Competition in the public school sector: evidence on strategic interaction among US school districts

Johannes Rincke

Centre for European Economic Research and Department of Economics, University of Mannheim, P.O. Box 10 34 43, D-68034 Mannheim (Germany), phone: +49 621 1235 217, fax: +49 621 1235 223, email: rincke@zew.de

Paper in revised version, forthcoming in *Journal of Urban Economics*.

Abstract

This paper provides evidence on strategic interaction among local school districts. The analysis makes use of a significant change in the institutional environment for school districts in Michigan in 1996, when the state established a voluntary inter-district choice program. The school districts' participation decisions are modelled as discrete choice decisions using a spatial latent variable model. Strong effects are found saying that lagged adoptions of neighbors positively affect the current probability of participation. A simple test exploiting limitations of student mobility in inter-district transfers suggests that the driving force for interdependencies among adoption decisions was competition for students.

Keywords: Strategic interaction, school districts, school choice, spatial probit

JEL Classification: D78, H77

---

1 Introduction

An ongoing debate revolves around the effects of competition on public school performance. Given that public schools cannot engage in price competition, the question which is typically asked is how a marginal increase in the degree of competition affects the academic achievement of students and the efficiency of public schooling. This is justified by the fact that student achievement and the efficiency of service provision are the key variables students, parents and taxpayers are interested in. However, looking at the correlation between output variables and competition measures does not reveal much about how the public school sector is reacting to the forces of competition. Consider an example with metropolitan areas, some of which have stronger competition among public schools in the sense that they are divided into more school districts.[1] With more school districts, it is easier for households to sort themselves according to preferences for public schooling, property and amenities. In general, to the extent that stronger sorting will increase the match quality between students and schools, competition will benefit average student achievement. Hence, even if the behavior of public schools and school districts as schooling producers given their student body is unaffected by the degree of competition, stronger competition may nevertheless lead to better outcomes. Of course, for thinking about and assessing reforms towards increased parental choice, a better understanding of the channels through which competition affects the relevant outcomes of public schooling is crucial. Most importantly, we need more insight into the behavior of public schools facing increased competition from other public and private schools.

This paper takes a straightforward approach and examines the effect of increased competition in the public school sector on the behavior of local school districts. In particular, I ask whether public schools really compete for students and resources. For answering this question, I make use of a significant change in the institutional environment of the public school sector in Michigan in 1996, when a voluntary inter-district choice program was established. Under this program, students were given the right to enroll at public schools outside their district of residence. Local school districts would not be forced to accept non-resident students, but districts participating in the choice program and allowing for the enrollment of transfer students would receive additional state funds depending on the number of non-resident students enrolled. The analysis focusses on the districts' participation decisions in the second year of the program. It exploits the variation in the degree of competition for non-resident students which resulted from the initial participation decisions of all districts, and asks how competition affected the districts' readiness to experiment with the new policy. The results suggest that the school districts did use participation in the inter-district choice program to actively engage in competition for students and resources. Facing increased risk of losing students and resources, the school districts seem to have flexibly reacted to competition from neighboring districts. They did this by 'striking back', i.e. they were more likely to compete for non-resident students if neighboring districts did so. The results also suggest that the impact of neighbors' decisions on the participation probability was substantial, and that competition for students

[1] This is how Hoxby [24] measures competition among public schools.

contributed significantly to the share of districts allowing for inter-district transfers increasing from 37% in 1996/97 to more than 70% in 2002/03.

The present paper adds to the existing literature in explicitly addressing the reactions of schooling producers to increased competition. There is only a limited number of studies that have done so before. Vedder and Hall [36] and Hoxby [24] find evidence that public schools react to greater competition from private schools by paying higher teacher salaries. Evidence suggesting that competition enhances the work effort of teachers is presented by Rapp [30]. Finally, Hoxby [22] shows that increased competition among public schools reduces per-pupil spending and makes school districts allocate resources away from other inputs towards reducing the student-teacher ratio.

In contrast to the limited number of papers on the effects of competition on schooling producers' behavior and policies, an extensive literature has addressed the effects of competition on the performance of public schools and on student achievement. While the theoretical predictions are unclear,[2] the empirical findings suggest that the overall effects of competition are positive. Hoxby [22],[21] shows that competition working through residential choices as well as competition provided by recent choice reforms such as vouchers and charter schools positively affects student achievement and school productivity. Sandström and Bergström [34] find that school results in Swedish public schools have improved due to competition from independent schools. Couch et al. [14] find competition by private schools to positively affect public school performance.[3] Dee [15] and Hoxby [24] also address the question whether the achievement of students in pubic schools is improved when the proportion of students attending private schools is higher. Both studies conclude that the competition from private schools has a significant positive effect on the quality of public schools. Grosskopf et al. [19] find that stronger competition in terms of a lower market share of the biggest schooling producers reduces allocative inefficiencies in some communities.

Apart from being linked to the literature on the effects of competition on schooling producers the present study is also closely related to the vast and growing literature on strategic interaction among jurisdictions surveyed by Brueckner [9] and Revelli [33]. Most contributions in this literature have focussed on strategic interaction in tax rates (e.g, see Besley and Case [4], Brett and Pinkse [7], Hayashi and Boadway [20], Büttner [10], Brueckner and Saavedra [11], Bordignon et al. [6], and Egger et al. [16]) and expenditures (e.g, see Case et al. [13], Baicker [2] and Revelli [32]). Interaction in non-fiscal

[2]Hoxby [23], for instance, offers a principal-agent model of the productivity of schooling producers, showing that a system with property tax finance and Tiebout choice among many jurisdictions reduces rent taken by producers. Epple and Romano [17] show that low-ability students may be adversely affected by school choice due to peer-group effects.

[3]The robustness of the results of Couch et al. [14] has been questioned by Newmark [28].

policy instruments has been addressed by Brueckner [8], dealing with growth controls in California cities, and in a study on environmental policies of the US states by Fredriksson et Millimet [18].

