QUASI-MARKET COMPETITION IN PUBLIC SERVICE PROVISION:

USER SORTING AND CREAM-SKIMMING

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Abstract

Quasi-markets that introduce choice and competition between public service providers are intended to improve quality and efficiency. This paper demonstrates that quasi-market competition may also affect the distribution of users. First, we develop a simple theoretical framework that distinguishes between user sorting and cream-skimming as mechanisms through which quasi-markets may lead to high-ability users becoming more concentrated among one group of providers and low-ability users among a different group. Second, we empirically examine the impact of a nationwide quasi-market policy that introduced choice and activity-based budgeting into Danish public high schools. We exploit variation in the degree of competition that schools were exposed to, based on the concentration of providers within a geographical area. Using a differences-in-differences design—and register data containing the full population of students over a nine-year period (N=207,394)—we show that the composition of students became more concentrated in terms of intake grade point average after the reform in high-competition areas relative to low-competition areas. These responses in high-competition regions appear to be driven both by changes in user sorting on the demand side and by cream-skimming behavior among public providers on the supply side.

Keywords: public service performance; quasi-market; difference-in-difference design; competition; cream skimming.

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Concerns about the performance of public service providers have led to reforms in many countries that mimic the dynamics of the private market (Hood 1991; Moynihan 2006; Pollitt and Bouckaert 2004). These New Public Management reforms are based on the notion that the key constraint in countries with low levels of performance is the way in which the production of public services is organized—and that the link between accountability and performance is too weak. One set of reforms—often referred to as "quasi-markets"—focus on making the providers of public services more sensitive to the demand from users by introducing elements of user choice, activity-based funding, and managerial autonomy (Le Grand 2007).[1] Ultimately, the objective of these reforms is to improve quality and efficiency in the delivery of service (Gaynor, Moreno-Serra, and Propper 2013). However, a concern raised by previous literature is that quasi-markets could also lead to high-ability clients becoming more concentrated in certain areas (Le Grand 1991; Glennester 1991; Cookson et al. 2010). Despite such concerns, there is little empirical research on such responses to quasi-market reforms.[2]

This paper examines the consequences of quasi-market competition on distribution of users by ability. We distinguish theoretically between two mechanisms through which quasi-market competition may lead to users becoming more segmented such that high-ability users are concentrated among one group of providers and low-ability users among a different group of providers.

[1] Foged and Aaskoven (2016) and Wiborg (2015) have studied when politicians decide to introduce choice and competition.

[2] The literature on performance management emphasizes that linking incentive to performance indicator can make providers improve the indicators rather than actual goal achievement (Heinrich and Marschke 2010). Incentive theory suggests that incentives might lead to substitution away from unmeasured performance criteria (e.g., quality) to measured criteria (e.g., quantity) (Holmstrom and Milgrom, 1991). Kelman and Friedman (2009) distinguish between two types of strategies. In their typology, gaming refers to manipulating indicators without any actual improvements of public service provision, whereas effort substitution is the provision of services on dimensions linked to incentives while neglecting dimensions that are not. In an educational setting, schools may respond to incentives linked to test scores by *effort substitution*, such as "teaching to the test" (i.e., focusing on test-specific skills) (Jacob 2005) or "teaching to the rating" (i.e., focusing on students whose performance is important for funding) (Reback 2008), or by *gaming*, such as intentionally manipulating standardized test scores (Jacob and Levitt 2003).

First, one demand-driven response is that users with more resources may be more determined to turn their choice into action, which could lead to some providers having a high share of capable users, whereas others are left with less capable users. Second, there are also challenges on the supply side. Providers could try to attract the most capable clientele by means not related to improvements of service provision, such as increased advertisement, or cream-skim the most capable users and leave the more challenging clientele to others.

Examining the effect of quasi-market policies represents a challenge. The key elements of quasi-market policies—choice and activity-based funding of public providers—are often implemented in full scale and therefore often cover all providers, which makes it difficult to identify a valid control group. To conduct an empirical test of the responses to quasi-markets, we exploit a nationwide policy shift in Danish high schools that was implemented in January 2007. A key advantage of focusing on high schools compared to, for example, social work or job counseling is that measures of user ability in the form of grades are readily available.[3] More importantly, the reform involved key features of a quasi-market, thereby making it an excellent case to study the effects of such policies. First, the schools became self-governing institutions with increased managerial autonomy. Second, a mechanical and transparent funding system specified by law and based on activity-based funding replaced political negotiations between county governments and schools. Third, the reform divided schools into districts in which the schools had influence on the allocation of students. The overall result of the reform was that it moved public schools from a hierarchical environment governed by

[3] We measure ability based on intake grade point average. While we acknowledge that grade point average is a crude measure of ability, it is predictive for graduation and output grade point average (see Appendix Table 2 and Appendix Figure 2), which is relevant for the providers in our setting.

county governments to a quasi-market environment regulated by activity-based funding and demand.

We base our research strategy on the idea that competition in a quasi-market is a function of the geographical configuration of service providers. While the policy affected high schools nationwide, the intensity of the incentives induced by the reform varied across high schools according to the competition that the schools were exposed to in their geographical areas. Whereas areas with many schools facilitate a high degree of choice, areas with a low concentration of schools result in a limited degree of choice. As a result, a school in a geographical area with many competitors is subject to more exposure to a quasi-market policy that links budget to activity than does a school with few or no competitors. We exploit this variation in the intensity of competition—and a differences-in-differences design—to estimate the impact of the quasi-market. Thus, our research design relies on a comparison of changes in the distribution of students by ability in response to reforms of schools in geographical areas with many competitors and schools in areas with few or no competitors.

Using high-quality administrative data on the full population of high school students for the period 2003–2011, which includes a direct measure of user ability (grade point average [GPA] from middle school), our results suggest that the composition of students became much more segmented in the dimension of ability after the 2007 policy, but only in high-competition areas. Using more detailed data in the post-reform period, supplementary analyses show that the level of concentration by ability in certain schools in high-competition areas was stronger measured by actual enrollment than by patterns in students' application priorities, suggesting that parts of the segmentation by ability was due to cream-skimming among school administrators. We discuss threats to

our design and provide numerous sensitivity checks, including using different measures of competition and segmentation by ability across schools, which all support the robustness of our results.

Our study contributes to our understanding of the effects of introducing market mechanisms in the provision of public service by studying whether a quasi-market policy that introduced activity-based budgeting among public providers leads to high-ability clients becoming more concentrated in certain areas. First, we differentiate theoretically between changes in the distribution of clientele caused by factors on the demand side (i.e., high-ability students selecting into high schools with other high-ability students) and the supply side (i.e., behavior among providers). Second, our unique panel data also allow us to disentangle the effects of user sorting and behavior among providers empirically and demonstrate that the introduction of market mechanisms can lead to responses both by the users and the public providers.

Our study also points to the structure of the market as an important precondition for the distributional effects of quasi-market targeted public providers. The core idea of a quasi-market is that increased competition between providers will improve the quality and efficiency of the provision of public services. Our findings demonstrate that stronger competition may also introduce incentives for behavior that do not necessarily contribute to these improvements. This insight also relates to the literature on contracting out public services, which suggests that a key challenge is the potential lack of competitiveness on the provider side (Girth et al. 2012).

In the following section, we theorize why we could expect quasi-markets to increase segmentation of users in terms of ability. We then present in more detail the empirical setting of the study, including the Danish education system and how the reform changed the provision of public high school education. In the fourth section, we discuss the research design. In the fifth section, we present the results of the analyses, and in the sixth section, we discuss the theoretical and empirical implications of the findings. Particularly, we discuss the theoretical mechanisms and possible political responses to strategic behavior in relation to quasi-market policies.

IMPACTS OF INTRODUCING QUASI-MARKETS IN THE PUBLIC SECTOR

Quasi-market: Definition and Intended Consequences

A quasi-market constitutes a way of organizing the delivery of public services that is a hybrid of a hierarchical government structure and a traditional market. Le Grand (1991) defines a quasi-market as a publicly funded system for the provision of service in which users can choose between providers of a service, the providers have local managerial autonomy, and the funding of the providers depends on the number of users. Thus, the institutional set-up involves (1) free user choice of providers, (2) empowerment of local management, and (3) activity-based funding.

