A Welfare Analysis of School Choice Reforms in Ghana*

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Abstract

Do school choice programs increase opportunities for educational mobility or reinforce initial disparities in schooling? I address this question in the context of the public education system in Ghana, which uses standardized tests and a nation-wide application process to allocate 150,000 elementary school students to 650 secondary schools. As has been found in other settings, students from lower-performing elementary schools in Ghana apply to less selective secondary schools than students with the same test scores from higher-performing elementary schools. I consider four potential explanations for this behavior: differences in decision-making quality, imperfect information about admission chances, costs and accessibility of schooling, and preferences for school quality. I use detailed data from three cohorts of applicants to evaluate the relative importance of these explanations. My analysis suggests that differences in application behavior are largely due to poor decision-making and incorrect beliefs about admission chances, rather than differences in preferences or the costs and accessibility of schools. Additionally, I show that the effects of a series of reforms in the application process that expanded the number of choices students could list, and encouraged students to select a "diversified" portfolio of schools can both be explained as a consequence of uncertainty in the Ghanaian choice system.
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1 Introduction

Over the last decade, there has been growing emphasis on the importance of expanding access to education in developing countries. However, policy discussions and academic research in this area have primarily focused on eliminating disparities in enrollment rates, with less attention paid to differences in the quality of education that various students receive. In addition to ensuring universal enrollment, one potentially desirable feature of an education system is that it allow for educational mobility - that talented or motivated students who begin their educational careers in low-quality schools have an opportunity to transfer into a higher-quality schools as they progress through the educational system.

This paper examines inequalities in access to education and analyzes whether merit-based school choice programs promote educational mobility or reinforce initial disparities in schooling. I study this issue in the context of secondary school education in Ghana. Like many developing countries, Ghana has a centralized application system in which admission to secondary school is based on students' academic merit. Consistent with findings from other settings, I observe that students from low-performing elementary schools in Ghana apply to less selective secondary schools than students from high-performing schools with the same admission chances. I consider four potential explanations for this finding: differences in decision-making quality; incorrect beliefs about admission chances due to incomplete information; prohibitive costs and accessibility of attending high-quality secondary schools; and differences in preferences for school quality. Two features of the Ghanaian choice system potentially magnify the importance of imperfect information. First, students can only apply to a limited number of schools. Second, students have to submit their applications before they know their test scores. Drawing on insights from a model of optimal portfolio choice developed by Chade and Smith (2006), I use detailed data from three cohorts of applicants to evaluate the relative importance of these distinct hypotheses and conclude that differences in students' application behavior largely result from imperfect information rather than differences in preferences.

I use three complementary strategies in my empirical analysis to investigate why students with the same academic potential make different application choices. First, I examine the role of decision-making quality: are students from low-performing schools making mistakes in their application decisions? I explore this hypothesis by outlining a model of the school choice problem facing students and measuring whether students use the optimal choice strategy. I find that students from low-performing schools are less likely to use the optimal strategy and are subsequently less likely to gain admission to selective secondary schools. This analysis suggests that the complexity of the application process may be a key source of inefficiency in the Ghanaian application system.

Next, I test whether differences in students' beliefs about their admission chances can account for the differences in their application behavior: do students from low-performing schools underestimate their admission chances? I present a normal learning model in which students form expectations about their admission chances based on a signal their individual ability and the average ability of students in their elementary school. Intuitively, high-performing students from low-performing schools will under-estimate their admission chances while low-performing students from high-performing schools will over-estimate their admission chances. To test the explanatory power of this theory, I estimate students' posterior beliefs about their ability using the assumptions of the normal learning model. I then compare application decisions of students from low-performing and high-performing schools with the same beliefs about their ability and find that the differences in application behavior diminish substantially. Thus, imperfect information about admission chances appears to account for a large part of why talented students from low-performing schools apply to less selective secondary schools.

Finally, I examine the last two hypotheses: do schooling costs and distance prevent students from low-performing schools from applying to more selective schools; and do students from low-performing schools place a lower value on school quality? To investigate these two hypotheses, I use a discrete choice model to evaluate students' preferences for a range of school characteristics including cost, proximity and academic performance. I find that students from lower-performing elementary schools are more likely to apply to schools within close proximity and to public schools instead of private ones. However, students from lower-performing schools are no less likely to apply to prestigious secondary schools. This analysis implies that heterogeneity in preferences does not fully explain why talented students from low-performing schools do not apply to more selective schools. Rather, the first two explanations - differences in decision-making quality and beliefs about admission chances, seem to be relatively more important factors in accounting for differences in application behavior.

A testable prediction of these initial findings is that simplifying the application process or providing additional information and guidelines should encourage students from low-performing elementary schools to apply to a more selective set of secondary schools. To validate this prediction, I use variation from two recent policy reforms in Ghana to examine whether changes in the application process can reduce inequalities in access to education. The first reform increased the number of secondary schools that each student could list. The second reform assigned secondary schools into four categories based on their available facilities and restricted the number of schools that a student could select from each category. These restrictions effectively encouraged students to apply to a more diversified set of schools. Using a difference-in-differences approach to analyze the effect of each reform, I find that both reforms decreased the difference in selectivity of schools chosen by students from high-performing and low-performing elementary schools, which suggests that application and admission rules play a significant role in explaining differences in application behavior. Moreover, these results are consistent with a setting in which imperfect information has a strong impact on students' choices.

My analysis of the Ghanaian high school application system has direct implications for efforts to understand educational mobility in alternative contexts because it addresses a set of fundamental research and policy questions. The phenomenon that talented students from low-performing schools typically under-apply is evident across various settings and has been particularly well-documented with regard to college applications in the United States (Manski and Wise (1983); Avery and Kane (2004); and Bowen, Chingos and McPherson (2009) highlight this issue). This phenomenon raises concerns because there is substantial evidence that attending a more selective school may improve outcomes for high-achieving students and could reduce socio-economic differences in the long run (for examples studying the secondary school context, see Clark (2007), Pop-Eleches and Urquiola (2008), and Jackson (2009) on the returns to peer quality in merit-based systems; Cullen, Jacob and Levitt (2005, 2006), Hastings, Kane and Staiger (2008), Deming (2010) in lottery-based systems; and Duflo, Dupas and Kremer (2008) on the benefits of academic tracking).

This paper also builds on a growing literature on school choice under constraints. High school admission in Ghana is based on students' academic merit but there are two frictions in the application process: 1) students can only submit a limited number of applications and 2) students have incomplete information about their admission chances.[1] The result is that students must solve a complex optimization problem under uncertainty. A set of recent studies model this problem of constrained choice with incomplete information (Chade and Lewis (2006); Chade, Lewis and Smith (2008); Nagypál (2009); Haeringer and Klijn (2009)). Additionally, Calsamiglia, Haeringer and Klijn (2010) test several theoretical predictions in an experimental setting. Altogether, these studies provide a useful foundation for further empirical work and this paper incorporates their insights into an analysis of observational data.

Finally, this study relates to discussions in the mechanism design literature on issues of school choice reform and student welfare. Studies in this literature have primarily evaluated the efficiency and stability of assignment mechanisms (see Roth and Peranson (1999) and Abdulkadiroğlu and Sönmez (2003) for representative examples). However, there is growing interest in analyzing issues of equity and the distribution of welfare for students from different backgrounds, particularly in choice mechanisms which reward strategic behavior but where the optimal strategy is unclear. In such cases, a policy reform which simplifies the choice problem could serve as an equalizing intervention and provide more equitable opportunities for disadvantaged participants (see Abdulkadiroğlu, Pathak, Roth and Sönmez (2006) and Pathak and Sönmez (2008) for a discussion of strategic behavior under the assignment mechanism originally used by Boston public schools and Lai, Sadoulet and de Janvry (2009) for a related analysis of high school applications in Beijing). A complementary set of studies demonstrate how information provision can lead to large changes in schooling choices

[1] Similar conditions apply in several other settings. Comparable merit-based systems are used for secondary school admission in other countries including Kenya, Romania, and Trinidad and Tobago and for college entry in Canada and Mexico. Students often apply to schools before knowing their test scores or can only submit a fixed number of applications. Additionally, there are strong parallels between these contexts and the context of college choice in the US: students apply to a conservative number of schools because of application costs (both in terms of time and money); and students are relatively uncertain about their admission chances because admission is partly based on measures of students' academic performance which may be known at the time of applying (e.g. SAT/ACT scores and high school GPA), but also on assessments of other background information (such as personal statements, extracurricular activities and recommendation letters).

(Hastings and Weinstein (2008); Jensen (2010)). Although these studies suggest that school choice reforms can increase educational mobility, there is little direct evidence to support this hypothesis in merit-based admission settings.[2]

The paper proceeds as follows: Section 2 provides an institutional background on secondary school admissions in Ghana. Section 3 describes the administrative data used in this study and illustrates the differences in application behavior and admissions outcomes of students from high-performing and low-performing elementary schools. Section 4 formalizes the school choice problem in a theoretical model and motivates my empirical analysis. The next three sections examine potential hypotheses for differences in application behavior: Section 5 compares the decision-making quality of students from high-performing and low-performing elementary schools; Section 6 examines how imperfect information affects application choices; and Section 7 evaluates whether students have heterogeneous preferences for school characteristics. Building on the preceding analysis, Section 8 estimates the impact of two school choice reforms in Ghana using a difference-in-differences strategy. The final section concludes with a discussion of the results and their main implications.

2 Institutional Background

Compulsory education in Ghana consists of six years of primary school and three years of junior high school (JHS). At the end of junior high school, students compete for admission to senior high school (SHS). There are over 9,000 JHSs in the country but approximately 650 SHSs with only half the capacity of JHSs so spaces in senior high school are severely limited. The government has made some efforts to increase the number of SHSs in the country, but there remains substantial variation in school quality.

2.1 The Computerised School Selection and Placement System

Application to senior high school is centralized through a computerized school selection and placement system (CSSPS) which was introduced in 2005 (Box 1 outlines the system). Admission of JHS students into SHS is based on students' ranking of their preferred program choices and their performance on the Basic Education Certificate Exam (BECE) which is a nationally administered exam. Choices are often the result of discussions between students and their parents, teachers or friends. However, I refer to the student as the decision-maker throughout this paper for simplicity.

