	(0.0649)	(0.0680)	(0.0538)	(0.0551)	(0.0536)
Indep sch density	-0.00879	-0.0106	-0.0102*	-0.00643	-0.00173	0.000931	-0.00139	0.000666	-0.0193**	-0.00958	-0.00678	-0.0118
	(0.00541)	(0.00652)	(0.00601)	(0.00541)	(0.00442)	(0.00588)	(0.00476)	(0.00453)	(0.00917)	(0.0117)	(0.00759)	(0.00764)
Observations	50,325	37,875	50,292	50,304	50,325	37,875	50,292	50,304	54,381	40,744	54,385	54,461
Specification	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies	No added dummies
Estimator	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit	Logit
Log-likelihood	-963.2	-944.7	-975.2	-975.2	-2354	-2304	-2376	-2370	-1093	-1061	-1098	-1093

Standard errors clustered on municipality in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A6: Average marginal effects: Elasticities, Outcome period 1992-2000. Population density ≤ 3km, School density ≤ 6km. 0.5km*0.5km grid.

	(1)	(2)	(3)	(4)
Outcome variable:	dS2000	dS2000	dS2000	dS2000
Specification student variables:	≤ 3km	≤ 1.5km	50 nearest	100 nearest
GPA	-2.574*	0.306	0.875	2.110
	(1.338)	(0.353)	(1.826)	(2.612)
High educ parent	1.799***	0.746***	1.433***	1.616***
	(0.173)	(0.0742)	(0.150)	(0.188)
Fam disp inc	-0.538	-0.0976	-1.540**	-1.051
	(1.031)	(0.188)	(0.663)	(0.778)
Std Fam disp inc	0.142**	0.0742**	0.112*	0.0600
	(0.0669)	(0.0343)	(0.0575)	(0.0609)
Sw parent	-4.519***	-2.067***	-3.474***	-4.604***
	(0.853)	(0.328)	(0.739)	(0.862)
School-age Pop	0.232***	0.262***	0.224***	0.222***
	(0.0507)	(0.0530)	(0.0422)	(0.0445)
Voucher proxy	-0.837	-0.245	-0.372	-0.372
	(1.652)	(1.638)	(1.713)	(1.699)
Left	-0.193***	-0.210***	-0.225***	-0.207***
	(0.0648)	(0.0611)	(0.0658)	(0.0646)
Costs premises	-0.0117	0.0713	0.0238	-0.0733
	(0.675)	(0.688)	(0.693)	(0.666)
Mun sch density	-0.0527	0.00226	-0.0204	-0.0472
	(0.0575)	(0.0543)	(0.0527)	(0.0546)
Indep sch density	-0.0109**	-0.0103	-0.00948*	-0.00793*
	(0.00462)	(0.00696)	(0.00539)	(0.00482)
Observations	202,035	152,181	201,908	201,954
Specification	No added dummies	No added dummies	No added dummies	No added dummies
Estimator	Logit	Logit	Logit	Logit
Log-likelihood	-2413	-2371	-2426	-2412

Standard errors, clustered on municipality in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A7: Average marginal effects: Elasticities, Outcome period 1992-2000. Population density ≤ 1.5km, School density ≤3km. 1km*1km grid.

	(1)	(2)	(3)	(4)
Outcome variable:	dS2000	dS2000	dS2000	dS2000
Specification student variables:	≤ 3km	≤ 1.5km	50 nearest	100 nearest
GPA	-3.567**	-0.000150	-0.0809	0.619
	(1.447)	(0.426)	(1.781)	(2.846)
High educ parent	1.596***	0.752***	1.312***	1.356***
	(0.180)	(0.0822)	(0.171)	(0.214)
Fam disp inc	0.194	0.0604	-1.437*	-0.714
	(0.917)	(0.248)	(0.870)	(0.903)
Std Fam disp inc	0.0825	0.0636	0.116*	0.0651
	(0.0563)	(0.0485)	(0.0634)	(0.0543)
Sw parent	-3.152***	-1.550***	-2.200**	-2.641***
	(1.005)	(0.499)	(0.909)	(0.877)
School-age Pop	0.165***	0.210***	0.162***	0.163***
	(0.0291)	(0.0391)	(0.0314)	(0.0299)
Voucher proxy	-1.596	-1.304	-1.266	-1.317
	(1.889)	(1.851)	(1.894)	(1.930)
Left	-0.167**	-0.188***	-0.204***	-0.188***
	(0.0676)	(0.0635)	(0.0688)	(0.0685)
Costs premises	-0.173	0.0961	0.0559	-0.0515
	(0.658)	(0.654)	(0.652)	(0.656)
Mun sch density	0.0898***	0.118***	0.0950***	0.0939***
	(0.0308)	(0.0357)	(0.0315)	(0.0320)
Indep sch density	-0.00407	-0.00300	-0.00300	-0.00337
	(0.00273)	(0.00383)	(0.00275)	(0.00262)
Observations	50,325	37,875	50,292	50,304
Specification	No added dummies	No added dummies	No added dummies	No added dummies
Estimator	Logit	Logit	Logit	Logit
Log-likelihood	-1738	-1704	-1754	-1751