Quasi-market reforms are designed on the notion that one important reason for the differences in outcomes between public and private service providers is that public providers are primarily accountable to political authorities and, therefore, not forced to respond to the demands of the users (Chubb and Moe 1988). Quasi-market reforms intend to enhance accountability through increased user choice and activity-based funding while providing local managers the autonomy to act as they wish (Le Grand 2007). The idea is that introducing elements of activity-based funding and user choice makes the provider of public services more sensitive to the demand from the users,

which will translate into improved managerial quality (Bloom et al. 2015) and, ultimately, a higher quality of services (Gaynor, Moreno-Serra, and Propper 2013; DeAngelis 2017).

In some school choice programs, children are offered vouchers that cover part of the costs of attending a private school (e.g., Andersen and Serritzlew 2008; Angrist et al. 2002). Even if providers are non-profit, managers and employees may still respond to choice and activity-based funding. Administrators and staff could receive a direct payoff from certain types of spending. Particularly, administrators could spend resources on goods that the personnel value but that are not focused on the core performance objectives—such as upgrading employee lounges and travel that is not productive for the service provision.

If funding is paid automatically based on the number of users, providers have an incentive to attract users in a quasi-market as long as their marginal costs are below the funding provided per unit. Given that users value quality in their choice of provider, the manager and employees may seek to enhance the demand by improving the quality of their services. For example, within the educational sector, this could imply adjusting instruction practices and the curriculum in order to improve the quality and thereby attract students. Empirical evidence on the causal link between school competition, user choice, and school quality is, however, limited (Burgess 2016). Studying variation in competition across U.S. school districts, Hoxby (2000) concluded that higher competition raises school productivity by raising pupil achievement and reducing spending. Studying the same setting, Rothstein (2007) found considerably smaller and imprecise effects. More recent research, surveyed in Burgess (2016, p. 48), has studied institutional features in a variety of settings and also found mixed results on the causal link.

Quasi-markets and User Demand

Introducing choice and competition into public services provision is controversial. One concern is that it leads to concentration of users across providers based on the users' capabilities and resources because of changes in demand on the user side. For example, AbouAssi et al. (2019) found that income-based disparities affect perceptions of access to services. If high-achieving students select into specific schools, choice will increase segmentation by ability across schools (Carlson 2014). Cullen, Jacob, and Levitt's (2005) study of an inter-district transfer program of high schools in Chicago found that the more able students selected into schools with more capable students. Previous studies on inter-district open enrollment programs have also found that academic achievement (in addition to distance between school districts) is the most influential determinant of inter-district flow patterns (Carlson, Lavery, and Witte 2011).

Previous empirical studies of the effects of competition on sorting within education have produced mixed results. In a review of the evidence from the U.S. setting, Hoxby (2003) found no general effect of competition on sorting. A more recent review by Burgess, Propper, and Wilson (2007) concluded that the impact of choice on sorting depends on supply flexibility. Sorting may also be particularly present in settings in which a service is funded based on a fixed price per user (i.e., without a price mechanism), as an indefinite demand for the most attractive providers can be expected (Lipsky, 2010). In addition to user sorting, distribution of users by ability could also be supply-side-driven and explained by behavior among providers.

Quasi-Markets and Behavior Among Service Providers

Instead of (or in addition to) improving quality, providers could respond strategically to the introduction of market mechanisms. As providers are rewarded by the enrollment of users, they have an incentive to focus their attention on changing the composition of users. Specifically, in the

context of education, schools have an incentive to enroll students with a strong educational record who have demonstrated high ability. First, serving more capable students increases measures of performance (such as the school's GPA), which sends a strong signal to possible users regarding the quality of the school (Glennerster 1991). Second, given that student ability is highly predictive of school dropout, it may be less costly to maintain high-ability students in the program. Third, it might be more satisfying for teachers to interact with more capable students (Lipsky 2010). Public providers may apply different types of strategies to affect the composition of users and attract "profitable" users.

One strategy involves affecting users before they choose a provider. A challenge in a quasi-market is asymmetric information between the public authorities, the provider of the service, and the ultimate users (Glennerster 1991; Lowery 1998). When it is difficult for users to acquire valid information regarding the quality of service delivered by the provider, providers may have an incentive to influence the information available to potential users. It might be legitimate for providers to advertise how their educational programs are superior to other providers (e.g., because they have more capable personal or more advanced courses). However, instead of trying to improve quality, providers might respond strategically by what Bischoff and Blaeschke (2016) referred to as "window dressing." For example, students (or their parents) usually only observe a school's overall performance with imprecise measures such as the average grade performance across the entire cohort, which is determined by both the composition of students and the quality of the educational program. Sometimes parents even simply rely on their social network for information (Fleming et al. 2015). Thus, schools could respond to a quasi-market reform by improving facilities that are not strictly related to instructional quality (e.g., buildings or sports facilities) (Le Grand, 1991, p. 1262–1263). In their study, Andersen and Serritzlew (2007, p. 352) found that

increased competition (induced by a voucher system for private schools) increases the costs of providing public schooling. They argued that the reason for this is that providers might choose to compete on factors such as "(…) number and exoticism of field trips, quality and appearance of teaching materials," which might not closely relate to student learning and school performance.

Providers may also apply strategies during the admission process, which takes place after users choose providers. If providers administer this process, they may use their discretion to cream-skim and select the easiest to serve among potential enrollees (Le Grand 2007). While theoretical work has argued that we should expect small cream-skimming effects in user choice programs (Altonji, Huang, and Taber 2015), there are some reasons to believe that they could be substantial. Studies of the effects of performance management suggest that linking financial rewards to performance measures creates incentives to improve performance indicators without taking other relevant considerations into account (Bevan and Hood 2006). For example, Soss, Fording, and Schram (2011) found that organizations respond to the introduction of performance management by reshaping the clientele rather than serving it more effectively. In an educational context, administrators in schools that are over-subscribed may try to be selective with respect to the intake of students by cream-skimming the more able students and avoiding the difficult-to-serve. While recent research has suggested that teachers are more willing to prioritize the students with the lowest performance (Jilke and Tummers 2018) or the students with the most engaged parents (Baviskar 2019), the organizational response might differ in light of clear incentives to prioritize the best-performing students. For instance, Jilke, Van Dooren, and Rys (2018) found that public providers of eldercare respond equally to applicants of different ethnicities, while private providers

facing more competition do not, which can be viewed as a form of cream-skimming. Finally, Lubienski, Gulosino, and Weitzel (2009) found patterns of several exclusionary strategies in response to three different school choice programs in the U.S.

Quasi-Markets and Exposure to Competition

Exposure to actual competition from other providers is an important boundary condition for the effectiveness of quasi-markets (Burgess et al. 2004; Le Grand 2007). To exercise choice, users need to have real alternatives. Whereas areas with many providers facilitate a high degree of choice, areas with only one or a few providers result in a limited degree of choice. As a student in a marketplace with many providers is more likely to switch to another school, schools in a geographical area with many competitors are subject to stronger incentives than schools in areas with few competitors or local monopoly. Therefore, competition in a market is a function of the geographical configuration of service providers. Managers in a highly competitive environment face greater incentives to attract students than their counterparts in areas with less intensive competition. As a result, the actual number of alternatives in a geographical area appears to be critical for the impact of market-oriented reforms, both intended and unintended. Thus, linking budgets to activity may provide schools with greater incentives to respond strategically in a more competitive marketplace.

In sum, there are ample arguments suggesting that the creation of a quasi-market might result in an increased concentration of high-ability users within certain providers. We differentiate theoretically between reactions on the demand side (i.e., high-ability users selecting provider with other high-ability users) and the provider side (i.e., providers attracting or selecting high-ability users) and expect that both mechanisms will increase segmentation of clientele by ability.

RESEARCH DESIGN

Empirical Setting

To study the impact of a quasi-market on user sorting and cream-skimming behavior among providers, we examine a school reform that was introduced among Danish high schools in January 2007. In Denmark, basic education comprises a preschool class and nine years of mandatory education. Having completed basic education, students may continue to high school (grades 10 through 12), move on to vocational training, or enter the labor market. After graduating basic schooling, students are free to apply to any high school of their choice, and each student makes a prioritized list of high schools. If the number of applicants to a high school exceeded capacity before the reform, local education authorities (DK: *fordelingsudvalg*), assigned by the local counties, were responsible for the allocation of students across schools. As a general principle, the travel distance between the school and the prospective student should be taken into account (DK: *nærhedsprincippet*), but there were no formal rules on how the authorities should prioritize students or on the allocation algorithm (for example, whether Deferred Acceptance or Immediate Acceptance should be applied).[4] The General Upper Secondary Education Program—which is the largest academic high school program—consists of a broad range of subjects in the humanities, the natural sciences, and the social sciences.[5] The program overall admits approximately

[4] To the best of our knowledge, no central information about attainment (i.e., GPAs) or student composition (i.e., socioeconomic background) was available before 2011, when the Ministry for Education started to publish GPAs for individual schools. It is thus likely that students formed their priorities for high schools based on anecdotal evidence from older cohorts and siblings.