In practice, admission under the CSSPS occurs through the following process:

[2] MacLeod and Urquiola (2009) develop a theoretical model which predicts that competition in school choice systems will lead to socio-economic stratification if admission is merit-based. This prediction is consistent with the empirical patterns I find in the Ghana. Additionally, Avery (2009) presents results from a pilot study which offered guidance counseling to a randomly selected group of high-achieving low-income students and finds suggestive evidence that the intervention had positive effects in students' college application choices and admission outcomes.

1. Students submit a list of ranked choices (stating a secondary school and an academic track within that school for each choice)

2. Students take the standardized entrance exam

3. Students who perform well enough to qualify for admission to SHS are admitted to a school[3]

On average, less than half of all candidates receive a sufficient grade in the BECE to qualify for admission to SHS. Qualified students are assigned in merit order to the first available school on their list and schools admit students up to their capacity. (See Appendix for a more detailed description of the *deferred acceptance algorithm* which the CSSPS uses for student assignment.) Students who do not gain admission to any of their chosen schools are administratively assigned to an under-subscribed school with available spaces. Efforts are made to place students in their home district or region wherever possible but there is limited regard for students' stated preferences.

A notable aspect of the Ghanaian school choice system is that students have to submit their applications before taking the entrance exam. Therefore, students have incomplete information about their admission chances even though admission is based on test scores. Moreover, cutoffs are endogenously determined by the quality of applications to a given school since schools only define the number of spaces available that year, but not the explicit test score required for admission. Thus, the application process is characterized by a substantial amount of uncertainty.

Finally, students can only submit a limited number of choices. The number of permitted choices has increased since the CSSPS began in 2005 but the number is still restricted. Students were allowed to list up to three choices in 2005 and 2006, this increased to four choices in 2007 and to six choices in 2008. Between 95 and 99 percent of students listed the full number of choices in each year, which suggests that the constraint is indeed binding and that a vast majority of students would prefer to list more schools if permitted.

2.2 The Application Decision

The CSSPS issues a handbook which provides limited advice to students about their selection of schools. First, the guidelines specifically instruct students to be truthful about their *ordering* of choices, urging that "choices must be listed in order of preference" (p.5). However, the handbook also emphasizes that applicants should make a calculated application decision because they are only allowed to list a limited number of choices and are not guaranteed admission to any particular default school:

[3]The requirements for admission to SHS are that students receive a passing grade in the four core subjects (Mathematics, English, Integrated Science and Social Studies) as well as in the two additional subjects required for the program they intend to pursue. Available programs include: General Arts, General Science, Agriculture, Business, Home Economics, Visual Arts and Technical Studies.

> Parents should take the registration exercise seriously and select schools where their wards chances of admission are brightest. Over-estimation and under-estimation of candidates' academic capabilities should be avoided. (p.9)

In outlining the Roles and Responsibilities of Candidates, the document states that "[c]andidates must assess their chances of gaining admission into very competitive Senior Secondary schools" and concludes that "[it] is therefore important to make realistic choices in order to make the new system effective" (p.10-11). The CSSPS handbook therefore emphasizes that certain students could benefit from choosing their *set* of listed schools carefully.

Thus, students receive two primary instructions: to carefully consider their admission prospects when selecting schools and to rank selected choices truthfully.

3 Data

I use two main types of data to analyze application behavior in Ghana: 1) CSSPS administrative data on student background characteristics, entrance exam scores, choices, and admission outcomes, and 2) supplementary data on school characteristics, including a standardized measure of schools' academic performance.

3.1 Student Information

CSSPS data cover the universe of students who applied to public and participating private secondary education institutions in Ghana between 2005 and 2009 and report each student's ranked list of secondary school choices. [4] The data also include the aggregate BECE score and the name and location of secondary school for the set of students who qualified for admission. The school selection forms collect limited background information on each candidate but provide the name and location of the junior high school they attended. Table 1 presents some descriptive statistics.

For the majority of my analysis, I focus on the 85 percent of students who attended public junior high schools because these students are most likely to comply with their senior high school assignments instead of opting to attend one of the few elite private schools which have independent admission procedures but are substantially more expensive. I convert BECE scores into percentiles because a student's relative performance in a given year determines her admission chances. To examine the extent of educational mobility, I define higher-performing elementary schools as those

[4] The data are especially informative because virtually all students submit a complete list. This is a remarkably high participation rate compared to most school choice programs which have been studied in the US. For example, less than 50 percent of students in Boston Public Schools listed the full number of available choices in Abdulkadiroğlu, Pathak, Roth and Sönmez's (2006) study and 40 to 60 percent did in Charlotte-Mecklenburg Public Schools (Hastings, Kane and Staiger, 2008). This comprehensive coverage of applications allows me to compare students from a wide range of backgrounds and to examine the general equilibrium effects of Ghana's policy reforms.

where the average BECE score is above the median average for all schools in the country. Similarly, lower-performing schools are those with below-average performance. Evidence that students incorrectly estimate their admission chances can be seen in the prevalence of administrative assignments: 22 percent of students received an administrative assignment in the first year of the program; however, this share decreased over time and fell to 2 percent in 2009.

3.2 School Characteristics

I supplement the CSSPS student data with information on school characteristics. The Ministry of Education maintains a register of schools which is updated each year to provide information on each school's location and to indicate whether a school is public or private and single sex or coeducational. The secondary school register also provides information on whether schools are day or boarding, technical or academic, and lists the types of programs offered and number of vacancies in each program. Finally, I obtained school-level distributions of grades in the Secondary School Certificate Examination (SSCE) for each of the four core subjects (English, Mathematics, Social Studies and Integrated Science). The SSCE is taken at the end of secondary school and used for admission to university. It is also centrally administered to students at a national level so exam scores are therefore comparable across schools. Students must receive a grade of A to E in each of the four core subjects in order to pass the exam. I use the average percentage of students receiving a grade of A to E in each subject as an index of academic performance. There is substantial variation in school quality with some schools having a close to 100 percent pass rate and others producing not a single successful candidate. Table 2 summarizes the senior high school data.

3.3 Evidence of Systematic Differences in Application Behavior

As Figure 1 illustrates, there is a strong correlation between the choices of students who attend the same junior high school. In particular, for a given test score, a student from a relatively high-performing JHS applies to a more selective school than a student from a relatively low-performing JHS. Additionally, students from high-performing schools are admitted to more selective senior high schools than students from lower performing junior high schools with the same test score. Overall, higher-performing students are less likely to get an administrative assignment. However, students from higher-performing schools are more likely to get an administrative assignment than students with the same test scores from lower-performing junior high schools (Figure 2). To more systematically analyze decision-making behavior in the Ghanaian secondary school application system, I outline a formal model of the school choice problem in the next section.

4 School Choice Model

4.1 Setup

Following Chade and Smith (2006), I model the application decision in terms of a portfolio choice problem. Consider a finite set of students $I = \{1, \cdots, K\}$ each with ability T_i^* which is unknown to the student, and a finite set of schools $S = \{1, \cdots, M\}$ each with a known selectivity level q_s. Each student receives some utility U_{is} from attending a school.[5] Given the uncertainty about her exam performance, each student has some subjective probability of being admitted to a given school, $\Pr(T_i^* > q_s) \equiv \tilde{p}_{is} \in [0, 1)$. Note that this setup implies that students' subjective expectations of their admission chances are a rank-preserving transformation of their actual admission chances, such that $q_s = q_t \iff p_{is} = p_{it} \iff \tilde{p}_{is} = \tilde{p}_{it}$. Thus, each student has some expected value of applying to a school: $z_s = \tilde{p}_{is} U_{is}$.

Students are faced with the task of selecting an application portfolio which is an ordered subset A of schools. Finally, there is an application cost $c(|A|)$ which is associated with selecting a portfolio of size $|A|$ schools. In the CSSPS case, institutional restrictions permit a fixed number of applications n, so $c(|A|) = 0$ if $|A| \leq n$ and $c(|A|) = \infty$ if $|A| > n$.

In the resulting portfolio choice problem, each student chooses an application set $A_i = \{1, \cdots, N\}$ to maximize net expected utility:

$$\max_{A \subseteq S} f(A) - c(|A|) \tag{1}$$

In particular, the optimal portfolio (A^*) consists of a ranked set of chosen schools and solves:

$$\max_{A \subseteq S} f(A) = \tilde{p}_1 U_1 + \tilde{\pi}_2 \tilde{p}_2 U_2 + \cdots + \tilde{\pi}_N \tilde{p}_N U_N$$

where the subscript indicates the sth-ranked choice in the application set, and $N \leq n$. Note that $\tilde{p}_s$ denotes the unconditional probability of being admitted to school s, and $\tilde{\pi}_s \tilde{p}_s$ is the conditional probability of being admitted to school s given that a student is not admitted to any of her more preferred choices.[6]

[5] We can think of this utility as a comprehensive measure of the positive and negative factors associated with attending a school (including the costs of tuition payments and distance traveled as well as the benefits of available facilities, peer quality, and the net present value of expected future income).

[6] This basic notion of conditional probabilities is sufficient for the present analysis. However, the more general observation here is that merit-based assumption implies that a student's admission chances are correlated, so rejection from school s reduces the expected admission chances at all other schools. For example, a student who receives a negative shock and performs poorly on the BECE will have a lower chance of gaining admission to all schools than if she had performed as well as expected. As such, her realized admission outcome for a given school provides additional information on her admission chances for her lower-ranked choices.

4.2 Equilibrium Solutions

Denote the optimal application set for a student with beliefs $B(\tilde{p}_1, \cdots, \tilde{p}_M)$ by $A^*(\tilde{P})$ and its s^{th} element by $s^*(\tilde{P})$. We can then consider three cases: 1) perfect information, 2) unconstrained choice, and 3) imperfect information with constrained choice. Examining all three cases in turn illustrates how institutional features alter the school choice problem.

Case 1: Perfect Information In the case of perfect information, there is no uncertainty about admission prospects so students know that they are either guaranteed admission to a school or certain to be rejected. We can summarize the information set as follows: $\tilde{p}_{is} = p_{is} \in \{0,1\}$. In this case, the student solves:

$$A^*\left(\tilde{P}\right) = \max_{A \subseteq S} f(A) = \max\left(U_{is} \mid p_{is} = 1,\ U_{is} > 0\right) \tag{2}$$

The optimal solution is to apply to the most preferred choice in the set of schools to which admission is guaranteed. Thus, the application set consists of only one school - that which gives the student the highest payoff for attending.