The paper proceeds as follows. In the next section, the Michigan inter-district school choice program and potential factors affecting policy preferences of districts are described. Section 3 deals with the estimation approach. In section 4, the data and the estimation results are presented and discussed, and section 5 concludes.

2 Inter-district school choice in Michigan

Inter-district school choice allows students to attend a public school in a school district other than the district of residence. In the US, some states have enacted mandatory choice laws. In these states, school districts are, under certain conditions, obliged to enroll non-resident students at local public schools. In contrast to this, participation of school districts in Michigan and several other states is voluntary. While school districts cannot prevent resident students from choosing a school outside the district, they can prevent the transfer of non-resident students to local schools. For each school year, a school district in Michigan has to determine whether or not it will accept applications for enrollment by non-resident students. That is, the districts' decisions whether or not to participate in the program are not made once-and-for-all, but can be adjusted for each commencing school year. Moreover, the number of positions available may be specified. Michigan's inter-district public school choice program has been launched by a state law enacted in 1996.[4] Under the new law, districts were free to enroll any applicant in the district's schools provided that the student's home district belongs to the same regional educational service agency. In Michigan, regional educational service agencies are called Intermediate School Districts (ISDs). ISDs originally were created to provide local school districts with services and programs too expensive or too extensive to be offered by districts individually. In 1997, Michigan had 554 school districts and 57 ISDs.

It is important to notice that in its school finance scheme Michigan had shifted from a system relying primarily on local property taxes to a scheme with a per-student state guarantee financed essentially by an increase in the state's sale taxes rate in 1994. The reform markedly increased the degree of centralization in Michigan's school finance scheme. In 1992/93, local revenues on average

[4] For details see Michigan Compiled Laws, Section 388.1705 (Act 300, 1996).

contributed 65 cents to each dollar of total revenues, while 31 cents came from state funds. By 1997/98, the share of local revenues had dropped to 28% and the proportion of state revenues had soared to 68%. The minimum school foundation allowance going from the state to local school districts was \$ 4,200 per student for the school year 1994/95 and had increased to \$ 5,124 per student for the school year 1997/98.[5] Districts losing students under the school choice regime would thus immediately suffer a significant decrease in revenues. At the same time, the school choice program offered districts the chance to attract students from elsewhere and thereby to raise their revenues.

School districts attracting students from other districts do not only receive additional state funds, but also face an increase in costs. In general, districts will consider to enroll non-resident students only if per-student state aid is at least as high as the costs to serve an additional student. For many school districts, this condition will not hold. This, however, does not preclude that there are strong incentives for many school districts to make use of inter-district school choice. Suppose, for instance, that the districts have perfectly adjusted their capacity to the number of resident students, but that some districts, given their physical capital such as school buildings and the number of teachers employed, operate somewhat below their capacity limit in terms of student enrollment. For these school districts, luring non-resident students to local schools makes good sense, since the cost of serving some additional students will be modest. Of course, the competition for students and state funds is a zero-sum game, so if some districts stand to gain students and funds, others stand to lose. Since adjusting capacity is costly or, for small changes in enrollment, even impossible, districts that lose students now face incentives to participate in inter-district choice in order to fully exploit their capacity. Again, other districts will be affected, and so forth. The bottom line is that even if the initial situation is one with only a minority of districts benefitting from inter-district transfers, student mobility across district borders will ultimately provide many districts with incentives to compete for non-resident students. It should be noted, however, that the fiscal incentive to attract or retain students is mitigated by the capitalization effects of inter-district school choice and the corresponding effect on property tax revenues. As Reback [31] has shown for inter-district choice in Minnesota, residential property values appreciate in districts where students are able to transfer to preferred schools outside the district and decline in districts that accept transfer students.

The school districts' attitude toward school choice might also be affected by factors other than capacity and revenues. In the following, the variables included as controls in the empirical specifications are briefly discussed. First of all, the districts' preferences may vary with size. Bigger districts are more

[5]For details on the school finance reform in Michigan, see Michigan Department of Treasury [27].

closed, so open enrollment may be a less relevant policy for them. Smaller district may also show a stronger tendency to welcome transfer students due to economies of scale, and they may be more flexible in adjusting to the opportunities provided by the new state law. Another important factor influencing the propensity to participate in open enrollment might be the quality of local public schools in terms of educational achievement. Districts with better schools are more likely to be able to attract non-resident students and should therefore be more inclined towards school choice than districts with worse schools. On the other hand, districts with worse schools will see more students leaving, and the incentives to compensate for the loss in revenues may be stronger. With regard to some characteristics, a district's position relative to its immediate neighbors may be relevant. The point is that, due to transportation to more distant schools being either unavailable or prohibitively costly, school districts will be able to attract students only from nearby districts. A district's relative attractiveness for potential transfer students and the average characteristics of non-resident students whose application is anticipated will therefore depend on a district's characteristics relative to its neighbors. To capture this, I construct two additional control variables. The first one describes a districts' relative position with respect to the share of minority students. This variable is conveniently defined as the difference between the district's own share of minority students and the mean of this share for all contiguous districts within the ISD,[6] weighted by district population. The relative position with regard to the districts' median housing value is constructed in the same way. This variable is meant to capture the potential capitalization effects of inter-district school choice. Districts with property values well above those of neighboring districts may be particularly hesitant to participate given the potential of inter-district choice to diminish property value differentials which reflect differences in school quality.

Based on the preceding discussion, I include as control variables in the empirical specification enrollment as a measure for the districts' size; the student-teacher ratio, measuring the capacity for enrollment of transfer students; total revenues per student as a measure for fiscal stress; the average percentage of 7^{th} graders performing satisfactorily in reading and math; the difference between own and neighbors' share of minority students; and the difference between own and neighbors' median housing value.

[6]Recall that participating districts did only accept applications from students residing within the same ISD.