Standard errors, clustered on municipality in parentheses, *** p<0.01, ** p<0.05, * p<0.1

Table A8: Municipality type dummies, and using only Stockholm County. Average marginal effects: Elasticities, Outcome period 1992-2000, Population density ≤ 3km, School density ≤ 6km. 1km*1km grid

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Outcome variable	dS2000	dS2000	dS2000	dS2000	dS2000	nrS2000	dS2000	nrS2000
Specification student variables:	≤ 3km	≤ 1.5km	50 nearest	100 nearest	SAMS	SAMS	Municip	Municip
GPA	-2.745*	-0.0665	0.0466	0.173	1.457	1.655**	2.693	5.923**
	(1.449)	(0.414)	(1.520)	(2.444)	(2.977)	(0.819)	(2.250)	(2.981)
High educ parent	1.649***	0.617***	1.373***	1.486***	2.090***	0.707***	1.742***	1.771***
	(0.210)	(0.0700)	(0.194)	(0.253)	(0.780)	(0.171)	(0.399)	(0.607)
Fam disp inc	-1.652	-0.561	-2.827***	-2.242**	-1.823	-0.106	-2.946**	-2.492**
	(1.267)	(0.347)	(0.915)	(0.966)	(1.983)	(0.621)	(1.208)	(1.069)
Std Fam disp inc	0.196***	0.121***	0.205***	0.160***	0.245*	0.0893	0.214*	0.207**
	(0.0654)	(0.0467)	(0.0667)	(0.0557)	(0.138)	(0.119)	(0.119)	(0.0814)
Sw parent	-2.841***	-1.659***	-1.897**	-2.481***	-2.086	-1.173***	-1.072	-2.257
	(1.004)	(0.345)	(0.957)	(0.816)	(1.528)	(0.416)	(1.625)	(1.435)
School-age Pop	0.288***	0.314***	0.277***	0.274***	0.651***	0.669***	0.580***	0.589***
	(0.0687)	(0.0720)	(0.0572)	(0.0600)	(0.131)	(0.136)	(0.102)	(0.112)
Voucher proxy	-0.711	-0.0558	-0.188	-0.357	-0.809	-0.345	-0.158	-0.954
	(1.581)	(1.579)	(1.633)	(1.641)	(2.687)	(2.386)	(2.583)	(2.412)
Left	-0.145**	-0.161***	-0.161**	-0.153**	-	-	-	-
	(0.0623)	(0.0546)	(0.0629)	(0.0628)				
Costs premises	-0.104	-0.123	-0.141	-0.138	-0.0777	0.0182	-0.275	-0.106
	(0.635)	(0.637)	(0.637)	(0.625)	(0.763)	(0.761)	(0.690)	(0.660)
Mun sch density	-0.113	-0.0851	-0.0900	-0.0968	-0.412*	-0.362*	-0.296*	-0.349*
	(0.0746)	(0.0707)	(0.0696)	(0.0710)	(0.222)	(0.190)	(0.179)	(0.202)
Indep sch density	-0.00524	0.000365	-0.00346	-0.00264	-0.0127	0.0556	0.00334	0.00844
	(0.00402)	(0.00519)	(0.00418)	(0.00404)	(0.0462)	(0.0348)	(0.0325)	(0.0321)
Observations	50,325	37,875	50,292	50,304	3,919	3,211	3,919	3,919
Specification	Mun type dummies	Mun type dummies	Mun type dummies	Mun type dummies	Stockholm county	Stockholm county	Stockholm county	Stockholm county
Estimator	Logit	Logit	Logit	Logit	Logit	Poisson	Logit	Poisson
Log-likelihood	-1915 – -2333	-1915 – -2263	-1915 – -2327	-1915– -2323	-705.9 – -743.1	-849 – -891.4	-152.7 – -192.4	-470.6 – -710.6

Standard errors are clustered on municipality in parentheses, except for the SAMS level regressions, where standard errors are clustered on the SAMS level.
*** p<0.01, ** p<0.05, * p<0.1