Case 2: Unconstrained Choice In the absence of constraints on the number of applications one can submit, the maximum application set is equivalent to the full set of available choices, $n = M$. Thus, the student chooses:

$$A^*\left(\tilde{P}\right) = (1, 2, \ldots, N^*), \, where \; (U_{i1} > \ldots > U_{iN^*} > 0) \tag{3}$$

The solution is to apply to all schools in the choice set which yield positive utility. In practice, this case is evident in school choice programs which have no limit on the number of schools that students can list. Even with uncertainty about admission prospects, students can avoid the complex optimization problem because there is no cost to listing the full set of schools.

Case 3: Imperfect information with constrained choice In this case, there is uncertainty about admission prospects so that $\tilde{p}_s \in [0, 1)$. Additionally, there are some constraints on the number of schools to which students can apply, which means that $n < M$. Under these conditions, there is no simplification so the student must solve the full optimization problem outlined in equation (1):

$$A^*\left(\tilde{P}\right) = \max_{A \subseteq S} f(A) - c(|A|) \tag{4}$$

In a recent paper, Chade and Smith (2006) demonstrate that this is a difficult problem to solve: "we find ourselves faced with the maximization of a submodular function of sets of alternatives—to be sure, a complex combinatorial optimization problem" (p. 1293). The authors propose an intuitive solution concept which is computationally demanding yet provides a means to derive the characteristics of the optimal portfolio.[7] Their contribution is central to this analysis.

In essence, the optimal application strategy calls for three main factors:

1. Order schools based on utility
$$U_{i1} > U_{i2} > \cdots > U_{iN}$$

2. Order schools based on selectivity
$$\begin{aligned} & \tilde{p}_{i1} < \tilde{p}_{i2} < \cdots < \tilde{p}_{iN} \\ \Rightarrow\ & q_{i1} > q_{i2} > \cdots > q_{iN} \end{aligned}$$

   (Note that the second line follows from the earlier modeling assumption that students' subjective rankings of school selectivity have the same ordering and the actual rankings of schools selectivity.)

3. Diversify selectivity of choices. Chade and Smith (2006) establish that the optimal portfolio is a diversified one. It is more aggressive than the optimal single choices and not an interval of schools with similar selectivity levels. There are incentives to "gamble upward" and include a selective, high payoff school instead of an additional school of moderate selectivity and desirability.

4.3 Empirical Implications

The first implication of this theoretical model is that students are solving a complex optimization problem. Therefore, students who have weak decision making ability or lack guidance will likely make poor choices. Second, the model demonstrates that students should make their application decisions based on the expected value of applying to a school, $z_s = \tilde{p}_{is}U_{is}$. Thus, differences in observed application behavior for students with the same test scores will primarily result from differences in three factors: their understanding of the school choice problem and ability to adopt the optimal application strategy, their beliefs about their admission chances ($\tilde{p}_{is}$), and their preferences for school characteristics (U_{is}). In the following sections, I consider the relative importance of these theoretical insights in explaining observed differences in application choices.

5 Decision-Making Quality

One clear implication of the school choice problem facing Ghanaian secondary school applicants is that it is optimal for applicants to rank their chosen schools in order of selectivity. Consider

[7] Most earlier theoretical discussions circumvent the complexity of this problem by reducing the choice space to a set of two schools (see Nagypál 2009 and Chade, Lewis and Smith (2009) for examples of college choice models with two college types).

student i who applies to two schools with admission chances $p_{i1} < p_{i2}$ (let $p_{i1} = 0.2$ and $p_{i2} = 0.5$, for example). If the student ranks school 1 below school 2, and is rejected from school 2, then she effectively wastes a spot by listing school 1 since admission chances are correlated so she has an even lower chance of gaining admission to school 1. Alternatively, if she lists school 1 above school 2, then she has a higher expected utility.

I do not observe students' expected admission chances in the data, but I do observe school selectivity, given by the performance distribution of students admitted to the school in previous years. Noting that admission chances (p_{is}) are inversely correlated with school selectivity (q_s), I use six measures to evaluate the quality of students' decision making (see Section A.2. in appendix for more detail).

Table 3 indicates the main predictors of the selectivity of the senior high school to which a student gains admission. The table includes three panels for the years 2007, 2008 and 2009. Each panel presents coefficients from a linear regression of following form:

$$SHSQuality_{ij} = \alpha_0 + \alpha_1 BECE_{ij} + \alpha_2 \mu_j + \alpha_3 DecisionMakingQuality_{ij} + \epsilon_{ij} \qquad (5)$$

where μ_j is the average test score in student i's junior high school j. I use a measure of whether students rank their choices in order of selectivity as an indicator of the quality of students' decision-making.

If there was perfect educational mobility, a student's exam performance would largely predict the quality of her senior high school so that high-performing students would attend high quality senior high schools regardless of their educational backgrounds (i.e., irrespective of the quality of their junior high schools). A formal test of this would be to examine whether $\alpha_1 = 1$ and $\alpha_2 = 0$. In 2007, the coefficient on a student's performance was significantly lower than one ($\alpha_1 = 0.50$) and the quality of her junior high school played a significant role in explaining her admission outcome ($\alpha_2 = 0.17$) as did the various indicators for the quality of her decision-making ability. By 2009, the coefficient on student performance had increased to 0.62. Moreover, 84 percent of students ranked their selected schools such that their first choice was more selective than their lowest-ranked school in 2007. This rose to 93 percent of students in 2009. Thus, the results indicate that students' individual ability has played an increasing role in explaining the quality of senior high school students attend, while the quality of a student's junior high school has become decreasingly relevant and there has been an improvement in the overall quality of students' decision-making.

Overall, students from low-performing schools are more likely to make poor decisions (as demonstrated by the fact that they are more likely to rank a more-selective school lower than an less-selective school even though the dominant strategy is to rank more selective schools higher in the list). This implies that students from low-performing schools may not fully understand the application process or may lack guidance about the optimal application strategy.

6 Beliefs about Admission Chances

A second explanation for differences in application choices is that students from low-performing schools may have incorrect beliefs about their admission chances. This section formalizes the notion that differences in application choices may result from imperfect information because students may incorrectly estimate their admission chances.

6.1 Normal Learning Model of Beliefs

To begin, assume that student i in school j has true ability T^*_{ij}. Further, assume that ability is normally distributed within each junior high school, j:

$$T^*_{ij} \sim N\left(\mu_j, \sigma^2_j\right)$$

Where μ_j is the mean ability level of students within school j. Given the timing of the application process, the student does not know T^*_{ij} when she applies to secondary schools. Instead, she only knows the mean ability of students in her school, μ_j and she sees a signal of her individual ability (given by her relative performance in her school, for example):

$$s_{ij} = T^*_{ij} + \epsilon_{ij}$$

Assuming that μ_j and s_{ij} are both normal, the student will have a normal posterior belief about her ability, with mean:

$$T_{ij} = \lambda\mu_j + (1-\lambda)\, s_{ij}$$

Finally, assume that students make application decisions based on their posterior expectations of their ability levels. Thus, two students with the same posterior T_{ij} from the same junior high school will apply to equally selective senior high schools as their first choice.[8] (Even though they may not choose the same schools, their first-ranked choices should be equally as selective.)

We do not observe s_{ij} or T_{ij} directly. However, we see a student's BECE score which is her true ability: $BECE_{ij} = T^*_{ij}$. Note that

$$\begin{aligned}
E\left[T_{ij} \mid T^*_{ij},\ \mu_j\right] =& E\left[\lambda\mu_j + (1-\lambda)\, s_{ij} \mid T^*_{ij},\ \mu_j\right] \\
=& E\left[\lambda\mu_j + (1-\lambda)\left(T^*_{ij} + \epsilon_{ij}\right) \mid T^*_{ij},\ \mu_j\right] \\
=& \lambda\mu_j + (1-\lambda)\, T^*_{ij}
\end{aligned}$$

It follows that if we know λ then we can form an expectation of the mean of the student's posterior when she applied, and can then use this estimate to compare whether students with the

[8] Two specific cases under which this assumption would hold are: students have homogeneous preferences; or there is enough variation in the characteristics of schools within a given selectivity band such that two students with different preferences can both find schools which maximize their idiosyncratic utility but are equally as selective.

same posterior apply to schools of the same selectivity level.

6.2 Empirical Estimation of Beliefs

To estimate λ, note that if students i and k from school j choose equally selective schools as their first choice, then

$$\begin{aligned} T^*_{ij} + \epsilon_{ij} =& T^*_{kj} + \epsilon_{kj} \\ \epsilon_{ij} - \epsilon_{kj} = T^*_{kj} - T^*_{ij} =& BECE_{kj} - BECE_{ij} \end{aligned}$$

Thus, using the differences in BECE scores for students in the same school who applied to equally selective first choice schools, we can estimate

$$var\left[\epsilon_{ij} - \epsilon_{kj}\right] = 2var\left[\epsilon_{ij}\right] = \left[BECE_{kj} - BECE_{ij}\right]^2$$

Effectively, an estimate of $var\left[\epsilon_{ij}\right]$ is 0.5 times the mean squared difference in the actual scores of the pairs. Using this, we can then calculate

$$\widehat{\lambda} = \frac{\widehat{var\left[\epsilon_{ij}\right]}}{\widehat{var\left[\epsilon_{ij}\right]} + \widehat{\sigma^2_j}}$$

where $\widehat{\sigma^2_j}$ is the variance in test scores for students in school j. The mean estimates from the data for the 2007 to 2009 cohorts of applicants are $\widehat{\sigma^2_j} = 0.39$ and $\widehat{var\left[\epsilon_{ij}\right]} = 0.33$.

Figures 3 and 4 display the results from using this approach. I find that the differences in selectivity of application portfolios virtually disappear when I compare students with the same posterior T_{ij} from high-performing and low-performing schools. This suggests that students from low-performing schools under-estimate their admission chances and apply to less selective schools as a result. Conversely, students from high-performing schools tend to over-estimate their admission chances which would explain why they have a higher likelihood of receiving an administrative assignment conditional on their BECE scores (as illustrated in Figure 2). Taken together, it appears that differences in students' expected admission chances can potentially explain observed differences in application choices.

7 Preferences for School Characteristics

The two preceding sections have demonstrated that differences in decision-making quality and imperfect information about admission chances are both plausible explanations for why students from low-performing elementary schools do not apply to more selective secondary schools. In this section, I examine a third hypothesis - that students have different preferences for school characteristics.