3 A spatial discrete choice model of participation in school choice

As mentioned above, the Michigan open enrollment law requires a school district in each year to announce whether in the following school year it will admit non-resident students at local schools. This is a discrete choice decision problem which is captured in an econometric model using a simple latent variable framework. Suppose that the observable policy decision y_{it} is related to the latent predisposition towards the adoption of open enrollment, y^*_{it}, according to

$$y_{it} = 1[y^*_{it} > 0], \qquad i = 1, \ldots, N \tag{1}$$

where $1[\cdot]$ is the indicator function. Suppose furthermore that district i's predisposition towards the adoption of open enrollment in period t is a function of lagged adoption decisions of other districts $\{y_{j,\,t-1}\}_{j\neq i}^{N}$, i's lagged own decision $y_{i,\,t-1}$ and a vector of exogenous characteristics x_{it} where the first element is unity. A linear specification for the latent variable would then be

$$\begin{aligned} y^*_{it} &= z_{it}\delta + u_{it} \\ &= \phi \sum_{j\neq i}^{N} \omega_{ij}\, y_{j,\,t-1} + \lambda\, y_{i,\,t-1} + x_{it}\beta + u_{it}, \end{aligned} \tag{2}$$

where ω_{ij} is the weight assigned to district j by district i, ϕ, λ and β represent (vectors of) coefficients and u_{it} is a well-behaved idiosyncratic error with variance σ^2_u and distributed symmetrically about zero. The inclusion of $y_{i,\,t-1}$ accounts for inertia in the policy process by which the districts' participation decision is determined. The conditional probability that district i adopts open enrollment policies is

$$\Pr\left(y_{it} = 1 \,|\, \{y_{j,\,t-1}\}_{j=1}^{N}, x_{it}\right) = \Pr\left(y^*_{it} > 0 \,|\, \{y_{j,\,t-1}\}_{j=1}^{N}, x_{it}\right). \tag{3}$$

With an appropriate assumption on the distribution of u, the composite parameters ϕ/σ_u, λ/σ_u and β/σ_u are identified and average partial effects can be estimated using standard maximum likelihood techniques. Of course, the parameter of primary interest in this specification is ϕ. A non-zero value of ϕ would imply that the attitude towards the adoption of open enrollment in any given district depends on lagged adoption decisions in other districts.

With respect to the latent variable model displayed in eq. (2), a number of issues must be addressed. First of all, the question arises why strategic interaction among districts should take the specific form assumed here. When addressing spatial effects in limited dependent variable models, the literature has mostly relied on a spatial auto-regressive probit with contemporaneous interaction in latent variables.[7] In the context of this study, the structural equation for a spatial auto-regressive probit would be

$$y_{it}^{*} = \phi \sum_{j \neq i}^{N} \omega_{ij}\, y_{j,t}^{*} + \lambda\, y_{i,t-1} + x_{it}\beta + u_{it}. \tag{4}$$

There are a number of reasons making the model from eq. 2 an attractive choice compared to the spatial auto-regressive framework in eq. 4. First of all, the school districts' participation decision is the result of a complex political process, and it seems reasonable to account for a certain time lag when the districts adjust their behavior to decisions in neighboring districts. In contrast to this, the underlying idea for using the structural equation 4 is that the districts would adjust their behavior to decisions they expect to see elsewhere. Note, however, that the latent variables are jointly determined for all units of observation. Therefore, in the spatial-autoregressive model the linear combination of neighbors' predispositions appearing on the right hand side is endogenously determined. Although maximum likelihood estimation of the parameters is feasible based on a reduced form of eq. 4, the procedure is computationally involved. Another drawback of the spatial auto-regressive model lies in the difficulty to give the interaction coefficient a clear interpretation. Since in eq. 4 the interaction coefficient is related to a function of latent variables, no partial effect can be computed to assess the strength of neighbors' impact on i's actual decision. Obviously, the model with neighbors' lagged decisions appearing on the right hand side avoids the simultaneity issue.[8] The structural equation 2 is a particularly attractive choice in applications where lagged decisions are good predictors of actual predispositions. As we will see, this is the case here. It is also worth noting that the model with neighbors' lagged decisions does not put any restriction on the size of the interaction coefficient.[9] However, as in most probit or logit estimates the parameter estimates and the estimate for the variance of the error are not separately identified anyway. Case [12] discusses the issue in a related context.

A second issue is the potential presence of spatial error correlation. Consider an example with two regions A and B, where districts in A are more inclined towards school choice than districts in B due to some common time-invariant unobserved characteristic. With the diffusion rate being higher in A than in B, the specification in eq. 2 would erroneously attribute the effect of the un-

[7] For general treatments see McMillen [26] and Beron and Vijverberg [3]. An application to technology adoption behavior is given in Case [12].

[8] Other studies relying on time lags to identify spatial interactions include Hayashi and Boadway [20] and Fredriksson and Millimet [18].

[9] In spatial auto-regressive models, the interaction coefficient is restricted to be less than one in absolute value.

observed characteristic to neighbors' past decisions. Hence, accounting for the potential presence of spatially correlated components in the errors is crucial.

In this paper, spatial error correlation is taken into account in a simple but straightforward way. The approach takes the example of unobserved region-specific effects literally and includes in eq. 2 a number of dummy variables for regions. Of course, for the approach to make sense these regions have to be defined in a meaningful way. With regard to the Michigan school districts, the natural way to proceed is to define regions according to Intermediate School Districts as regional educational service agencies. ISDs are higher level authorities in the federal educational system of Michigan, and the vertical impact of ISD policies on local school districts may well lead to spatial correlation in the school districts' behavior towards open enrollment. Suppose, for instance, that ISDs engage in policy coordination among affiliated districts,[10] or that ISD officials have certain preferences towards inter-district school choice and try to affect policies at the local level accordingly. The dummy variables will take account of any such region-specific effect on district policies and thereby help to remove spatial correlation from the errors. A test for the presence of spatial error correlation in a model without interaction among districts is used to make sure that the approach works. Suppose that the residuals follow a spatial auto-regressive process,

$$u_{it} = \rho \sum_{j \neq i}^{N} \omega_{ij} \, u_{j,t} + \epsilon_{it}, \tag{5}$$

where $\epsilon \sim N(0, I_N)$. Since y^*_{it} is a latent variable, the ordinary residuals, $\hat{u}_{it} = y^*_{it} - z_{it}\hat{\delta}$, are not observed. The null hypothesis of spatial independence ($\rho = 0$) is therefore tested based on generalized residuals using the Lagrange-multiplier (LM) test for probit models proposed by Pinkse and Slade [29]. Running the test on generalized residuals from a standard probit and a probit including ISD dummies will reveal to which extent the inclusion of ISD dummies removes spatially correlated components from the residuals.