[5] Apart from the general upper-secondary education program (also known as "STX"), the Danish educational system comprises two other three-year high school programs: the higher commercial examination program (HHX) and the higher technical examination program (HTX). HHX focuses on business and economics in combination with general subjects. HTX focuses on technological and scientific subjects in combination with general subjects. In addition, some private schools supply the STX program. As the 2007 policy affected only the STX program, we choose it as the object of our focus.

30,000 students every year.[6] To graduate from high school with a diploma, students need a GPA above a proficiency standard.[7] The program is regulated by national law, which states the purpose, content, and organization of the program, as well as teaching requirements (teachers generally need a university degree).

The 2007 reform introduced significant changes to the high school system. The background of the reform was a large structural reform of the whole local government system in Denmark. Prior to the reform, counties governed by locally elected politicians operated the high schools. The counties had the formal responsibility for the management of the schools, such as hiring and firing teachers, as well as the funding of all high schools within the county.

The reform consisted of three integrated elements that closely resemble the theoretical concepts of a quasi-market. These elements also followed what was already implemented in other areas of education in Denmark (e.g., the universities and some vocation-oriented educations). First, as of January 1, 2007, high schools became self-governing institutions run by school boards and were made responsible for financial as well as hiring and firing decisions. This also implied that the high schools could keep any budget surplus across years. Simultaneously dated with the intro-

[6] The number of high schools is quite stable in the studied period. However, it was decided before the reform to open two new high schools in 2005. Since we do not observe these high schools throughout the study period, they are excluded from the sample of analysis. In addition, a number of educational institutions merged during the period of study. However, only one of these mergers included multiple STX schools. The remaining mergers took place between different types of programs (e.g., STX with HHX, HTX or vocational educations).

[7] The final GPA score is the simple mean of two intermediate average scores. The first is based on the grades in the national exams. The second intermediate score is based on classroom grades, which constitute an internal assessment by the student's teacher. The final GPA score is calculated as the simple average of the exam and classroom performance GPA scores.

duction of the high school reform, the 13 counties were abolished and replaced by five administrative regions.[8] Because of the reform, school principals became responsible for daily management, and the schools were provided more autonomy to act as they deemed appropriate.[9]

Second, from January 1, 2008, an activity-based funding system was implemented. As a result, the schools became almost exclusively financed by activity-based grants. For each student enrolled, the school received 56,000 DKK (approximately 9,000 USD) annually, and for each student that graduated, the school received 14,200 DKK (approximately 2,300 USD). As a supplement to the activity-based grants, subsidies and fees were provided to partially offset the change in subsidy levels that the schools experienced during the implementation period. These subsidies and fees gradually decreased, so that the reform was fully implemented by 2011.

Third, schools became their own admission authority, in coordination with other schools in the same geographical area. Within each region, high schools were required to create new school districts (consisting of several schools), each with its own allocation committee responsible for the selection process in case of over-subscription. The allocation committees consisted of the principals within the school district and one to two members of the regional council. In total, the reform resulted in the formation of 16 school districts.[10] When applying to high school, students make a prioritized list of schools (both before and after the reform) and can apply to any high school they prefer. Although the committees are required to follow a set of guidelines in the allocation process,

[8] The high school policy followed a large-scale structural reform. The reform changed the size and number of local governments. The number of municipalities was reduced from 271 to 98. In addition, task responsibilities changed between the municipal, regional, and national levels. A political majority made the formal agreement of the reform in June 2004.

[9] All boards may not act similarly, which could affect school performance as argued by Heemskerk, Heemskerk and Wats (2015) and Heemskerk (2019). Still, the move from political hierarchy to self-governed schools run by boards may increase the average managerial autonomy.

[10] The formation of school districts did, to a large extent, follow the former counties, with a few exemptions. In the Capital Region (Copenhagen)—where the density of high schools is higher than in the rest of the country—four committees were established, and in the region of northern Jutland—where the density of high schools is low—only one committee for all high schools in the region was established.

the criteria by which students should be allocated among schools within the school district are multifaceted and relatively vague. The committees should first try to assign all students to their first choice. If any of the high schools on the student's list had the capacity, the committee was required to assign the student to one of those schools. However, in the case of over-subscription at some schools, the committee had the authority to decide which students were assigned to their first-priority high school.[11]

The creation of allocation committees has at least two important implications. First, the establishment of committees signals that it was not the intention of the policy to make the schools able to pick and choose the most able students. If this were the case, policymakers could have given the principals direct authority to do so. The politicians responsible for this legislative work emphasized the importance of the committees when the bill was introduced: "This proposal suggests that the high schools should enter binding cooperation with each other in the local areas. It is extremely important that these cooperations are established because cooperation increases the use of capacity" (ft.dk 2004). This is further supported by the fact that the Minister of Education in 2011 (in office based on the same parliamentary majority as the initial policy) sent a letter to all principals following a number of newspaper articles concerning potential creaming of students that stated that the "schools that receive more admissible 1st priority applications than they are able to admit should pass all applications to the allocation committee and the allocation committee should make the distribution of all applicants" (ft.dk 2011). Second, that the creation of the allocation committees makes it more difficult for the schools to cream-skim students makes

[11] The government modified the admission rules in 2012. With effect from March 2012, a national law stated that the committees were required to use the travel distance between the student's home address and the high school as the main criteria for assigning students to high schools. Although the revised law still leaves some room for discretion—such as the possibility to calculate the travel distance in different ways—it constitutes a sharp reduction in the ability of schools to select certain types of students. As we study the period 2003–2011, our analysis is not affected by this change.

the test of our argument more conservative. However, we would argue that theoretical as well as empirical evidence suggests that cream-skimming is still possible. On theoretical grounds, we would argue that we should understand the allocation of students within these committees as a negotiation. However, the principals of popular schools with many first-priority applicants have a much better starting point for the negotiation than the principals of the less popular schools. Also, without regulation of the process (or without proper oversight), it is possible for the more popular schools to enter the negotiations without revealing all their cards. Empirically, qualitative evidence from a consultancy evaluation of the committees supports that the most popular schools indeed used their position in the negotiations. Two clear examples are (1) "It is difficult to get insights into the allocation, since the Aarhus principals are those who have something to give. They sort of sit on the gold and refer the students they cannot use" (principal, Central Region) and (2) "It is very much up to the schools who they choose to pass on, and it is no secret that the school who passes the students on makes the decision and that it might seem a bit non-transparent how things ends up the way they do" (principal, Capital Region) (Pluss 2012).

Empirical Strategy

As mentioned initially, examining the effect of quasi-market policies is challenging because quasi-market policies are often implemented in full scale, which makes it difficult to identify a valid control group. When less comprehensive policies are introduced, such as vouchers for some users, they also only introduce a small amount of competition to the provision of service. To study the impact of the 2007 high school reform on the distribution of students by ability, we analyze geographical variation in competition. Specifically, we base our empirical strategy on the variation in pre-reform market concentration, which is a result of the geographical location

of schools. The geographical distribution of high schools resulted in some students having virtually no choice, as only one school was accessible in their region. Thus, some schools were effectively local monopolists, whereas other high schools, particularly those in the more urbanized areas of the country, were subject to the choice of the students.

We apply a differences-in-differences strategy that relies on the changes in outcomes at schools in high-competition areas in comparison to those in low-competition areas. We exploit that some students faced only one real choice of high school, whereas others could prioritize the high schools they wanted within a reasonable travel distance. Importantly, if students in low concentration areas are willing to travel long distances—and the schools therefore still are subject to some degree of competition—our approach would underestimate the responses to the reform and provide a lower-bound estimate.

Data

We use a dataset that contains the universe of Danish public high school students. The main data (provided by Statistics Denmark) contains information on all students enrolled in a Danish high school from 2003 through 2011. Using a unique personal identifier, we merge the high school data with a student register that contains data for all students who graduated from a Danish ninth grade and a dataset with background information on the full population for the period 2003 to 2011, containing information such as gender, birth date, residence municipality, education, and parental education. Our core sample consists of 207,394 students in 115 high schools.[12] Finally, we link these data to registers on student applications, which allows us to distinguish between student sorting and schools' admission decisions (although only available in the post-reform period).