The administrative data on students' ranked application choices provides a natural opportunity to analyze students' revealed preferences for school characteristics using standard methods of discrete choice analysis.[9] However, estimation of student preferences through discrete choice analysis is complicated by the fact that students applying to secondary schools in Ghana have incentives to be strategic in order to ensure that they gain admission to one of their chosen schools. In particular, a student's first-ranked choice may not necessarily be preferred to all available schools because students may be taking their admission chances into account when selecting their application portfolios. To address this point, I draw on the fact that a student's first-ranked choice is revealed preferred to schools that are equally as selective. The remainder of this section outlines my methodological approach more formally.

7.1 Demand for Schools

To estimate student preferences, I begin by assuming that student i's expected utility from attending school s, (U_{is}) depends on a set of observed and unobserved factors, where the observable component is a linear function of school selectivity q_s and a vector of student-specific school characteristics X_{is}.

- **Assumption 1:** Demand for school selectivity is additively separable from demand for other school characteristics

$$U_{is}^{*} = \alpha q_s + \beta X_{is} + \epsilon_{is} \tag{6}$$

The error term in this utility function denotes students' valuation of school characteristics which are unobserved by the researcher. The subscript "is" indicates that school characteristics result from an interaction between school attributes and student characteristics. For example, proximity to a given school varies across students.

Because students are constrained in their choice of what set of schools to apply to, we cannot necessarily conclude that a student applies to her most preferred school. However, if we assume that students rank selected schools in order of utilities - $U_{i1} > U_{i2} > \cdots > U_{iN}$, then we can conclude that the first choice school is preferred to the other schools in a student's application portfolio. Finally, recall that students pick schools based on $z_s = \tilde{p}_{is} U_{is}$. This suggests that any school in the application portfolio is preferred to all other schools which are equally or less selective.

[9] The theoretical foundations of this econometric approach are reviewed in Train (2003). Several recent empirical studies have used application data to analyze revealed preferences in school choice settings, including: Avery, Glickman, Hoxby, and Metrick (2004); Griffith and Rask (2007); and Hastings, Kane and Staiger (2008).

Taken together, these observations imply that the first ranked choice is preferred to all other schools in which a student has equal admission chances:

$$\begin{aligned} \tilde{p}_{i1}U_{i1} &> \tilde{p}_{it}U_{it} \quad \forall \ t \ \text{s.t.}\, \tilde{p}_{it} = \tilde{p_{i1}} && (7)\\ \frac{\tilde{p}_{i1}}{\tilde{p}_{it}}U_{i1} &> U_{it} && (8)\\ U_{i1} &> U_{it} && (9) \end{aligned}$$

where $U_{is} = \beta X_{is} + \epsilon_{is}$ because there is no variation in school selectivity given that all schools in the choice set are equally selective.

We can specify a discrete choice estimation framework for the selection of a first choice school based on the fact that student i chooses the most preferred school s out of the set of all schools with equal selectivity (S^p). The dependent variable of interest is defined by:

$$y_{is} = \begin{cases} 1 & \text{iff}\, U_{is} > U_{it} \quad \forall \ t\,\epsilon\, S^P \\ 0 & otherwise \end{cases}$$

Thus, the probability that student i lists school s as a first choice is:

$$P_i\left(s\right) = Pr\left(U_{is} > U_{it} \quad \forall \ t\epsilon\, S^P\right)$$

Focus on the subset of alternatives in this restricted choice set (S^p) yields a valid estimate of student preferences due to the independence from irrelevant alternatives (IIA) property of the multinomial logit model. If we assume that the error term ϵ_{is} is independently and identically distributed (i.i.d.) extreme value, then the probability that student i chooses school s as a first choice can be written as:

$$\begin{aligned} P_i\left(s\right) &= Pr\left(U_{is} > U_{it} \,\forall\, t \,\in\, S^P\right) && (10)\\ &= \frac{e^{X_{is}\beta}}{\sum_{t\epsilon S^P} e^{X_{it}\beta}} && (11) \end{aligned}$$

This yields the log-likelihood function:

$$LL\left(X, \beta\right) = \sum_{i=1}^{N}\sum_{s=1}^{S^P} y_{is}ln\frac{e^{X_{is}\beta}}{\sum_{t\epsilon S} e^{X_{it}\beta}} \tag{12}$$

7.2 Beliefs

Since I do not observe students' subjective probabilities of admission ($\tilde{p}_{is}$), I assume that they are systematically related to students' actual admission chances, p_{is}.

- **Assumption 2:** Students form expectations about their admission chances based on the selectivity of schools in the previous year so that $\tilde{p}_{is} = g(p_{is})$ where the function $g(\cdot)$ is a rank-preserving transformation which ensures that $\tilde{p}_{is} = \tilde{p}_{it} \iff p_{is} = p_{it}$.

The key requirement of this assumption is that students should be able to accurately gauge which set of schools are equally as selective as their first choice. Although this assumption is somewhat restrictive, it allows for students to have different beliefs about their absolute admission chances and only imposes that students have correct beliefs about their relative chances of admission into various different schools. (I.e. certain students may be more or less confident than others, but they must be uniformly biased about their chances of gaining admission to all schools.) This condition permits a wide range of functional forms for $g(\cdot)$ such as $\tilde{p}_{is} = p_{is} + c_i$, $\tilde{p}_{is} = c_i \cdot p_{is}$ or $\tilde{p}_{is} = (p_{is})^2$, where students consistently over or under estimate their admission chances in a systematic manner. However, it does not allow for more flexible cases such as $\tilde{p}_{is} = c_{is} \cdot p_{is}$, where the degree of bias (c_{is}) varies for a given student across schools.

7.3 Heterogeneity

To examine heterogeneity in preferences, I estimate the model outlined in Section 7.1 and allow the estimates of β to vary by student performance (percentile ranking) and JHS quality, μ_{ij} (the average percentile ranking of peers in a student's 9th grade class), by interacting school characteristics with these two student characteristics. The formal test is effectively to estimate:

$$U_{ijs} = \beta_1 X_{is} + \beta_2 (X_{is} \times BECE_i) + \beta_3 (X_{is} \times \mu_{ij}) + \epsilon_{ijs}$$

and evaluate whether $\beta_3 \neq 0$. Finally, I cluster standard errors at the junior high school level to allow for correlation in preferences for students in a given school.

7.4 Results

I estimate the model using students' choices in 2008 when they faced the fewest number of constraints. I restrict the sample to focus on students who demonstrate an understanding of the optimal school choice strategy by ensuring that their first choice school is more selective than their lowest-ranked school (condition (6) in Appendix section A.2). Furthermore, I limit my analysis to public school students since these are the students who are most likely to comply with their admission outcomes instead of opting out into the set of elite private schools which have an independent admissions process. Additionally, private JHS students may have stronger preferences for attending private senior high schools even within the centralized application system. Lastly, I split the sample by gender and focus on the set of students who qualify for admission to senior high school since I only observe test scores for these students.

Tables 4 presents summary statistics for the unrestricted 2008 sample and Tables 5 and 6 report estimates from a multinomial logit regression using data from the 2008 sample of public school students. Out of the terms interacted with JHS quality, the coefficients on school distance for both male and female students and the indicator for a public secondary school for males are statistically significant. However, the indicator for whether a school was established before Ghana gained independence (a measure of historical prestige) is not significant. Additionally, there is no significant difference in students' preferences for single sex schools or schools with boarding facilities.

Taken together, this analysis suggests that distance and costs of attending a higher-quality school may be more important determinants of application behavior than preferences for school quality per se. These results are consistent with findings from Burgess, Greaves, Vignoles and Wilson (2009) who study school choice in England. The authors find that preferences for academic performance do not substantially vary across different socio-economic groups and largely attribute educational inequality to differences in access to high quality schools.

8 Effect of School Choice Reforms

A final approach to understanding why certain students fail to apply to selective schools is to evaluate whether students from different educational backgrounds respond differently to school choice reforms. If changes in features of the assignment mechanism lead to a decrease in the distinctions between students from high-performing and low-performing schools, then this would suggest that part of the difference in application behavior may be due to the application rules governing the school choice system and not to preferences alone.

8.1 School Choice Reforms in Ghana

The nature of the CSSPS has changed since it was established in 2005. Firstly, the number of permitted choices has increased over time. Students were allowed to list up to three choices when the CSSPS began in 2005, this increased to four choices in 2007 and to six choices in 2008. Moreover, Ghana Education Service introduced an additional reform in 2009 which was designed to improve the decision-making ability of students. (Box 2 details these changes.)

The noteworthy characteristics of the 2009 reform are as follows:

1. Public secondary schools were assigned into four categories based on their "available facilities" and students were restricted in their selection of schools from each category. In particular, students could only pick one Category A school, two Category B schools, and no more than five Category C or D schools.

2. Students were allowed to list up to six program choices as they had been in the past, but were no longer allowed to pick more than one program from any given school.

This categorization only affected choices in 2009 since it was not available in earlier years. Students in the 2008 cohort submitted their lists of choices in September 2007 and the categories were not publicized until February 2009 when students in the 2009 cohort were submitting their choices, so there is no possibility that the categorization had a causal effect on choices prior to this.

The categorization of schools under this new scheme is positively correlated with school age (historical prestige) and academic performance. Figure 5 provides some descriptive statistics and illustrates the distribution of selectivity for schools in each category. On average, the median BECE percentile of students admitted in the year preceding the reform was 76.87 for Category A schools but 18.03 for Category D schools. However, correlation between school quality and categorization is not perfect. In particular, some schools which were assigned to Category A were obviously elite but others were not of high quality by any observable measures. Discussions with Ghana Education Service revealed that schools were categorized based on their capacity to admit students, their historical selectivity, as well as the concern for spatial variation by ensuring that each region contains at least one school from each category.

The complexity of the choice problem and features of the optimal portfolio naturally suggest the use of a rule of thumb as an alternative to explicitly solving the optimization problem. Although this may not always be optimal, a rule of thumb provides an easy means to approximate the optimal portfolio choice when agents are hampered by decision-making costs or limitations. In particular, suppose that schools lie on a continuum of desirability and selectivity. On one end of this spectrum, a *reach* school represents a highly preferred school which is highly selective. The *safety* school is at the other end of the spectrum and reflects a less preferred option but one which has lower admission standards and so ensures a successful application. In the middle lie a set of *match* schools where admission chances are favorable and there is strong appeal. Students can approximate the best portfolio by applying to at least one reach, one match, and one safety school.[10] Additionally, it is optimal to rank schools based on payoffs and admission standards.

The new conditions imposed by the Ghanaian categorization reform are similar in spirit to the reach, match and safety school rule of thumb. Category A primarily consists of more selective "reach" schools, Category B of less selective schools and Categories C and D consist of the least selective schools. The key restriction in the program, however, is that these categorizations are specified in absolute terms and not in relation to an individual student's expected admission chances.