Since eq. 2 has $y_{i,t-1}$ as an explanatory variable, a potential problem could also arise from serial correlation in u. Unfortunately, the absence of serial correlation cannot be tested based on a single cross-section of observations. Instrumenting the potentially endogenous lagged decision would allow to circumvent this problem. Apart from the fact that the standard approach of instrumenting in a limited dependent variable framework does not cover the case of a binary endogenous explanatory variable, it is extremely difficult to

[10] Note that under Michigan law ISDs could run their own ISD-wide school choice programs. Local school districts in these ISDs would then be exempt from the provisions of the statewide program. See Michigan Compiled Laws, Section 388.1705b (effective since June 1997).

find valid instruments for a lagged dependent variable. In the light of these difficulties, I use a different approach to check whether the findings on district interactions are affected by serial correlation in the residuals. Taking advantage of data on the districts' school choice policies from 1999 to 2002, I estimate a probit for the 2002 cross-section with lagged own decisions from the previous three years and a full set of ISD-dummies as explanatory variables. With three lags included, the model is likely to account for any unobserved heterogeneity which might cause the errors in eq. 2 to be serially correlated. Comparing the results from the original model and the model with additional lags included will then provide evidence on the robustness of the interaction coefficient.

A further issue is the choice of the weights ω_{ij}. In general, it is difficult to define appropriate weights since no general criterion for discriminating between alternative definitions is available. In the present case, however, things should be less complicated than in many other applications. Note firstly that students in 1997 could only transfer to districts within the same ISD. Hence, policies of districts outside the ISD should not have affected participation decisions. Consequently, the weights should select as neighbors only districts within the ISD. Secondly, given the costs associated with being enrolled at a school which is far away from a place of residence, competition for students should in most cases take place among adjacent districts. Hence, the row-standardized spatial weights are defined as

$$\omega_{ij} = \frac{d_{ij}}{\sum\limits_{j \neq i}^{N} d_{ij}} \quad \text{if } i \neq j \quad \text{and} \quad \omega_{ij} = 0 \quad \text{if } i = j,$$

where d_{ij} is an indicator taking value 1 if j belongs to the same ISD and is adjacent to i, and zero otherwise.[11]

A final point in the discussion of the estimation approach relates to the possibility that the districts' response to lagged decisions of neighbors systematically differs between certain groups of districts. A natural asymmetry to explore is the one between adopters (districts which adopted school choice in $t-1$) and non-adopters. More specifically, I also estimate a model where

[11] I also experimented with a number of other metrics where, for instance, I adjusted the weights according to the size of neighbors measured by enrollment or population. The results were very similar to those obtained with the weights described here.

neighbors' policies are interacted with $y_{i,t-1}$,

$$\begin{aligned} y^*_{it} &= \phi_1\, y_{i,t-1} \sum_{j\neq i}^{N} \omega_{ij}\, y_{j,t-1} \\ &+ \phi_2\,(1-y_{i,t-1}) \sum_{j\neq i}^{N} \omega_{ij}\, y_{j,t-1} + \lambda\, y_{i,t-1} + x_{it}\beta + u_{it}. \end{aligned} \tag{6}$$

For districts which have adopted open enrollment in $t-1$ the second term on the right hand side of eq. (6) equals zero. Hence, ϕ_1 measures the extent to which neighbors' lagged decisions affect current policies. If open enrollment has not been adopted in $t-1$, the first term equals zero, and ϕ_2 measures the neighborhood influence on current policies. A difference between ϕ_1 and ϕ_2 would indicate that it depends on lagged own decisions how districts are affected by policies in neighboring districts. Of course, other asymmetries in responses can be analyzed in a similar way.

4 Data, estimation and results

The empirical analysis is based on data on 521 Unified School Districts in Michigan.[12] The analysis focuses on the behavior of school districts in the first two years of the Michigan open enrollment program. Since indicators for lagged decisions are included in all specifications, the spatial interaction among districts is identified using the cross-section of districts from the second year of the program, 1997. Table 1 provides descriptive statistics on district participation in 1996 and 1997 both for the sample of 521 districts and a reduced sample of 338 districts which is used for estimations including ISD dummies.

In the first year, 192 out of 521 districts in the sample allowed for enrollment of non-resident students. In 1997, 60 districts joined and 16 districts left the program. With 236 open enrollment districts, the participation rate in 1997 was 45.3%. Table 2 provides descriptive statistics on district characteristics for 1997.[13]

[12] A minority of 30 Michigan school districts runs only elementary schools and is excluded from the sample. Furthermore, the concept of neighborliness used in this study is not applicable to two Unified School Districts which are islands. Detroit City School District served almost 165,000 students in 1997 (about 10% of all students in Michigan) and is

Table 1: District participation 1996-1997 - descriptive statistics

	Full sample		Reduced sample	
	Mean	S.D.	Mean	S.D.
Participation in 1997	.453	.498	.494	.501
Participation in 1996	.369	.483	.391	.489
Nob	521		338	

Table 2: School choice in 1997 - descriptive statistics (Nob=521)

District characteristics	Mean	S.D.	Min	Max
% neighbors participating in 1996[a]	.359	.392	.00	1.00
Enrollment[b]	2.80	3.30	.077	26.1
Student teacher ratio	14.9	1.91	7.29	19.7
Revenues per student[c]	7.21	1.26	5.35	14.7
% math/reading satisfactory grade 7[d]	.557	.130	.063	.896
Difference between own and neighbors' median housing value[e]	.010	.278	-1.41	1.98
Difference between own and neighbors' % minority students	-.038	.184	-.896	.752

[a] Neighbors defined as contiguous districts in own ISD; [b]in 1,000 students; [c]in 1,000 $; [d]defined as the sum of percentages of students in grade 7 with satisfactory proficiency in math and reading divided by two; [e]in 100,000 $.