[12] The raw data contain 235,319 students in STX schools. We drop 10,381 observations in institutions that are either private or excluded from default system for other reasons (for example, students on the island Bornholm). To ensure a balanced panel, we restrict the sample to schools that exist in all years, which requires us to drop 9,892 observations. We drop observations from three more schools because their school districts are unknown (corresponding to 2,013 observations). Finally, 5,639 observations are dropped because of missing information on ninth-grade GPA. No further data restrictions are imposed. Appendix Table 1 shows the number of schools in the different sample specifications. Appendix Table 4 shows that the results are not sensitive to a specification including data from the unbalanced sample, in which we include schools not observed in all periods.

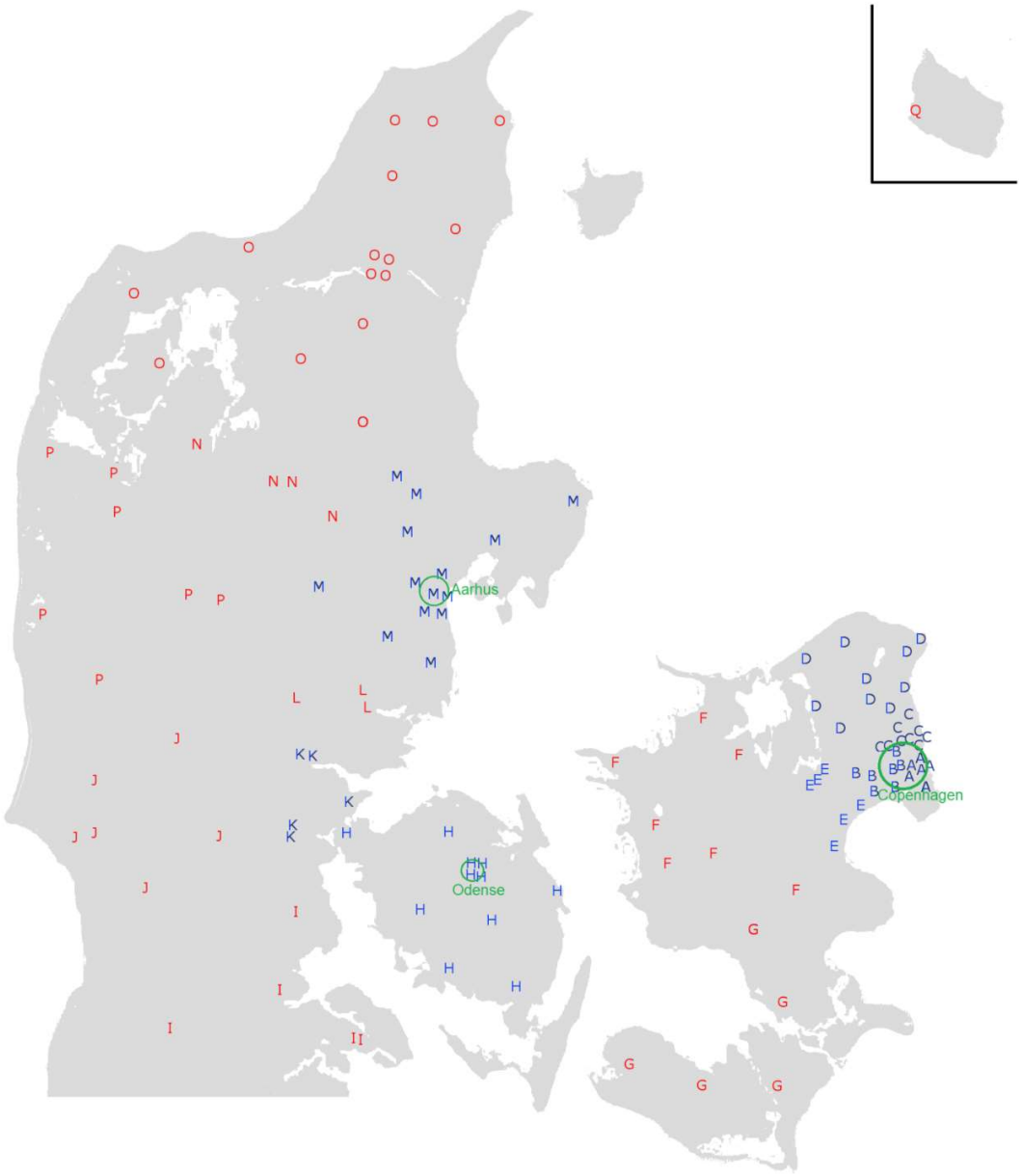

Figure 1: School locations, districts, and concentration

Notes: Each letter corresponds to a district. Blue indicates a high-concentration area. Red indicates a low-concentration area.

Measure of Competition

For each school, we measured the number of other schools within 20 kilometers (approximately 12.4 miles). Danish high school students usually enter the program at age 15 or 16, and in the studied period, the driving age was 18. Thus, the students are dependent on public transportation, biking or their parents driving them to school; thus, we would argue that this constitutes an upper limit for a reasonable travel distance. For each school district, we calculate the average number of high schools within this distance and define high-competition school districts as those in which the average number of competitors is above the median. Figure 1 shows the distribution of high schools and school districts. The figure illustrates the geographical variation in the concentration of schools. Schools are marked by a letter that denotes the 16 school districts (indicated by A through P). Blue represents a school district with a high concentration of schools, whereas red represents low-concentration areas. There is considerable variation in the degree of competition across geographical areas. The high competition is (not surprisingly) concentrated in the school districts around the main cities (i.e., Copenhagen, Aarhus, and Odense). In the results section, we demonstrate that the findings are robust to changes in the specification of the measure of competition (see Figure 3).

Measure of Distribution of Ability Across Schools

Given that student dropouts are predictable based on certain student characteristics, schools may be especially interested in attracting those students, as they may be less costly to maintain in the program. We argue that one of the most important observable characteristics is students' educational history. Compared to socio-economic background, students' GPA from their ninth-grade exam (i.e., middle school final exam) is a particularly strong predictor of success in high school,

measured both by educational achievement and by dropouts (see Appendix Table 2 and Appendix Figure 2).[13] Thus, schools have a strong incentive to attract and enroll students with a strong education history who have demonstrated high ability.

To quantify concentration by ability across schools, in our main specification, we use the R^2 from estimating an ordinary least squares (OLS) regression of ninth grade GPA on a set of high school dummies (an approach similar to Söderström and Uusitalo 2010). This approach makes it possible to handle the fact that the sorting variable is not categorical, which allows us to use the full variation in the variable. We standardize the ninth grade GPA to have a mean of zero and a standard deviation of one within each cohort. To account for any mechanical changes in the distribution by ability across schools due to increased cohort sizes and the structural composition of the student body within areas, we do not compare the R^2 to a baseline of zero spread, but instead to a randomized baseline. In our main specification, we obtain the randomized baseline by randomly reshuffling students to high schools within school districts 50 times and compute the average R^2 across these randomized specifications.[14] In supplementary analyses, we use the dissimilarity index—an alternative measure that has been used in the literature (e.g., Burgess et al. 2004)—to test the sensitivity of our conclusion to the measure of the distribution of students by ability. While the dissimilarity index might be more intuitive than our preferred measure, it is based on a binary indicator and thus cannot take the full variation into account. We construct a variable that takes the value of 1 if the student's GPA is below the cohort median. The supplementary analyses confirm that the results are not sensitive to the choice of metric.

[13] Examinations became mandatory for students in public schools in 2007. Although students were not required to take the tests prior to 2007, only a very small proportion of students did not (e.g., of all students in public school, only about 1% did not take the 2002 written examinations in Danish and mathematics).

[14] Appendix Table 5 shows the results from a model in which we use the raw data and calculate the R^2 without the permutation procedure. The specification without the randomization procedure produces results that are very close to the baseline estimates.

We follow Söderström and Uusitalo (2010) and calculate bootstrapped standard errors clustered at the high school level.

As we seek to disentangle the impacts of the policy on user sorting and selection among schools, we compare the distribution of ability in terms of those who apply for a specific school and those who end up being admitted. Unfortunately, student-level data on applications are available only for post-reform years (2009–2011). Nevertheless, by calculating the post-reform difference in the concentration of high-ability students at the school level between applications and admissions, we examine whether administrators at schools with excess demand are likely to cream-skim high-ability students.