8.2 Difference-in-Differences Estimation

In the remainder of this section, I evaluate the effects of two policies which may have encouraged educational mobility in Ghana: 1) increasing the number of permissible choices and 2) providing

[10] This rule of thumb is a commonly accepted guideline for college choice in the US. The website www.go4ivy.com recommends that the following thresholds be used to define school types: Reach/Stretch: 1 to 49 percent admission chance, Match/Likely: 50 to 85 percent admission chance, Safety: 86 to 99 percent admission chance. They provide the following additional guidance: "We recommend that you choose at least two colleges in each category (stretch, likely, safety) to help maximize your chances of getting in. Try to minimize the number of schools in the outer ranges. For example, consider applying to no more than one single-digit stretch school (i.e. 7%) because such schools do not match your background well. You can probably find an equally prestigious school where you have a better chance of getting in."

information and a set of guidelines on school choice strategies. I estimate the impact of the first policy by observing changes following the increase from 4 choices in 2007 to 6 choices in 2008. I estimate the impact of the second policy by observing the changes following the categorization reform in 2009.

More specifically, I evaluate the effect of the reforms by estimating the following regression:

$$Y_i = \alpha_0 + \alpha_1 BECE_i + \gamma_h + \delta_a + \eta_{ah} + \epsilon_i \tag{13}$$

Where γ_h indicates a student who attended a high-performing JHS, δ_a denotes the period after a reform and η_{ah} is the interaction of these two terms. This difference-in-differences framework allows me to compare the change in application behavior for students from lower performing schools relative to the change for students from higher performing schools. As earlier, I define students from lower performing schools as those who come from a school where the average performance of students in the BECE is below the median average for all schools. Conversely, students from higher performing schools are those who attend a JHS where the average score of students is above the median average for all schools.

Policy reforms such as these are likely to have substantial distributional effects (Bitler, Gelbach and Hoynes (2006)). As an extension of the basic difference-in-differences estimation, I examine whether the reforms had heterogeneous effects on students across the performance distribution by estimating a separate parameter for each BECE score percentile. I do this by introducing a percentile indicator variable β_p and estimating the following regression:

$$Y_i = \beta_0 + \beta_p + \gamma_h + \delta_a + \eta_{ah} + \theta_{ph} + \theta_{pa} + \theta_{pah} + \epsilon_i \tag{14}$$

The θ parameters capture individual changes for students at each BECE score percentile.

8.3 Results

Table 7 illustrates the results for the mean coefficients estimated from equation (13). I find a decrease in the difference in selectivity of schools to which students from high-performing and low-performing schools applied following the reforms. Both groups of students applied to more selective first choices, and less selective sixth choices but the gap between their choices decreased.[11] With regard to admission outcomes, I find a decrease in administrative assignments following each reform and a slight increase in the difference-in-difference between students from high-performing and low-performing schools (indicating that the share of administrative assignments decreased, for low-performing students more than for high-performing students). Moreover, I find that the difference in the selectivity of schools to which students from lower-performing junior high schools were admitted

[11] Pallais (2009) finds a similar result in her analysis of the effect of increasing the number of free score reports provided for ACT-takers.

increased following both reforms, but I find that the difference in differences also increased following the reforms. These changes in admission outcomes capture two opposing forces: on one hand, the decrease in administrative assignments implies an increase in the selectivity of schools to which low-performing students from high-performing schools are admitted; on the other hand, the changes in selectivity of choices implies a decrease in the advantage of attending a higher performing school to begin with. The effect of decreased administrative assignments outweighs the changes in application choices so the net impact of these two factors is that students from high-performing schools ended up getting into more selective schools on average following the reforms.

Beyond these general changes, there is some degree of heterogeneity in the difference-in-difference estimates for students across the BECE performance distribution. Figures 6 and 7 display the results from estimating a separate coefficient for each BECE score percentile using equation (14) with the mean selectivity of chosen schools and the selectivity of the secondary school to which a student was admitted as the outcomes of interest. The dashed line in each figure illustrates the mean effect (estimated using equation (13)), while the solid line indicates the individual coefficients for students at each percentile of BECE performance. Notably, the difference in admission outcomes for students from high-performing and low-performing schools is slightly more pronounced at the tails of the distribution, although not at a statistically significant level. Furthermore, the general effect of increasing student choices is to increase the selectivity of admissions for students in the middle of the test score distribution, while imposing restrictions on choice lowered the quality of schools for high-performing and low-performing students and additionally increased the selectivity level of schools for students in the middle of the distribution. Finally, there was no systematic variation in the difference-in-difference estimates along the test score distribution.

The implications of this analysis are that the applications choices of students from high-performing and low-performing schools became increasingly similar following each reform on average. However, students from high-performing schools continued to apply to more selective schools even after the categorization reform. Additionally, administrative assignments fell following each reform, but students from high-performing schools ended up gaining admission to more selective schools than students from low-performing schools on average, emphasizing the substantial re-distributional effects of these reforms.

9 Conclusions

This paper set out to examine why there is limited educational mobility in school choice settings. I find that low expectations about admission chances and poor decision-making quality explain a substantial part of why students from low-performing schools do not apply to higher-quality schools. I also find that students have different preferences for certain school characteristics but seem to place equal value on school quality. Altogether, these findings suggest that changes in application or admission rules can lead to sizeable changes in application behavior and varied changes in admission outcomes depending on the general equilibrium effects of student assignment to available spaces. Consequently, policy measures which provide information and guidance on application strategies can greatly increase the equity and efficiency of school choice systems by enabling talented students from low-performing schools to exercise their preferences for attending higher quality schools. I document the differential effects of two school choice reforms which support this prediction.

This paper has broader implications for other contexts in which policy makers seek to encourage high-performing students from underprivileged backgrounds to apply to more selective schools. First, these findings suggest that the elimination of school choice constraints could potentially lead to decreases in student sorting along socio-economic characteristics and to increases in sorting along academic dimensions. Practical steps in this direction include: the introduction of the common application for college admissions in the US, increases in the number of free reports for standardized test scores, and the elimination of limits on the numbers of applications students can submit in centralized choice-systems. Notably, however, these interventions benefit all students uniformly so may not necessarily decrease advantages for students from high-performing schools. Second, students' application behavior seems to rely heavily on students' ability to understand the school assignment mechanism and to implement an effective school choice strategy, so reforms will likely have only a limited impact on expanding students' educational opportunities unless they are accompanied by targeted efforts to improve the level of guidance and information available to students in lower-performing schools. Lastly, schooling choices also appear to be driven by considerations about non-academic factors (especially cost and proximity) so that socio-economic differences in application behavior will likely persist unless there are complementary efforts to increase access and affordability.

Ultimately, the theoretical models and empirical evidence presented in this paper demonstrate that merit-based school choice systems promote educational mobility if there is perfect information and unconstrained choice. Two practical interventions which could alleviate inequality in the absence of these ideal decision-making conditions would be to provide targeted guidance counseling and increase the availability of information on admission chances.

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Table 1: Student Summary Statistics (2005-2009)

	2005	2006*	2007	2008	2009
Student characteristics					
Age (mean)	17.01	17.10	17.17	17.13	17.25
Male	55.40	54.80	54.62	54.90	54.26
Attended a public JHS	83.71	82.17	83.80	83.03	84.32
Number of JHS classmates (mean)	77.43	63.86	63.44	62.88	67.62
Application choices					
Number of choices permitted (total)	3	3	4	6	6
Listed maximum number of choices	98.34	98.79	99.91	94.80	99.98
Admission outcomes					
Admitted to a school	55.49	-	51.97	47.22	46.24
Number of admitted students (total)	162,077	-	167,279	160,936	183,484
Admitted to first choice	24.57	-	22.72	22.36	29.74
Administratively assigned	22.76	-	16.60	9.19	2.13
Admitted to school in JHS district	41.18	-	39.32	36.97	33.41
Admitted to school in JHS region	76.13	-	76.46	75.64	74.74
Admitted to boarding school	56.32	-	67.15	65.72	61.75
Observations	292,070	309,911	321,891	340,823	396,832

Notes: Table reports percentages except when alternative measures are indicated in parentheses.*Data on admission outcomes for 2006 are incomplete.

Table 2: Senior High School Summary Statistics (2005-2009)

	2005	2006	2007	2008	2009
School characteristics					
Public	93.86	81.74	81.20	78.58	80.59
Mixed	91.68	91.60	91.50	91.58	90.53
Males only	3.70	3.66	3.71	3.55	3.73
Females only	4.62	4.73	4.79	4.87	5.75
Technical or vocational institute	12.29	12.33	12.33	12.26	12.36
Has boarding facilities	44.24	50.39	51.34	51.44	51.45
Programs per school (mean)	3.62	3.62	4.04	4.01	4.31
Vacancies reported					
Vacancies per program (mean)	66.48	63.86	75.38	65.01	88.03
Vacancies per school (mean)	246.24	241.79	313.03	260.81	366.23
Number of vacancies (total)	160,590	159,157	204,340	176,566	235,849
Academic performance					
SSCE pass rate in core subjects	53.39	63.37	68.94	71.12	70.41
SSCE pass rate in mathematics	45.17	66.81	54.03	60.48	50.81
Observations	651	657	649	677	644

Notes: Table reports percentages except when alternative measures are indicated in parentheses.

Table 3: Factors Predicting the Selectivity of a Student's Senior High School

2007	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Student's BECE score percentile	0.649	0.509	0.509	0.502	0.500	0.495	0.497	0.499	0.501	0.491
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Average score in student's JHS		0.213	0.177	0.175	0.173	0.168	0.169	0.173	0.175	0.168
		(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Decision-making quality index (I)				0.037	0.039	0.047	0.050	0.037	0.038	0.012
				(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
District fixed effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% of students with I = 1				19.39	25.76	49.94	68.31	32.04	83.59	

2008	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Student's BECE score percentile	0.713	0.584	0.583	0.578	0.576	0.570	0.572	0.574	0.573	0.560
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Average score in student's JHS		0.201	0.149	0.143	0.141	0.136	0.136	0.141	0.146	0.129
		(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Decision-making quality index (I)				0.068	0.062	0.053	0.050	0.044	0.068	0.021
				(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
District fixed effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% of students with I = 1				4.58	7.71	27.38	50.68	21.94	89.72	

2009	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
Student's BECE score percentile	0.729	0.646	0.645	0.639	0.639	0.632	0.632	0.629	0.637	0.623
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Average score in student's JHS		0.132	0.067	0.063	0.062	0.057	0.058	0.060	0.065	0.054
		(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Decision-making quality index (I)				0.041	0.041	0.044	0.048	0.040	0.065	0.017
				(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.000)
District fixed effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
% of students with I = 1				9.99	11.15	35.34	56.61	40.10	92.70	

Notes: Indicators of decision making quality used in columns (4) to (9) correspond to indicators 1 to 6 in Appendix A.2.. Decision-making quality measure used in column (10) is an index of indicators 1 to 6. All coefficients are statistically significant at the 0.1 percent level.