The data on district participation are from Arsen et al. [1], p. 33. Data on enrollment, minority students, teachers, revenues, and math/reading proficiency are for the 1997/98 school year and have been obtained from the K-12 database of the Michigan Department of Education, Center for Educational Performance and Information (CEPI). The data were accessible via the web page of the Department at the time of writing. Data on the median value for specified owner-occupied housing units in 1999 are from the School District Demographic System of the National Center for Education Statistics (NCES).

The first step in the analysis is to run two baseline regressions where the potential impact of neighbors' lagged policies is ignored. The baseline regressions are meant as a first test whether the approach of estimating a discrete choice model for the adoption of open enrollment policies with the given set of control variables is meaningful at all. Furthermore, the baseline regressions will help us to address the issue of spatially correlated unobserved effects. Table 3 reports the results.

The first two columns display coefficients and average partial effects of a simple

excluded as an influential observation.

[13]The descriptive statistics for the reduced sample are very similar to those displayed in Table 2 and are omitted.

Table 3: School choice in 1997 - baseline probit estimations

Specification includes ISD-dummies	No		Yes	
	Coeff.	dP/dX	Coeff.	dP/dX
Participation in 1996	2.36 ***	.718	2.74 ***	.635
	(.164)		(.309)	
Enrollment	-.014	-.003	.026	.004
	(.026)		(.041)	
Student teacher ratio	-.182 ***	-.038	-.330 ***	-.053
	(.045)		(.086)	
Revenues per student	-.191 ***	-.040	-.354 ***	-.057
	(.066)		(.124)	
% math/reading satisfactory	1.34 **	.278	3.06 ***	.489
	(.613)		(1.04)	
Difference between own and neighbors' median housing value	-.724 **	-.150	-1.34 **	-.215
	(.350)		(.529)	
Difference between own and neighbors' % minority students	.388	.081	.397	.063
	(.487)		(.624)	
Nob	521		338	
Log-likelihood	-196.52		-97.57	
Percent correctly predicted	85.6		87.6	
p-value for test for spatial error correlation[a,b]	.00		.608	

Standard errors in parentheses; [a] neighbors defined as contiguous districts in own ISD; [b] based on 10,000 replications; significance of coefficients: *** 1% level, ** 5% level.

probit specification with participation decisions in 1997 as the dependent variable. Five out of the seven explanatory variables show coefficients significant at least at the 10% level, and the model correctly predicts more than 85% of all decisions. As expected, the participation decision in 1996 is a strong predictor for participation in 1997. Furthermore, the coefficients of the student-teacher ratio and the revenue variable are significant and show the expected sign. The results also suggest that districts with higher proficiency levels are more and that districts with housing values above those in neighboring districts are less inclined towards adopting school choice. Taken together, the estimation results for the baseline model suggest that a number of important school district characteristics affecting the adoption of open enrollment as a district policy have been identified.

The second set of results in Table 3 is from a probit of participation decisions in 1997 on the same set of explanatory variables as before and, in addition, a full set of ISD dummies. Note that the estimation with ISD dummies is based on a sample of only 338 observations. The reason is that in 22 out of 57 ISDs all affiliated local school districts either adopted open enrollment in 1997, or they all opted out of the program. With dummy variables for ISDs, these observations have to be removed from the sample in order to avoid complete separation. With the reduced sample and the additional regressors, the general picture is the same as before, although the average partial effects of the student teacher ratio, revenues per student, proficiency level and housing values now are somewhat more pronounced. This is only partly attributable to the inclusion of the dummy variables. It also reflects the fact that after dropping observations from ISDs with no variation in the dependent variable the link between the explanatory variables and participation decisions is more clearly visible.

As mentioned in the previous section, controlling for region-specific effects is a straightforward way of removing spatially correlated components from the residuals. To see how this approach works in the present setting, a LM test for spatial error correlation has been performed for both specifications. As suggested by Pinkse and Slade [29], a bootstrapping method is used to derive p-values for the null of zero spatial error correlation. This accounts for the fact that the LM test statistic does not have a limiting χ^2-distribution but, instead, depends on the matrix of spatial weights. The results are reported in the last row in Table 3. Based on 10,000 replications, the result for the model without ISD dummies clearly suggests the rejection of the null of zero spatial correlation in errors. In contrast to this, once region-specific dummies are included, the p-value of the test reveals that there is no significant amount of spatial error correlation. Therefore, when moving to specifications with spatial interaction in adoption decisions, there is little reason to suspect that the results will be significantly affected by spatially correlated unobserved effects once the impact of ISDs on district policies is accounted for.

We now turn to estimates of the spatial probit model, where the focus is on identifying the impact of neighbors' lagged decisions on actual participation decisions. A first set of results with the dependent variable being the districts' decisions in 1997 is displayed in Table 4. Note that, as suggested by the results of the tests reported above, a full set of ISD dummies is included to remove spatially correlated components from the errors. The main result from Table 4 is that there is positive neighborhood influence in the adoption of open enrollment policies, and that the impact of lagged adoption decisions of neighbors on current policies is substantial. A one percentage point increase in the share of neighbors participating in the first year of the school choice program increases the current probability of adoption by about 0.2%, implying that a district with a share of participating neighbors one standard deviation above that of an otherwise identical reference district is about 7.8% more likely to accept transfer students. A likelihood ratio test on equality of the log-likelihood of the spatial probit and the baseline probit with ISD dummies gives a test statistic of 5.48. This is significantly different from zero at the 2% level, implying that not accounting for the impact of neighbors' lagged

Table 4: School choice in 1997 - spatial probit

	Coefficient	dP/dX
% neighbors participating in 1996[a]	1.29 **	.200
	(.560)	
Participation in 1996	2.83 ***	.636
	(.323)	
Enrollment	.023	.004
	(.043)	
Student teacher ratio	-.363 ***	-.056
	(.090)	
Revenues per student	-.365 ***	-.057
	(.126)	
% math/reading satisfactory	3.32 ***	.516
	(1.07)	
Difference between own and	-1.50 ***	-.233
neighbors' median housing value	(.542)	
Difference between own and	.385	.060
neighbors' % minority students	(.642)	
Nob	338	
Log-likelihood	-94.83	
Percent correctly predicted	87.3	

Standard errors in parentheses; [a] neighbors defined as contiguous districts in own ISD; significance of coefficients: *** 1% level, ** 5% level; additional regressors: dummy variables for ISDs.

decisions removes a significant amount of information from the system.