Difference-in-Differences Specification

To obtain our difference-in-differences estimate, we first compute the average level of distribution by ability before and after 2007, separately for high and low competition areas. We then calculate the change in this average from pre- to post-2007, respectively, for low and high competition areas and, finally, subtract these two changes from each other to obtain the difference-in-differences estimate. It is worth noting that in this approach, each school receives a weight corresponding to its share of students. Giving each school the same weight does not change the conclusions and leads to almost identical point estimates.

Descriptive Statistics

Table 1 provides summary statistics for our full sample and for splits into pre- and post-reform periods and into high- and low-competition areas. Students are, on average, 16.6 years old when they enroll in high school. There is positive selection into high school: enrolled students have a ninth-grade GPA above their middle school cohort mean, and they tend to come from more advantageous socioeconomic backgrounds (i.e., parents with higher educations). In addition, there is a larger proportion of girls than boys. On average, there are 8.6 schools within a school district. The average size of a high school enrollment cohort is approximately 200 students, with substantial variation across schools. The average number of students is higher in the post-reform period, and the GPA is slightly lower, which indicates that more students enter high school in the post-reform period, particularly students from the lower part of the GPA distribution. We also see that the student composition is rather similar in high- and low-competition areas in both the pre- and post-reform periods. However, the average school size and number of schools in the district differ.

Table 1: Descriptive Statistics

	All schools		Low comp.	High comp.
	Mean	SD	Mean	Mean
A. All years 2003–2011				
Female	0.61	0.05	0.64	0.60
Ninth-grade GPA	0.67	0.14	0.65	0.68
GPA above cohort median	0.49	0.08	0.48	0.50
Parental years of schooling	14.21	0.54	13.97	14.38
Age at enrollment	16.62	0.13	16.66	16.59
High-competition area	0.58	0.50	0.00	1.00
Enrollment	207.11	62.78	186.89	221.59
Schools in school district	8.57	3.46	7.67	9.21
Unemployment rate (%)	4.82	0.99	5.05	4.66
Number of priorities used	1.72	0.70	1.23	2.08
1st priority/enrolled	0.84	0.16	0.85	0.84
B. Pre period 2003–2006				
Female	0.61	0.05	0.64	0.60
Ninth-grade GPA	0.72	0.11	0.72	0.73
GPA above cohort median	0.49	0.06	0.49	0.50
Parental years of schooling	14.13	0.49	13.95	14.26
Age at enrollment	16.59	0.14	16.65	16.55
High-competition area	0.58	0.50	0.00	1.00
Enrollment	177.01	52.31	161.69	187.98
Schools in school district	8.57	3.46	7.67	9.21
Unemployment rate (%)	5.5	1.28	5.81	5.27
C. Post period 2007–2011				
Female	0.61	0.05	0.64	0.60
Ninth-grade GPA	0.63	0.17	0.61	0.64
GPA above cohort median	0.49	0.09	0.47	0.50
Parental years of schooling	14.24	0.56	13.98	14.42
Age at enrollment	16.64	0.12	16.67	16.62
High-competition area	0.58	0.50	0.00	1.00
Enrollment	225.37	70.71	202.15	242.00
Schools in school district	8.57	3.46	7.67	9.21
Unemployment rate (%)	4.39	0.87	4.56	4.27
Number of priorities used	1.72	0.70	1.23	2.08
1st priority/enrolled	0.84	0.16	0.85	0.84
Number of schools	115		48	67

Notes: GPA above cohort median is an indicator of whether the ninth-grade GPA is above the median among high school entrants for this school year. Parental education is the average years of education among all household members aged 30 or older, measured two years before high school enrollment. The unemployment rate is the annual registered unemployment rate in the municipality of residence in the year of enrollment, from Statistics Denmark. Note that there is a data break in the unemployment data from 2006 to 2008.

RESULTS

Impact of a Quasi-Market on the Distribution of Students Across Schools

We present our results of the impact of the high school reform on the between-school variation in student ability first by comparing the trends in high- and low-concentration areas. As discussed in the theory section, the high school reform provided an incentive for schools in high-competition areas to compete for profitable students. Figure 2 shows the trend in segmentation by ability for the period 2003–2011 based on the raw R^2 scores. The identifying variation in our DiD model comes from a change in treatment intensity over time. The identifying assumption would be violated if the distribution in ability changed differently over time in low- and high-concentration areas in the absence of the reform. As the figure shows, the between-school variation is quite similar in both areas before the reform, indicating that the common trend assumption is valid.[15] After the reform, however, there is a sharp increase in the segmentation by ability in the highly competitive areas (black line), but not in the areas with low competition (gray line). The level of segmentation by ability is fairly constant within low-concentration areas over time—with no unusual jump—which provides evidence that the reform had a negligible effect on the distribution of students across schools in these areas. Figure 4, which is based on permuted scores where we account for potential random changes in the segmentation by ability as described in the measurement section, shows a similar pattern.

[15] Appendix Table 3 presents results from a placebo specification. We code year 2005 as if it were the treatment year and run the analysis similarly to the model in our main specification. The DiD estimate (lower-right corner of appendix Table 3) is close to zero and not statistically significant. This placebo test provides evidence that suggests the high- and low-competition areas did not change differently in the period before the reform, which also supports the validity of the common trend assumption.

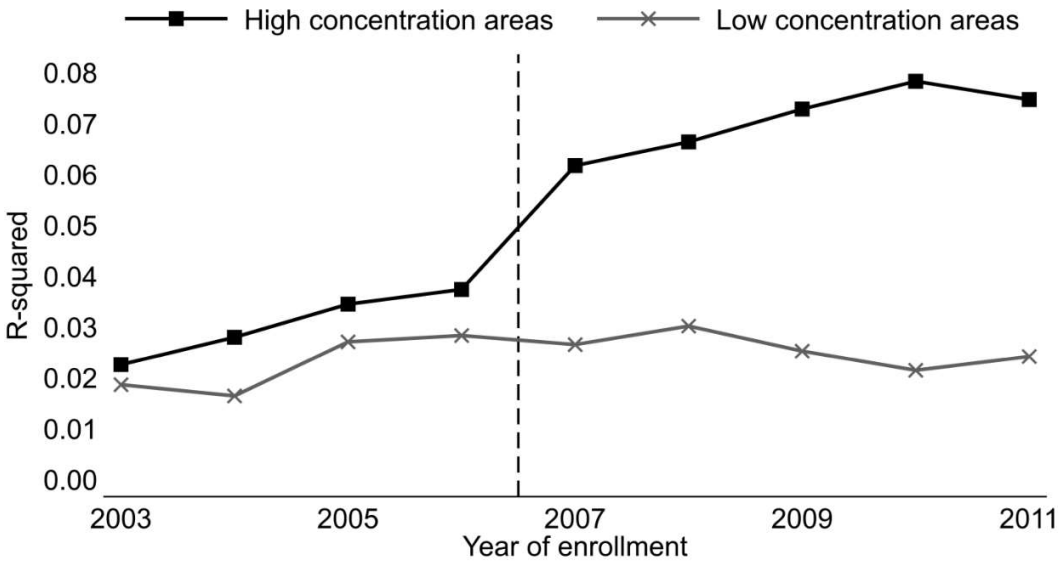

Figure 2: GPA segmentation 2003-2001

Notes: The connected lines are created as follows: For each year we regress ninth-grade GPA of enrollees on high school indicators, for low- and high-concentration areas, respectively. The connected lines plot the R-squared from these regressions.

Table 2 reports formal estimates of the effect of the reform on the distribution by ability from a differences-in-differences model. The results show that the between-school variance increases on average after January 2007 by 0.034 in high-competition areas. In contrast, we find little indication of changes in low-concentration areas, as the pre–post difference is small and not statistically indistinguishable from zero. The DiD estimate (lower right corner of Table 2) is positive and statistically significant, which suggests that competition influenced the distribution by ability across schools.

Table 2: Regression results. Segmentation by ability in high school student enrollment 2003–2011 using the R^2 approach.