Table 4: Summary Statistics for Discrete Choice Sample (2008)

	Male		Female	
Quality of Junior High School	Low	High	Low	High
Student characteristics				
Background information				
Age	17.28	16.47	16.67	16.03
Has a disability	0.02	0.01	0.03	0.02
Attended a public JHS	90.75	59.45	89.15	57.26
Average BECE score percentile in JHS	13.95	62.07	15.70	63.31
Student's BECE score percentile	34.33	69.13	29.25	65.70
Application behavior				
Listed maximum number of choices	94.46	92.22	94.29	92.63
Listed SHSs only	70.25	73.78	90.70	91.34
Listed same program for all choices	7.72	13.86	10.96	18.41
Listed same school for all choices	0.05	0.03	0.04	0.03
First choice more selective than last	79.39	83.59	79.37	84.23
Characteristics of first choice program and school				
Academic performance				
SSCE Pass rate	80.36	89.87	80.95	89.25
Average BECE score of admits (2007)	62.94	80.83	64.04	81.87
Historically prestigious	15.95	36.97	13.78	31.96
Other school characteristics				
Public	1.00	1.00	1.00	1.00
Mixed sex	88.61	65.09	84.78	59.21
Males only	10.97	34.80	0.00	0.00
Females only	0.03	0.01	14.81	40.64
Technical or vocational institute	1.99	1.71	0.23	0.10
Has boarding facilities	82.32	90.62	82.32	91.54
Located in student's JHS district	40.10	31.30	42.61	29.25
Located in student's JHS region	81.45	67.31	81.19	62.49
Distance from student's JHS district	0.45	0.55	0.41	0.56
Number of programs offered	5.17	5.05	5.18	5.26
Number of vacancies	426.02	448.78	414.02	410.76
Program choice				
General Arts	36.76	34.17	47.06	47.03
General Science	14.79	18.96	7.95	10.58
Admissions Outcomes				
Administratively assigned	9.60	5.73	14.76	8.21
Admitted to first choice school	27.16	38.26	20.67	29.28
Admitted to school in JHS district	42.78	32.30	41.90	30.63
Admitted to school in JHS region	83.95	69.90	81.88	66.19
Admitted to boarding school	56.17	76.62	54.04	75.33
Number of students	50,976	42,704	29,388	37,776

Table 5: Discrete Choice Model Estimates (Males)

School characteristics	[1]	[2]	[3]	[4]
Historically prestigious	0.323	0.433	0.389	0.437
	(0.034)	(0.069)	(0.052)	(0.068)
SSCE Pass Rate	*-0.001*	*-0.001*	-0.007	*-0.003*
	(0.001)	*(0.002)*	(0.002)	*(0.002)*
Public	2.821	4.808	5.157	5.141
	(0.622)	(1.777)	(1.396)	(1.611)
Single sex	1.942	0.841	1.525	0.857
	(0.040)	(0.087)	(0.064)	(0.086)
Boarding facilities	0.654	0.578	0.565	0.545
	(0.038)	(0.057)	(0.051)	(0.060)
Distance	-3.755	-4.859	-4.463	-4.866
	(0.048)	(0.088)	(0.069)	(0.085)
Number of vacancies	0.003	0.003	0.003	0.003
	(0.000)	(0.000)	(0.000)	(0.000)
BECE score*Historically prestigious		*-0.209*		*-0.152*
		(0.125)		*(0.134)*
BECE score*SSCE Pass Rate		*0.001*		-0.018
		(0.005)		(0.005)
BECE score*Public		*-3.861*		*-0.108*
		(2.901)		*(1.982)*
BECE score*Single sex		1.761		1.956
		(0.154)		(0.174)
BECE score*Boarding facilities		0.256		*0.154*
		(0.123)		*(0.120)*
BECE score*Distance		2.156		1.437
		(0.146)		(0.144)
BECE score*Number of vacancies		-0.001		-0.002
		(0.000)		(0.000)
JHS Quality*Historically prestigious			*-0.227*	*-0.119*
			(0.129)	*(0.147)*
JHS Quality*SSCE Pass Rate			0.025	0.038
			(0.007)	(0.008)
JHS Quality*Public			-5.443	-5.381
			(2.336)	(1.914)
JHS Quality*Single sex			0.901	*-0.339*
			(0.152)	*(0.182)*
JHS Quality*Boarding facilities			0.333	*0.248*
			(0.180)	*(0.195)*
JHS Quality*Distance			2.030	1.041
			(0.163)	(0.180)
JHS Quality*Number of vacancies			*0.000*	*0.001*
			(0.000)	*(0.001)*

Notes: Dependent variable is an indicator for the student's first choice school. Alternatives consist of five schools which had the closest selectivity level to the student's first choice. Selectivity is measured by the average test score of students admitted to a school in the previous year. Regressions also include indicators for distance squared and number of programs offered. Sample consists of students who qualified for admission to SHS in 2008 and ranked their choices in order of selectivity (as defined by condition (6) in Appendix A.2.).Standard errors are clustered at the junior high school level. All coefficients are significant at the 5 percent level except for those in italics.

Table 6: Discrete Choice Model Estimates (Females)

School characteristics	[1]	[2]	[3]	[4]
Historically prestigious	0.522	*0.129*	0.284	*0.123*
	(0.032)	*(0.069)*	(0.060)	*(0.070)*
SSCE Pass Rate	0.005	0.007	0.005	0.007
	(0.002)	(0.002)	(0.002)	(0.002)
Public	1.816	6.728	5.014	6.575
	(0.583)	(1.867)	(1.295)	(1.691)
Single sex	1.388	0.850	1.092	0.855
	(0.044)	(0.085)	(0.071)	(0.085)
Boarding facilities	0.845	0.695	0.683	0.658
	(0.044)	(0.068)	(0.064)	(0.072)
Distance	-3.331	-4.723	-4.308	-4.753
	(0.053)	(0.091)	(0.082)	(0.092)
Number of vacancies	0.000	0.002	0.002	0.002
	(0.000)	(0.000)	(0.000)	(0.000)
BECE score*Historically prestigious		0.715		0.667
		(0.111)		(0.134)
BECE score*SSCE Pass Rate		*-0.004*		*-0.010*
		(0.005)		*(0.006)*
BECE score*Public		-8.542		-5.977
		(2.721)		(2.307)
BECE score*Single sex		0.809		0.840
		(0.144)		(0.176)
BECE score*Boarding facilities		0.482		*0.264*
		(0.167)		*(0.166)*
BECE score*Distance		2.679		2.077
		(0.154)		(0.147)
BECE score*Number of vacancies		-0.005		-0.003
		(0.000)		(0.001)
JHS Quality*Historically prestigious			0.542	*0.072*
			(0.120)	*(0.148)*
JHS Quality*SSCE Pass Rate			*0.003*	*0.011*
			(0.006)	*(0.008)*
JHS Quality*Public			-6.622	*-2.816*
			(2.258)	*(1.953)*
JHS Quality*Single sex			0.512	*-0.058*
			(0.139)	*(0.172)*
JHS Quality*Boarding facilities			0.586	*0.388*
			(0.197)	*(0.215)*
JHS Quality*Distance			2.368	0.831
			(0.185)	(0.202)
JHS Quality*Number of vacancies			-0.005	-0.002
			(0.001)	(0.001)

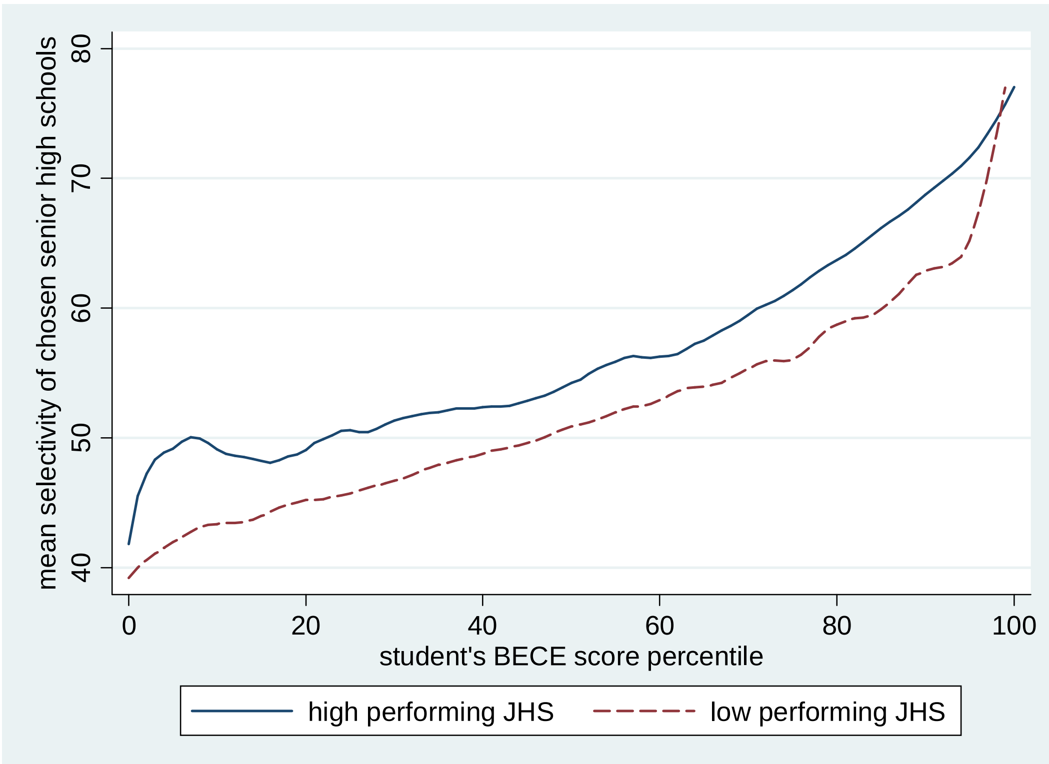
Notes: Dependent variable is an indicator for the student's first choice school. Alternatives consist of five schools which had the closest selectivity level to the student's first choice. Selectivity is measured by the average test score of students admitted to a school in the previous year. Regressions also include indicators for distance squared and number of programs offered. Sample consists of students who qualified for admission to SHS in 2008 and ranked their choices in order of selectivity (as defined by condition (6) in Appendix A.2.).Standard errors are clustered at the junior high school level. All coefficients are significant at the 10 percent level except for those in italics.