Districts which already adopted open enrollment in 1996 are about 64% more likely to allow for the transfer of non-resident students than districts which did not participate in the first year of the choice program. In addition, a number of other explanatory variables affect the districts' choices. An additional student per teacher decreases the probability of adoption by 5.6%, while $ 1,000 of additional revenues per student decrease the participation probability by 5.7%. These findings support the presumption that crowded schools and the relative abundance of available resources deter school districts from actively competing for non-resident students. Furthermore, ceteris paribus, a higher share of students scoring satisfactorily in reading and math increases the probability of adoption. A one percentage point increase in the share of proficient students is associated with an increase in the participation probability of 0.52%. This may reflect the fact that better local schools, holding fixed all other factors, make a district a more attractive choice for potential transfer students. Introducing inter-district school choice is therefore more likely to be a successful policy in districts with a high share of proficient students. Finally, the adoption probability decreases with the difference between a district's median housing value and the average median housing value in neighboring districts. On average, an increase in this difference by $ 1,000 makes participation in school choice about 0.2% less likely. This points to the fact that households which have invested in their children's education by purchasing (relatively) expensive housing will most likely suffer a loss in the value of their houses if their school district participates in inter-district school choice.

As mentioned in the previous section, a problem with the results presented so far is the potential presence of serial correlation in the errors. If u_{it} is correlated with $u_{i,t-1}$, the lagged dependent variable in eq. 2 is endogenous and the estimates of all coefficients are bound to be inconsistent. Why should the errors be serially correlated? The most plausible source of serial correlation in the errors is certainly the presence of an unobserved time-invariant effect in the equation describing the districts' predisposition towards open enrolment. A simple way to address this problem is to include a sufficient number of lags of the dependent variable as additional regressors. By conditioning on the observed outcomes from previous periods, we are likely to account for any important unobserved factors which drive the districts' participation decisions. This way of dealing with serial correlation in the errors driven by unobserved effects is similar in spirit to the approach of Blundell et al. [5], who analyze technological innovations of firms and propose to utilize the pre-sample history of innovation activity to account for unobserved effects. Of course, it is not possible to include a sufficient number of lags with data on the districts' participation decisions only from the first two years of the school choice program. I therefore use information on district participation in the Michigan school choice program from 1999 to 2002 provided by the Michigan Department of Education.[14] A problem with the data is that they do not allow to distinguish between school districts which did not participate in the program and districts which did participate and experienced a zero demand from non-resident students to be enrolled at the district's schools.[15] In what is reported below, districts with zero incoming transfer students are treated as not participating in the school choice program. Note that less than 2.7% of all districts with a strictly positive number of incoming transfer students report to receive less than two full-time equivalent students. Hence, it is highly unlikely that the picture of participation decisions emerging from the data by treating districts with zero transfers as non-participating is seriously biased.

Table 5 displays descriptive statistics for district participation from 1999 to 2002 both for the full sample and for a reduced sample of 334 districts.[16] Note that the share of participating districts lags behind in the reduced sample.

[14] The data have been provided by Dr. Arthur Vrettas at the Michigan Department of Education, who was in charge of the Schools of Choice Program at the time of writing.

[15] It is for this reason that I do not use this data in the main analysis.

[16] As before, the sample has be to reduced to avoid complete separation in an estimation including ISD dummies.

Table 5: District participation 1999-2002 - descriptive statistics

	Full sample		Reduced sample	
	Mean	S.D.	Mean	S.D.
Participation in 2002	.704	.457	.638	.481
Participation in 2001	.645	.479	.578	.495
Participation in 2000	.610	.488	.509	.501
Participation in 1999	.478	.500	.404	.491
Nob	521		334	

Source: Michigan Department of Education (see footnote 14).

Table 6: School choice in 2002 - probit with three lags of dependent variable

	Coefficient	dP/dX
% neighbors participating in 2001[a]	1.10 **	.207
	(.499)	
Participation in 2001	1.67 ***	.349
	(.301)	
Participation in 2000	.767 **	.156
	(.359)	
Participation in 1999	.076	.014
	(.328)	
Nob	334	
Log-likelihood	-113.53	
Percent correctly predicted	85.0	

Standard errors in parentheses; [a] neighbors defined as contiguous districts in own ISD; significance of coefficients: *** 1% level, ** 5% level; regression includes a full set of ISD dummies.

This is because most of the excluded districts are from ISDs with participation of all affiliated districts. Results of a probit of district participation in 2002 on neighbors' lagged decisions, three lags of the dependent variable and a full set of ISD dummies are shown in Table 6.[17] The average partial effect of neighbors' lagged decisions is about 0.21 compared to 0.2 in the spatial probit for the 1997 cross section. The impact of participation in the previous year is now 0.35, which is significantly lower than with only one lag included. The coefficient of the participation decision lagged by two periods is also significant. All other things being equal, a district which did participate two years ago is still about 16% more likely to allow for inter-district transfers. However, the positive effect of lagged adoption decisions is dying out with more distant lags. If we are willing to believe that the inclusion of three lags of the dependent variable is likely to remove any significant amount of serial correlation which might potentially be present in the errors, then the results displayed in Table 6 suggest that the positive and significant estimate for the interaction coefficient

[17]Including additional controls as in the regressions reported before did not significantly alter the estimates of coefficients and average partial effects.