	School concentration		
	High	Low	Difference (high-low)
Years 2003–2006	0.021	0.010	0.010 (0.005) [0.027]
Years 2007–2011	0.055	0.013	0.042 (0.012) [<0.001]
Difference (post-pre)	0.034 (0.009) [<0.001]	0.003 (0.002) [0.113]	0.032 (0.009) [<0.001]

Note: The table shows the difference in R^2 between regressing middle school GPA of actual enrollment cohorts on high school indicators and regressing 50 permutated cohorts on high school indicators. High/Low concentration is based on the number of schools within 20 km. Bootstrapped standard errors clustered on the high school level based on 200 iterations are shown in parentheses. P-values in brackets.

Robustness analysis

To study the sensitivity of our results, we assessed several alternative specifications. Table 3 shows results for an alternative measure of segmentation by ability (dissimilarity index), which generates results that are qualitatively similar to our main specification. Prior to the reform, the dissimilarity index was about 0.11 in high-competition areas, which indicates that one should move 11 percent of the students to achieve an equal distribution across schools. After the reform, the dissimilarity index increased to 0.16 in high-concentration areas, while it was essentially unchanged in low-concentration areas. Again, the DiD estimate (lower right corner of Table 3) is positive and statistically significant, which suggests that the level of school separation by ability increased markedly.

Table 3: Regression results. Segmentation by ability in high school student enrollment 2003–2011 using the dissimilarity index.

	School concentration		
	High	Low	Difference (high-low)
Years 2003–2006	0.108	0.076	0.032
			(0.013)
			[0.018]
Years 2007–2011	0.155	0.082	0.073
			(0.020)
			[<0.001]
Difference (post-pre)	0.047	0.005	0.042
	(0.010)	(0.006)	(0.011)
	[<0.001]	[0.378]	[<0.001]

Note: The table shows the Dissimilarity Index for high- and low-concentration areas before and after the reform based on the number of schools within 20 km. Bootstrapped standard errors clustered on the high school level based on 200 iterations are shown in parentheses. P-values in brackets.

Figure 3 presents estimates for a set of supplementary analysis results in which both the 20 km criteria used in the main specification and an alternative competition metric based on a 5 km distance are used. We also vary the criteria for high-concentration areas using the 25th percentile and the 75th percentile in addition to the median (used in our main specification). Figure 3 shows that the results are very similar when we use the 5 km and the 20 km criteria across different criteria for high-concentration areas. Figure 3 also shows that the DiD coefficient is larger when we split by the 75th percentile instead of the median, whereas it becomes smaller (but still significant) when we split by the 25th percentile. Finally, Appendix Figure 1 shows a similar pattern across different distance criteria and criteria for high-concentration areas when the dissimilarity

index is used. These supplementary results demonstrate that the findings are robust across specifications and, perhaps more interestingly, that effects are driven by highly competitive areas.

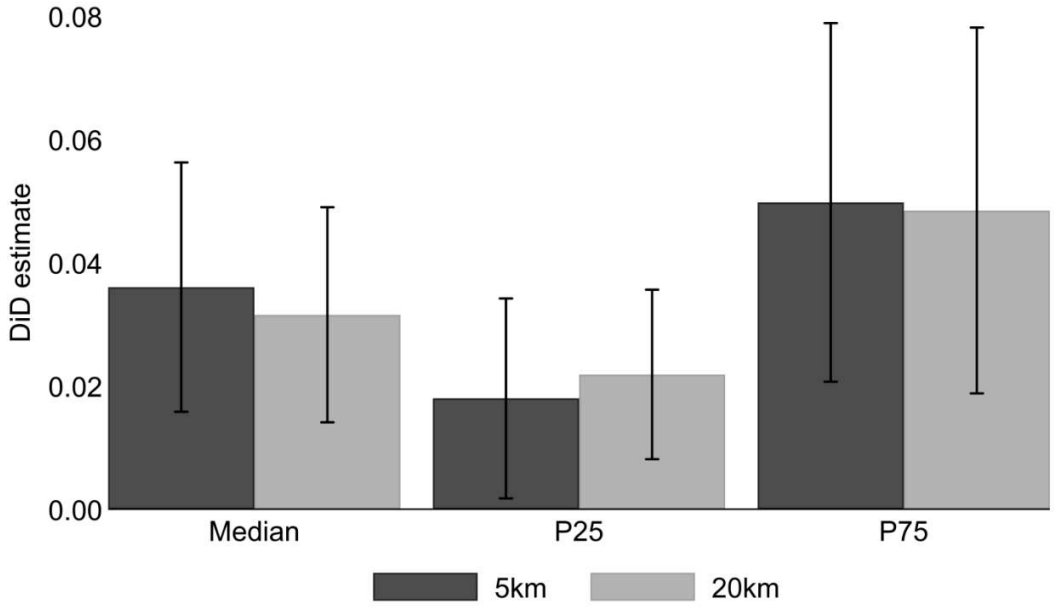

Figure 3: DiD estimates using alternative specifications

Notes: The estimates are based on the R-squared approach with 50 permuations. The lines show the 95 percent confidence intervals based on 200 bootstrap iterations clustered at the school level.

Demand-Side Driven Student Sorting or Supply-Side Driven School Selection?

For theoretical as well as political implications, it is important to understand the factors driving the changes in segmentation by ability across schools. The increased segmentation by ability as a response to the policy in areas with high competition—as shown above—could be explained by either students' sorting (encouraged by the schools or not) into schools or by over-subscribed schools systematically selecting certain students (as discussed in the theory section).

Figure 4 compares segmentation by ability in terms of those who apply for a specific school and those the schools end up admitting based on the permuted R^2 approach. Whereas seg-

mentation by ability in applications and enrollees is very similar in low-concentration areas, segmentation by ability is larger measured by actual admission than by applications in high-concentration areas in the three years following the reform. This difference is significant in all three years (not shown). Although we cannot rule out that similar patterns were present prior to the reform, the post-reform difference in segmentation by ability between applications and admissions in high-concentration districts may suggest that administrators at schools with excess demand cream-skim high-ability students. Overall, these findings indicate that the effect is driven not only by student sorting but also by over-subscribed schools selecting the highest-performing students.

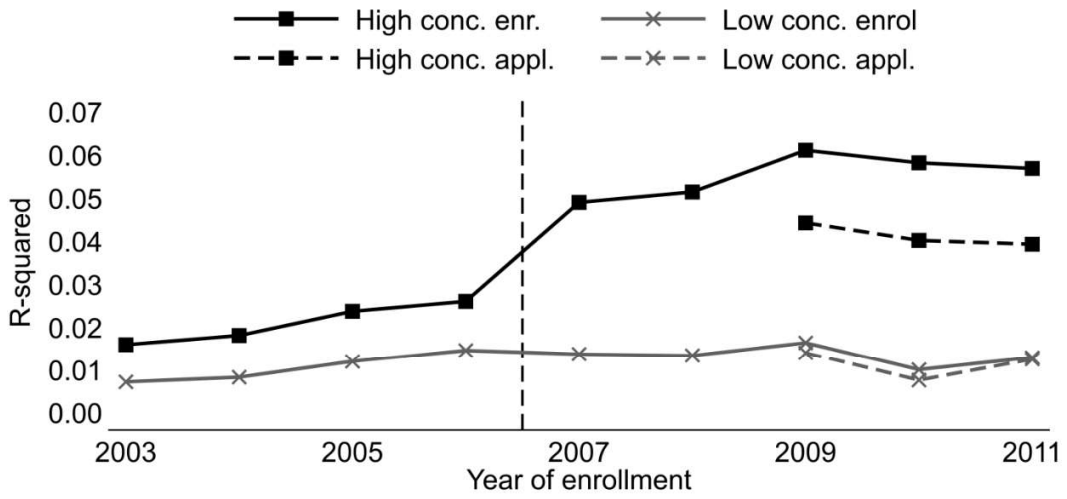

Figure 4: GPA segmentation in intake and applications 2003-2011

Notes: The connected lines are created as follows: First, for each year we regress ninth-grade GPA of enrollees/applicants on high school indicators, for low- and high-concentration areas, respectively, and save the R-squared Second, we randomly reallocate students to schools within the district, keeping school size constant. For each randomized allocation of students, we again regress ninth-grade GPA on high school indicators and save the R-squared. The connected lines plot the difference in the R-squared between the actual and the randomized allocation of students.