Table 7: Mean Differences in Application Choices and Admission Outcomes Before and After Reforms

	Selectivity of Choices			Admission Outcomes		
2007-2008 (increase from 4 to 6 choices)	First Choice	Last Choice	Portfolio Average	Administrative Assignment	Selectivity of SHS	Peer Quality in SHS
Student's BECE score percentile	0.311	0.126	0.234	-0.371	0.550	0.605
	(0.003)	(0.004)	(0.003)	(0.006)	(0.004)	(0.004)
High-performing JHS	2.091	5.484	3.515	0.025	0.889	1.241
	(0.362)	(0.382)	(0.309)	(0.005)	(0.258)	(0.212)
After reform	4.197	-3.321	-0.741	-0.071	3.292	-1.439
	(0.246)	(0.199)	(0.171)	(0.003)	(0.126)	(0.107)
After reform × High-performing JHS	*-0.699*	-6.971	-2.174	*0.006*	2.826	1.591
	(0.456)	(0.458)	(0.383)	*(0.006)*	(0.393)	(0.313)
	Selectivity of Choices			Admission Outcomes		
2008-2009 (categorization and restrictions)	First Choice	Last Choice	Portfolio Average	Administrative Assignment	Selectivity of SHS	Peer Quality in SHS
Student's BECE score percentile	0.292	0.015	0.186	-0.180	0.618	0.647
	(0.003)	(0.003)	(0.002)	(0.004)	(0.004)	(0.004)
High-performing JHS	1.921	2.837	2.766	*-0.004*	1.228	1.626
	(0.354)	(0.253)	(0.253)	*(0.004)*	(0.216)	(0.179)
After reform	2.123	-8.062	-0.441	-0.086	-0.344	0.793
	(0.222)	(0.202)	(0.141)	(0.003)	(0.126)	(0.097)
After reform × High-performing JHS	-1.755	-4.184	-1.938	0.032	0.757	*-0.107*
	(0.378)	(0.409)	(0.281)	(0.004)	(0.277)	*(0.218)*

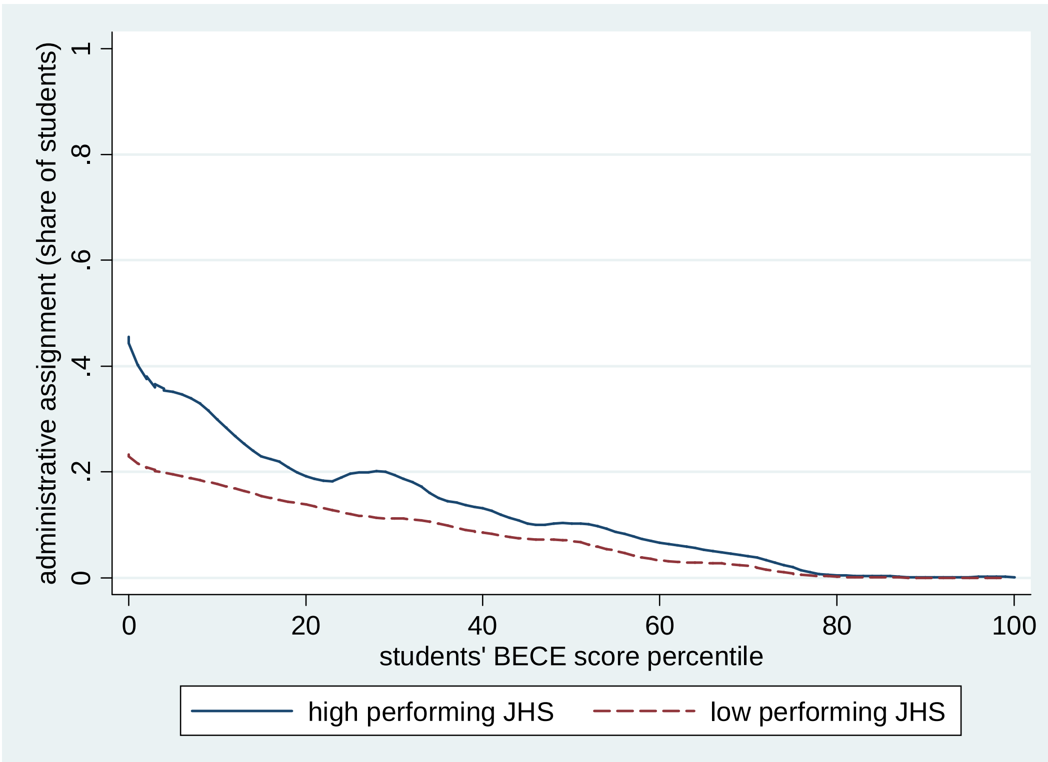
Notes: Tables report the difference in means for application decisions and admission outcomes. The top panel analyzes the 2008 reform which increased the maximum number of applications from four to six choices. The bottom panel analyzes the 2009 reform which imposed a shift from six unrestricted choices to six restricted choices under the new categorization system. The period "before" a reform is the preceding year, the period "after" is the year of the reform. Outcome of interest is indicated at the top of each column. All coefficients are significant at the 1 percent level except for those in italics.

Figure 1: Exam Performance and Application Choices (2008)



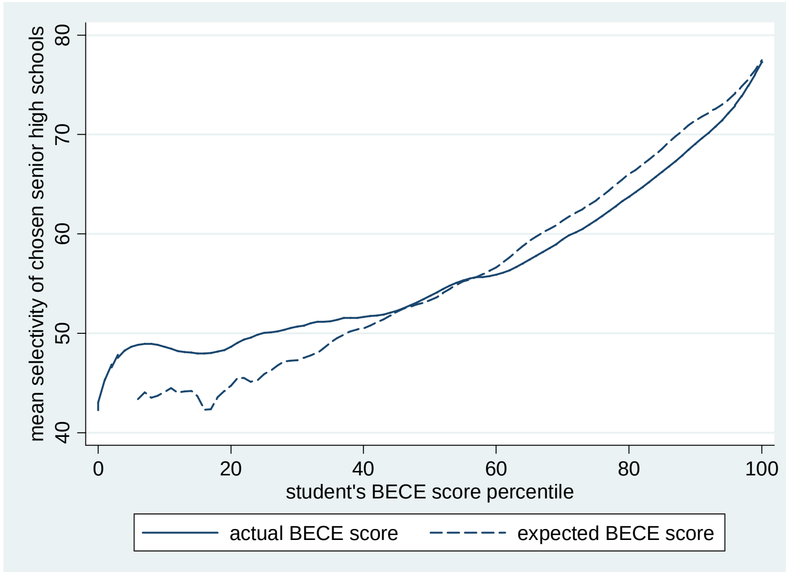
Notes: This figure illustrates differences in application choices for students with the same test scores but from low and high-performing junior high schools (JHSs). The x-axis is indexed by student percentiles in the standardized high school entrance exam (BECE). The y-axis illustrates the mean selectivity of the senior high schools to which a student applied. The solid line represents students who attended a high-performing JHS. The dashed line represents students who attended a low-performing JHS.

Figure 2: Exam Performance and Administrative Assignments (2008)

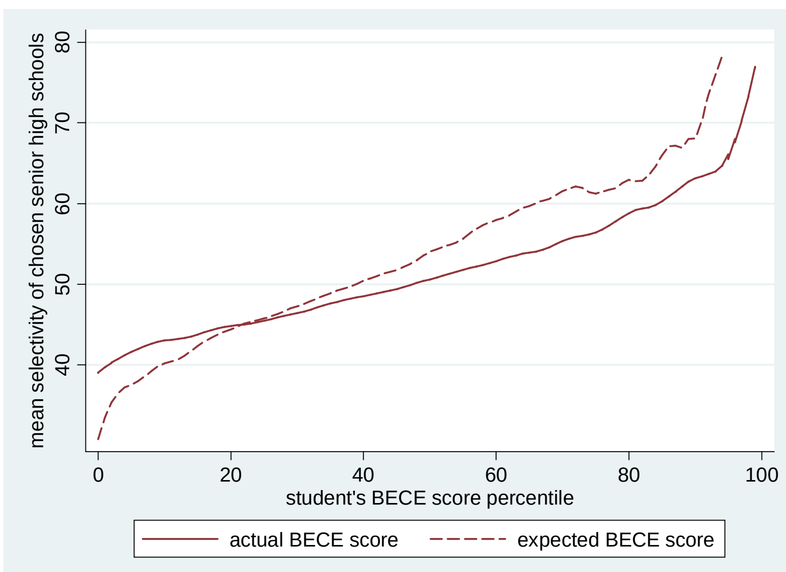


Notes: This figure illustrates differences in admission outcomes for students with the same exam scores, but from different junior high schools. The x-axis is indexed by student percentiles in the basic education certification exam (BECE). The y-axes illustrates the share of students receiving an administrative assignment. The solid line represents students who attended a high performing JHS. The dashed line represents students who attended a low-performing JHS.