Table 7: School choice in 1997 - probit with asymmetric responses

	Coefficient	dP/dX
Neighbors' impact on previous year adopters[a]	.764	.118
	(.797)	
Neighbors' impact on previous year non-adopters[a]	1.52**	.235
	(.618)	
Nob	338	
Log-likelihood	-94.41	
p-value for Wald test on equality of coefficients	.357	

Standard errors in parentheses; [a] neighbors defined as contiguous districts in own ISD; significance of coefficients: ** 5% level; additional regressors: see Table 4.

does not suffer from endogeneity bias.

Since the estimate of the spatial interaction coefficient does not seem to be affected by serially correlated errors, we now return to results derived from the districts' participation decisions in the second year of the school choice program. Table 7 presents the estimates for interaction coefficients from a probit allowing for asymmetric responses between previous year adopters and previous year non-adopters.[18] The hypothesis that previous-year adopters' choice of current policies is not affected by lagged decisions of neighbors cannot be rejected at the 10% significance level. At the same time, the interaction coefficient for previous year non-adopters is significant at the 5% level. The partial effect indicates that previous-year non-adopters are 0.24% more likely to participate in open enrollment if the share of previous-year adopters among neighbors is increased by one percentage point. The results suggest that school districts which did not participate in the first year of Michigan's inter-district school choice program were 'pulled' to participation in the second year by previous-year adopters in their geographical environment, while first year adopters seem to have been unaffected by the behavior of other districts. This finding is consistent with the view that participation in the choice program was propagated by its effects on the degree of competition for students and state funds. Note, however, that the difference in the estimates for the interaction coefficients is not significant at conventional levels.

In general, one might think of forces other than competition for non-resident students making the districts' participation decisions interdependent. For instance, some districts may have abstained from participation in the first year of the program's existence in order to learn from the experience with the new policy made by other districts. The positive impact of neighbors' lagged decisions could thus also be explained by the notion that the quality and the amount of information available to districts positively depends on the number

[18]The estimates of coefficients and average partial effects for the control variables are very similar to those obtained before and are omitted.

Table 8: Effect of lagged decisions of neighbors within and outside ISD

	Coefficient	dP/dX
Lagged decisions of neighbors within ISD	1.25**	.192
	(.554)	
Lagged decisions of neighbors outside ISD	-.465	-.072
	(.392)	
Nob	338	
Log-likelihood	-94.12	
p-value for Wald test on equality of coefficients	.010	

Standard errors in parentheses; significance of coefficients: ** 5% level; additional regressors: see Table 4.

of experiments in nearby districts.[19] The Michigan school choice law in its original formulation offers a simple way to discriminate between the competition hypothesis and alternative explanations for interdependencies among the districts' decisions. As mentioned earlier, the law allowed for inter-district transfers only within ISDs. Therefore, school districts who's school choice policies were motivated by concerns about losing students by inter-district transfers should have reacted to lagged adoption decisions of neighboring districts within the ISD, but they should have been indifferent towards decisions of neighbors outside their ISD. In contrast to this, the difference between neighbors within and outside the ISD should have played bo role if interdependencies among the districts' choices were driven by information spillovers. To discriminate between the alternative explanations, I estimate a model with the share of participating neighbors within the ISD and the corresponding share of adjacent districts outside the ISD included as separate regressors. The results are shown in Table 8. While the estimates for the interaction coefficient and the corresponding average partial effect for neighbors within the ISD are very similar to those presented in Table 4, the interaction coefficient for adjacent districts outside the ISD is insignificant. Hence, the average district was only influenced by adoptions of school choice which did affect the choices available to students residing in the district. This finding clearly supports the view that competition for students was the driving force for the districts' participation decisions being interdependent.

[19]There is a small body of theoretical literature on strategic behavior of jurisdictions in policy experimenting and policy innovation. See, e.g., Strumpf [35] and Kotsogiannis and Schwager [25].

5 Conclusion

The literature on competition between schools to date has focussed on providing evidence for the effects of competition on school performance, mostly measured by student achievement and school efficiency. The issue is important and the literature has made considerable progress in recent years, but the channels through which competition actually affects school performance often remain unclear. Hence, we do not know much about how public schools behave when competition increases.

In this paper, I have examined the behavior of local school districts in Michigan after the state introduced voluntary inter-district school choice in 1996. By offering students the possibility to choose a pubic school outside their district of residence, and by tying state funds for public schools to the number of pupils enrolled, the new state law initiated a new form of inter-district competition for students. The analysis offered in this paper has focussed on the district level. More specifically, the study has proposed a model for the school districts' decision whether or not to participate in the choice program, i.e. whether or not to allow for the enrollment of non-resident students at local schools. The crucial aspect of the model is that it allows for interactions of school districts in participation decisions. The results suggest that the school districts did actively compete for students once the playing field of inter-district choice was opened. Most importantly, lagged adoptions of school choice in adjacent districts had a significant and substantial positive impact on the districts' willingness to enroll non-resident students. Controlling for a number of district characteristics and region-specific effects, a one percentage point increase in the share of neighbors participating in the first year of the school choice program is found to increase the current probability of adoption by about 0.2%. The results also point to asymmetric responses, with districts already experimenting with open enrollment being unaffected by their neighbors' decisions and, in contrast to this, districts which did not adopt open enrollment before being strongly 'pulled' towards participation in the choice program. Facing an increased risk of losing students and resources, the school districts showed a sort of 'striking back' behavior, i.e. they were substantially more willing to compete for non-resident students if neighboring districts did so.

The finding that school districts positively interact with each other in the adoption of a new policy could also be explained by information spillovers. If some districts experiment with inter-district choice, this may provide other districts with valuable information concerning, for instance, the behavior of parents and students and administrative procedures. If the quantity and quality of information which is available to districts depends on the number of experiments made in nearby districts, one would also expect to find adoptions of school choice to be positively spatially correlated. The paper offers a simple test to discriminate between competition for non-resident students and information spillovers as potential driving forces for interdependencies among the districts' participation decisions. The test exploits limitations of student mobility in inter-district transfers and shows that school districts did only react to decisions in neighboring districts which did affect the choices available to resident students. This finding clearly supports the view that the districts behavior towards inter-district choice was shaped by competition for students and resources.