DISCUSSION OF POSSIBLE MECHANISMS AND POLITICAL RESPONSES TO STRATEGIC BEHAVIOR

As cream-skimming only explains part of the segmentation by ability, the findings suggest that part of the segmentation persisted because of students' self-selection into schools. Such a pattern

could in part be a consequence of schools' increased focus on marketing and attracting students. Although we cannot provide conclusive evidence on the mechanism, some descriptive and anecdotal evidence suggests that the reform changed the managerial focus in the schools. The increased focus on competitors and toward attracting students—as documented by Hansen (2011) and Hansen and Jacobsen (2016)—provides suggestive evidence on the role of managers and the change in managerial behavior in response to the 2007 reform. Specifically, surveys conducted among Danish high school managers pre- and post-2007 reform showed a large increase in the use of management tools such as customer analysis, analysis of market position compared to competitors, and marketing plans focused on attracting potential students (Hansen 2011). Similarly, a qualitative study, which interviewed the managers at five high schools in 2003, 2008, and 2012, found that the reform led to a stronger orientation toward attracting students (Hansen and Jacobsen 2016). These studies may suggest that the pattern in student sorting is partly a consequence of schools' increased focus on marketing and the attraction of students. Thus, even though application patterns partly explain the distribution by ability, we cannot rule out that this pattern occurs because of strategic behavior from the providers.

The findings also shed light on the circumstances under which strategic responses arise. Cream-skimming occurs because providers have control over the admission process through which applicants are allocated. This finding emphasizes the importance of the way in which the quasi-market is designed and the formulation of the specific rules governing the market. Given that elected officials are far from the frontline, they may have a limited understanding of the opportunities that service providers have to "game" the policy. Consequently, prior to the implementation, it may be difficult for elected officials to fully anticipate such strategic responses. However, policymakers may monitor the agents' behaviors after the introduction of the policy.

Such information about the implementation may reveal the nature and extent of strategic behavior.

In response to revealed strategic behavior, rather than eliminate the incentives system, policymakers may exploit this information and take measures to reduce the risk that the agents can game the system (for a discussion, see Kelman and Friedman 2009). First, the policymaker may introduce additional regulations (e.g., procedural rules) that limit the agents' opportunities to game the system. To avoid cream-skimming, one could regulate the selection enrollment process and allow little discretion for schools in order to limit their control over the allocation of students (Le Grand 1991). Second, policymakers could also alter the scheme by which schools are funded and introduce a weighting scheme so that schools receive higher funding for students who are expected to be difficult to serve (Ladd and Fiske 2001). Although weighting based on educational history or socio-economic background may increase incentives for schools to enroll less capable students, it may also introduce incentives to attract other types of students who are profitable under this new system.

In the Danish case, the government did modify the admission rules in 2012 and limited the extent to which schools could control the allocation of students in the admission process. With effect from March 2012, a national law stated that the committees were required to use the travel distance between the student's home address and the high school as the main criteria for assigning students to high schools. Although the revised law still leaves some room for discretion—such as the possibility to calculate the travel distance in different ways—it constitutes a sharp reduction in the ability of schools to select certain types of students. This may suggest that governments are able to take the necessary steps to cope with strategic behavior. However, the fact that application

patterns explain part of the change in the distribution by ability across schools suggests that limiting the possibility for cream-skimming might not fully offset the increase in concentration by ability—irrespective of whether this was the intention of the policymakers or not. Indeed, increased concentration by ability could have been an intended consequence of the studied policy, but the fact that the government took remedies to limit the distributional effects of the reform suggests that concentration by ability was not an intended consequence of the reform.

CONCLUSION

Quasi-markets that combine user choice, activity-based funding, and managerial autonomy have become a common way of organizing the provision of public services. However, if a substantial proportion of funding is allocated on the basis of a fixed amount of funding per user, providers can benefit financially by attracting, selecting, and maintaining profitable users.

In this study, we contribute to at least two literatures. First, we contribute to the literature on strategic behavior among public organizations by studying (strategic) responses to the introduction of quasi-market policies. In particular, we study the responses to a nationwide policy initiative in Denmark that made high school funding depend almost entirely on activity and increased school autonomy. The findings of the analysis suggest that the introduction of the quasi-market led to a more segmented composition of users in terms of ability. The study also shed light on the mechanism driving the increased segmentation by ability, though we cannot provide conclusive evidence. The variation in distribution by ability across schools appears to be explained by both student sorting—which may in part be due to strategic behavior among schools, as suggested by previous qualitative studies—and schools responding to the reform by

selecting high-ability students among their applicants, as indicated by our post-reform application data. Second, we also contribute to the literature on cream-skimming. The results also suggest that cream-skimming not only occurs at the front line, as shown in previous studies (e.g., Tummers 2016; Andersen and Guul 2019; Van Loon and Jakobsen 2017; Soss, Fording, and Schram 2011; Baviskar 2018) but also as an organizational response to increased competition among providers.

Whether distribution of students based on academic abilities is desirable is ultimately a political question. Nevertheless, statements from the politicians involved in the current reform—as well as their reactions to the revelation of potential cream-skimming—suggest that increased concentration of high-ability students was not an objective of the reform. Increased concentration of low-ability students in some schools could have detrimental effects. While the effects of increased segmentation by ability are not straightforward, it may be problematic for at least two reasons. First, serving the least capable clientele is possibly more demanding, and thus, the providers with the least capable users might not be able to deliver the same level of service as the providers with the most advantaged users. Second, more user segmentation might increase initial differences in abilities by negative or positive peer effects. In sum, user segmentation might ultimately widen the gap between users with high and low resources. Ensuring that all individuals, irrespective of their background, experience positive outcomes is often a main argument for the provision of public rather than private service (Boyne et al. 2003; Frederickson 1990; Le Grand 1982). Our identification strategy points to the important moderating role of market structures, as we find that the increase in segmentation by ability occurred merely in areas with a high concentration of schools. Importantly, the areas with a high concentration of

providers—where we see effects on the distribution by ability—are also where one would expect the highest gains in efficiency. This finding suggests that increased competition associated with quasi-market structures may have effects other than the suggested gains in efficiency.

The role of market structures also points to limitations regarding the generalizability of our findings. Thus, we would only expect to find similar segmentation effects of quasi-market policies in high-competition areas. In addition, our study is situated in the Danish public high school setting. Introducing quasi-market policies in other geographic areas and other types of services might have different effects. For instance, in other service areas, user ability is less easy to observe, rendering cream-skimming in the enrollment decision more difficult. However, cream-skimming may still occur based on other observable dimensions, such as ethnicity (e.g., Andersen and Guul 2019; Jilke, Van Dooren, and Rys 2018). Furthermore, the clientele might be less susceptible to strategic communication from the providers, and some services depend less on distance from the provider (e.g., several utility services). Ultimately, we acknowledge that it remains an empirical question for future studies whether similar effects of quasi-market policies occur under different circumstances.

Another important aim for future research is to study the dynamic nature of public sector reforms. Specifically, policymakers could take measures to mitigate strategic behavior such as cream-skimming. Even if a policy (unintentionally or not) leads to increased segmentation and strategic behavior at first, it is important to understand whether these effects persist over time. As argued by Heinrich and Marschke (2010), policymakers often design incentive systems with an imperfect understanding of agents' means for influencing the measures underlying a specific incentive system. However, given that strategic behavior is revealed ex post, policymakers could modify the system and take measures to mitigate such behavior after the

initial implementation of the policy. Thus, one task for future research is to examine if elected officials are merely passive or if they are responsive in terms of adopting new policy tools in response to revealed strategic behavior. Future research should study the impact of a decrease in the providers' autonomy to control the intake of users. Finally, as we also concluded in the literature review, it remains an open question for future research whether competition indeed increases the quality of service.

Overall, this study suggests that the use of quasi-market competition may lead to increased segmentation of users by ability. Quasi-markets may have effects on the segmentation of users by ability because managers and frontline workers have discretion in the allocation of users and an understanding of how the system works. This study provides compelling theoretical arguments for a distinction between demand-side and supply-side drivers of increased segmentation by ability, as well as empirical evidence in support of such effects of quasi-market policies. We emphasize that researchers as well as policymakers should be aware of these potential effects and develop and manage quasi-markets if they want to avoid the consequences in the future.

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DATA AVAILABILITY STATEMENT

Data for this research are stored on a secured server hosted by Statistics Denmark. Due to the sensitivity of the data, they cannot, according to the rules of Statistics Denmark, be made publicly available. We have uploaded all the Stata files used in this project to a Github repository: https://github.com/hhsievertsen/quasi_market_student_segregation and uploaded them with the manuscript. Thus, while we cannot share the data files due to confidentiality by Statistics Denmark, the Stata do-files allow any researcher to assess our methods. Moreover, any researcher with access to Statistics Denmark can replicate our findings using these files.