Acknowledgments

I am grateful to the numerous suggestions of Jan Brueckner (editor) and two anonymous referees. For insightful comments and suggestions concerning earlier drafts, I would like to thank Thiess Büttner, Federico Revelli, Robert Schwager and the participants of the Workshop on Fiscal Federalism at IEB (Barcelona), 2005.

References

[1] D. Arsen, D. Plank, R. Sykes, School choice policies in Michigan: the rules matter, Michigan State University, East Lansing 1999.

[2] K. Baicker, The spillover effects of state spending, Journal of Public Economics 89 (2005), 529-544.

[3] K.J. Beron, W.P.M. Vijverberg, Probit in a spatial context: a Monte Carlo analysis, in: L. Anselin (Ed.), Advances in spatial econometrics, Springer, Heidelberg, 2004, pp. 169-196.

[4] T. Besley, A. Case, Incumbent behavior: vote-seeking, tax-setting and yardstick competition, The American Economic Review 85 (1995) 25-45.

[5] R. Blundell, R. Griffith, J. Van Reenen, Dynamic count data models of technological innovation, Economic Journal 105 (1995), 333-344.

[6] M. Bordignon, F. Cerniglia, F. Revelli, In search of yardstick competition: a spatial analysis of Italian municipality property tax setting, Journal of Urban Economics 54 (2003), 199-217.

[7] C. Brett, J. Pinkse, Those taxes are all over the map: a test for spatial dependence of municipal tax rates in British Columbia, International Regional Science Review 20 (1997), 131-151.

[8] J.K. Brueckner, Testing for strategic interaction among local governments: the case of growth controls, Journal of Urban Economics 44 (1998), 438-467.

[9] J.K. Brueckner, Strategic interaction among governments: an overview of empirical studies, International Regional Science Review 26 (2003), 175-188.

[10] T. Büttner, Local business taxation and competition for capital: the choice of the tax rate, Regional Science and Urban Economics 31 (2001), 215-245.

[11] J.K. Brueckner, L.A. Saavedra, Do local governments engage in strategic property tax competition?, National Tax Journal 54 (2001), 203-229.

[12] A. Case, Neighborhood influence and technological change, Regional Science and Urban Economics 22 (1992), 491-508.

[13] A. Case, J.R. Hines, H.S. Rosen, Budget spillovers and fiscal policy interdependence: evidence from the states, Journal of Public Economics 52 (1993), 285-307.

[14] J.F. Couch, W.F. Shugart, A.L. Williams, Private school enrollment and public school performance, Public Choice 76 (1993), 301-312.

[15] T.S. Dee, Competition and the quality of public schools, Economics of Education Review 17 (1998), 419-427.

[16] P. Egger, M. Paffermayr, H. Winner, An unbalanced spatial panel data approach to US state tax competition, Economics Letters 88 (2005), 329-335.

[17] D. Epple, R.E. Romano, Competition between private and public schools, vouchers, and peer-group effects, The American Economic Review 88 (1998), 33-62.

[18] P.G. Fredriksson, D.L. Millimet, Strategic interaction and the determination of environmental policy across U.S. states, Journal of Urban Economics 51 (2002), 101-122.

[19] S. Grosskopf, K.J. Hayes, L.L. Taylor, W.L. Weber, On the determinants of school district efficiency: competition and monitoring, Journal of Urban Economics 49 (2001), 453-478.

[20] M. Hayashi, R. Boadway, An empirical analysis of intergovernmental tax interaction: the case of business income taxes in Canada, Canadian Journal of Economics 34 (2000), 481-503.

[21] C.M. Hoxby, School choice and school productivity (Or could school choice be a rising tide that lifts all boats?), in: C.M. Hoxby (Ed.), The economics of school choice, University of Chicago Press, Chicago, 2003, pp. 287-341.

[22] C.M. Hoxby, Does competition among public schools benefit students and taxpayers?, The American Economic Review 90 (2000), 1209-1238.

[23] C.M. Hoxby, The Productivity of schools and other local public goods producers, Journal of Public Economics 74 (1999), 1-30.

[24] C.M. Hoxby, Do private schools provide competition for public schools?, National Bureau of Economic Research, NBER Working Papers 4978 (1994).

[25] C. Kotsogiannis, R. Schwager, On the incentives to experiment in federations, CESifo Working Paper 1585 (2005).

[26] D.P. McMillen, Probit with spatial autocorrelation, Journal of Regional Science 32 (1992), 235-248.

[27] Michigan Department of Treasury, School finance reform in Michigan, proposal A: retroperspective, Office of Revenue and Tax Analysis (2002).

[28] C.M. Newmark, Another look at whether private schools influence public school quality: comment, Public Choice 82 (1995), 365-373.

[29] J. Pinkse, M.E. Slade, Contracting in space: an application of spatial statistics to discrete-choice models, Journal of Econometrics 85 (1998), 125-154.

[30] G.C. Rapp, Agency and choice in education: does school choice enhance the work effort of teachers?, Education Economics 8 (2000), 37-63.

[31] R. Reback, House prices and the provision of local public services: capitalization under school choice programs, Journal of Urban Economics 57 (2005), 275-301.

[32] F. Revelli, Performance rating and yardstick competition in social service provision, Journal of Public Economics (forthcoming).

[33] F. Revelli, On spatial public finance empirics, International Tax and Public Finance 12 (2005), 475-492.

[34] F.M. Sandström, F. Bergström, School Vouchers in practice: competition will not hurt you, Journal of Public Economics 89 (2005), 351-380.

[35] K.S. Strumpf, Does government decentralization increase policy innovation?, Journal of Public Economic Theory 4 (2002), 207-241.

[36] R. Vedder, J. Hall, Private school competition and public teacher salaries, Journal of Labor research 21 (2000), 161-168.