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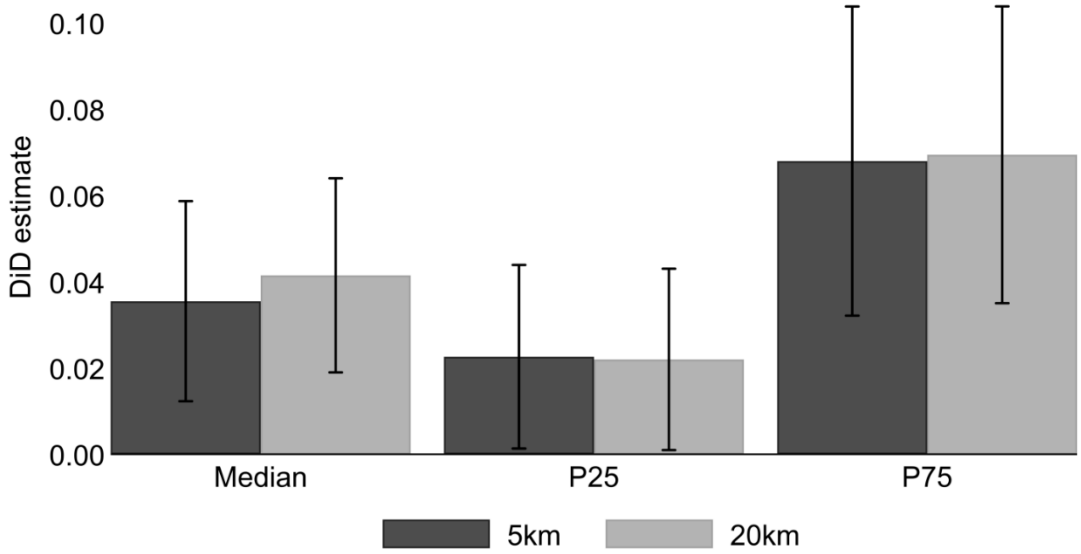
APPENDIX



Appendix Figure 1: DiD Dissimilarity Index estimates using alternative specifications

Notes: The estimates are based on the Duncan Dissimilarity Index approach. The lines show the 95 percent confidence intervals based on 200 bootstrap iterations clustered at the school level.

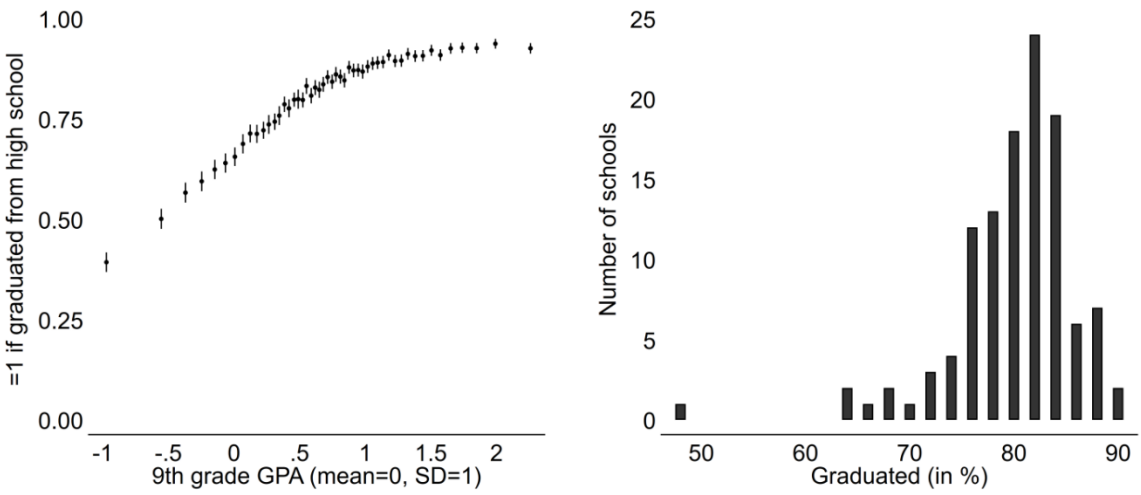
Appendix Table 1: Sample Selection

	Schools	Students
All students enrolled in high schools 2003–2011	156	235,319
Private high schools and other unaffected institutions	-14	-10,381
School not observed in all years	-25	-9,892
Unknown school district	-2	-2,013
Student 9th-grade GPA not observed	0	-5,639
Analysis Sample	115	207,394
(percent of raw sample)	(74%)	(88%)

Appendix Table 2: Regression results. Predicting high school performance

	Dependent variable	
	Graduated HS	HS GPA (SD)
A. Middle school GPA		
GPA (SD)	0.167	0.927
	(0.003)	(0.004)
	[<0.001]	[<0.001]
R^2	0.0795	0.495
B. Parental schooling		
Years of schooling	0.022	0.092
	(0.001)	(0.003)
	[<0.001]	[<0.001]
R^2	0.0139	0.0558
Mean of dep. var.	0.797	0.073

Note: The table shows the estimation results regressing the variables denoted in the column headers on a constant and, respectively, the middle school GPA (Panel A) and parental education (Panel B). The data are based on all cohorts enrolled in the years 2003–2006. Standard errors clustered on the high school level are shown in parentheses. P-values in brackets.



(a) Ninth-grade GPA and high school graduation

(b) Distribution of graduation rates across institutions

Appendix Figure 2: Variation in graduation rates

Notes: Graduation is defined as graduating within three years after enrollment in the same institution. Non-graduation, therefore, includes students who move institution, students who take longer to graduate (possibly because of special programs), and students who drop out. All students who enrolled in an institution included in the main analysis in the years 2003 to 2006 are included. In Figure (a) each marker shows the average graduation rate for two percent of the sample sorted by ninth-grade GPA, and the lines show the mean +/-2 times the standard error.

Appendix Table 3: Regression results. Placebo test of distribution by ability in high school student enrollment 2003–2006 using the R^2 approach.

	School concentration		
	High	Low	Difference (high-low)
Years 2003–2004	0.017	0.008	0.009*
			(0.005)
			[0.045]
Years 2005–2006	0.025	0.013	0.011
			(0.008)
			[0.134]
Difference (post-pre)	0.008	0.006*	0.002
	(0.005)	(0.003)	(0.007)
	[0.133]	[0.028]	[0.777]

Note: The table shows the difference in R^2 between regressing middle-school GPA of actual enrollment cohorts on high school indicators and regressing 50 permutated cohorts on high school indicators. High/Low concentration is based on the number of schools within 20 km. Bootstrapped standard errors clustered on the high school level based on 200 iterations are shown in parentheses. P-values in brackets.

Appendix Table 4: Regression results. Distribution by ability in high school student enrollment 2003–2011 using R^2 approach – unbalanced sample.

	School concentration		
	High	Low	Difference (high-low)
Years 2003–2006	0.021	0.010	0.011*
			(0.005)
			[0.021]
Years 2007–2011	0.055	0.013	0.043*
			(0.013)
			[<0.001]
Difference (post-pre)	0.034*	0.003	0.032*
	(0.009)	(0.002)	(0.010)
	[<0.001]	[0.136]	[<0.001]

Note: The table shows the difference in R^2 between regressing middle-school GPA of actual enrollment cohorts on high school indicators and regressing 50 permutated cohorts on high school indicators. High/Low concentration is based on the number of schools within 20 km. Bootstrapped standard errors clustered on the high school level based on 200 iterations are shown in parentheses. P-values in brackets.

Appendix Table 5: Regression Results. Distribution by ability in high school student enrollment 2003–2011 Using R^2 approach – not permuted.

	School concentration		
	High	Low	Difference (high-low)
Years 2003–2006	0.031	0.023	0.008
			(0.006)
			[0.151]
Years 2007–2011	0.071	0.025	0.045*
			(0.014)
			[0.001]
Difference (post-pre)	0.040*	0.003	0.037*
	(0.010)	(0.002)	(0.011)
	[<0.001]	[0.230]	[<0.001]

Note: The table shows the difference in R^2 between regressing middle-school GPA of actual enrollment cohorts on high school indicators and regressing permutated cohorts on high school indicators. High/Low concentration is based on the number of schools within 20 km. Bootstrapped standard errors clustered on the high school level based on 200 iterations are shown in parentheses. P-values in brackets.