Figure 3: Expected and Actual Exam Performance (2008)



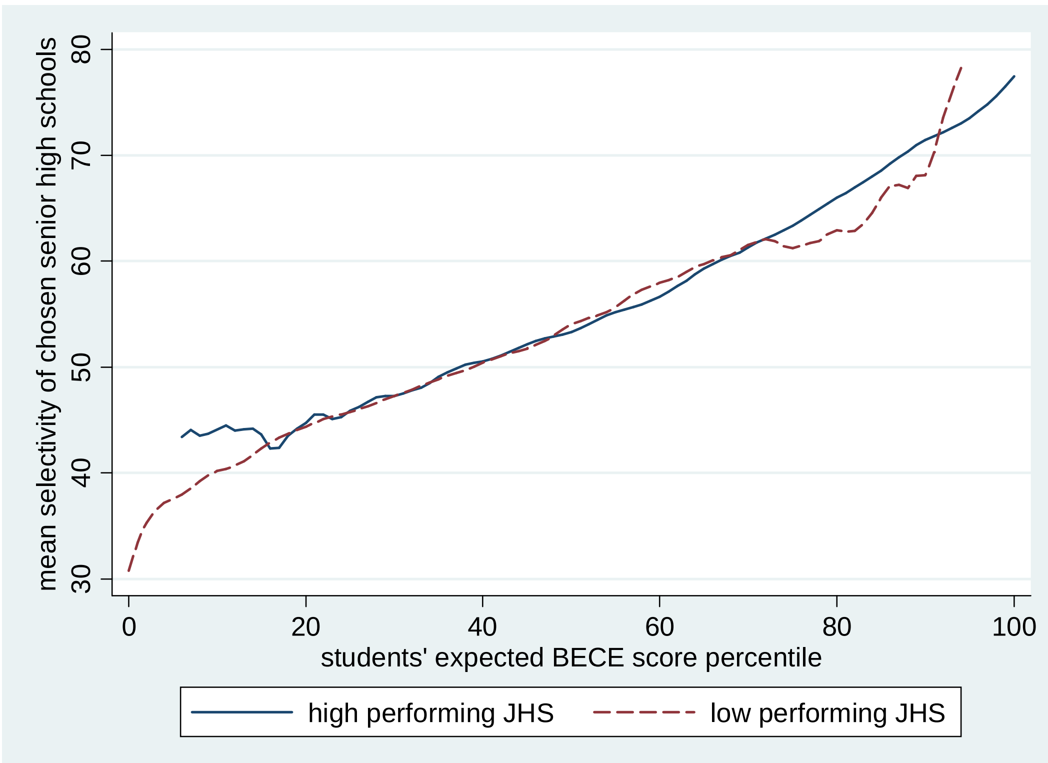
Students from high-performing junior high schools



Students from low-performing junior high schools

Notes: The top figure focuses on students who attended a high-performing Junior High School and the bottom figure focuses on students who attended a low-performing Junior High School. The y-axis illustrates the mean selectivity of the senior high schools to which a student applied. The solid lines indicate the relationship between students' application decisions and their *actual* BECE scores. The dashed lines indicate the relationship between students' application decisions and their *expected* BECE scores. Students' expected BECE scores are calculated by using a shrinkage estimator to weight students' individual BECE performance by the average performance in their junior high school (see Section 6 for more detail).

Figure 4: Expected Exam Performance and Application Choices (2008)

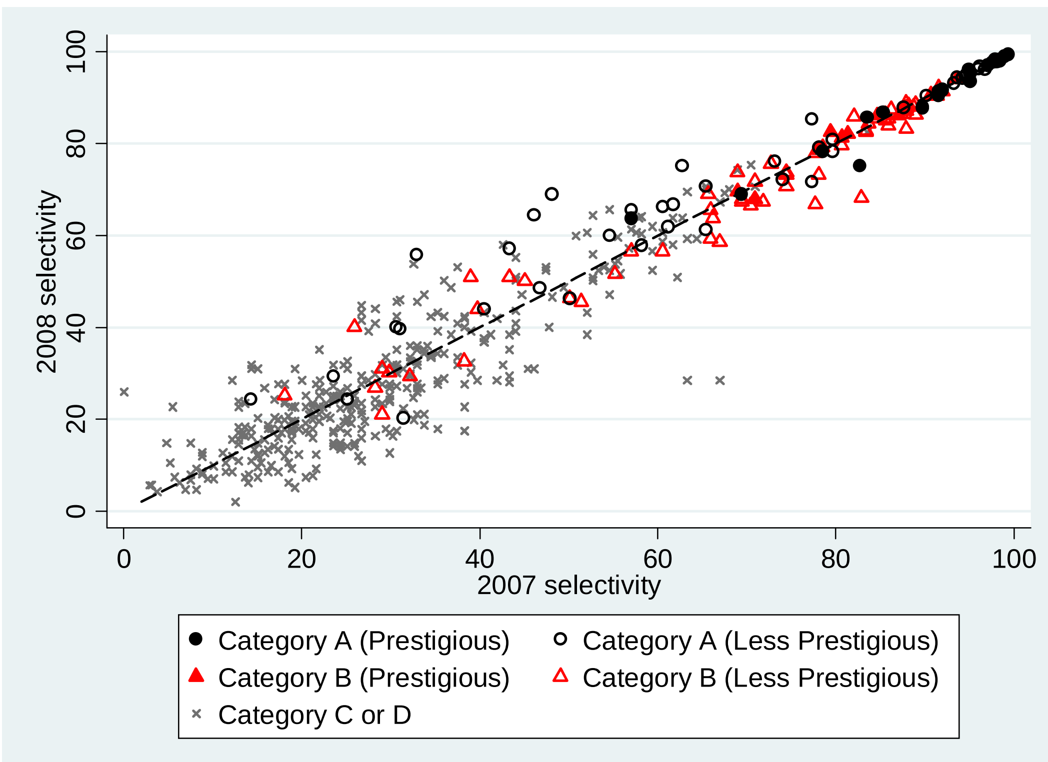


Notes: This figure illustrates differences in application choices for students with the same expected ability but from low and high performing junior high schools (JHSs). Students' expected ability level is calculated by using a shrinkage estimator to weight students' individual BECE performance by the average performance in their junior high school. The y-axis illustrates the mean selectivity of the senior high schools to which a student applied. The solid line indicates students who attended a high-performing JHS. The dashed line indicates students who attended a low-performing JHS.

Figure 5: Categorization and Quality of Public Senior High Schools

	School Quality			
	Selectivity[a]	Pass Rate[b]	Prestigious[c]	Total
Available Facilities				
Category A	76.87	73.23 %	22	65
Category B	70.26	66.71 %	10	72
Category C	40.05	48.07 %	2	178
Category D	18.03	41.19 %	0	178
Mean (Total)	41.37	52.87 %	(34)	(493)

Notes: [a]Median BECE percentile of students admitted to the school in 2008. [b]Percentage of students who scored between A and E in the SSCE maths exam in 2008. [c]Schools which were constructed before Ghana gained independence in 1957.

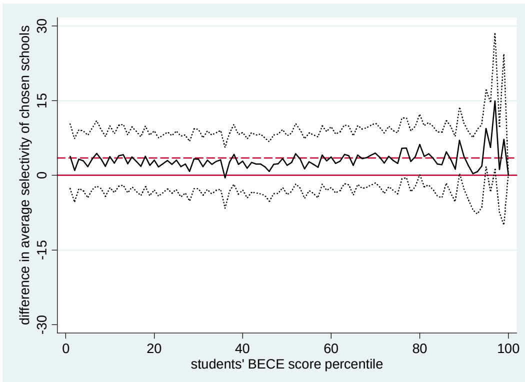


Notes: School selectivity indicates the median BECE percentile of students admitted to a school in a given year. Historically prestigious schools are those which were constructed before Ghana gained independence in 1957.

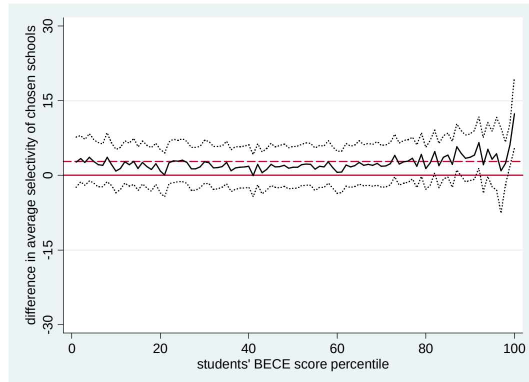
Figure 6: Differences-in-Differences Regression Estimates (Application Choices)

Differences between students from low and high performing schools

2007-2008

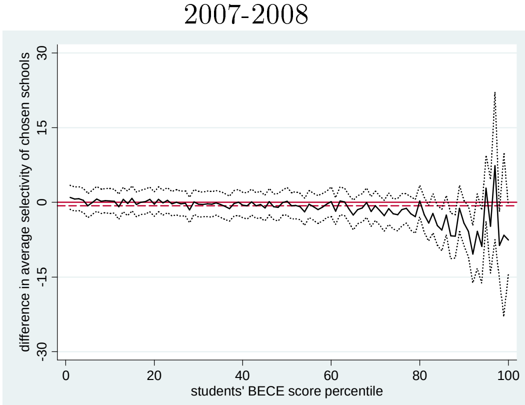


2008-2009

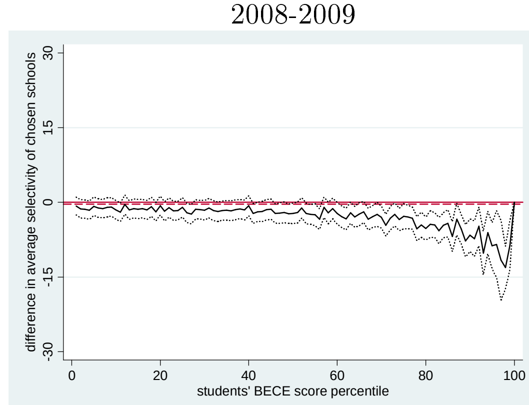


Differences between before and after a reform

2007-2008

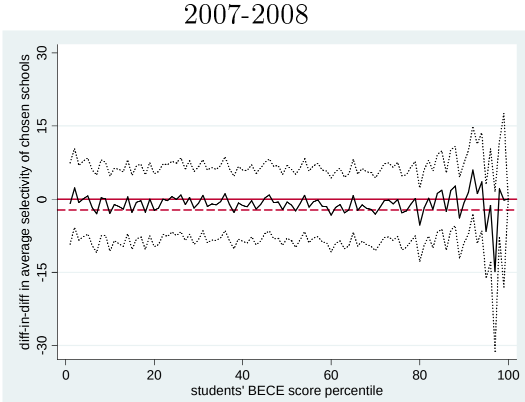


2008-2009

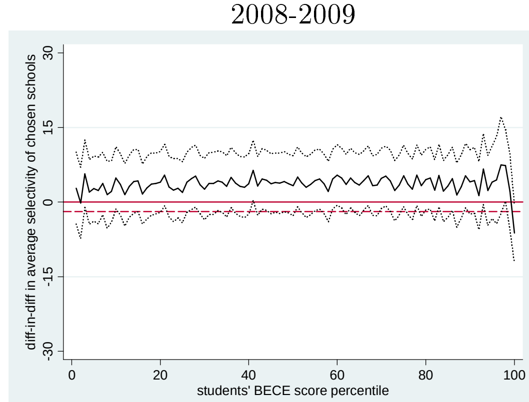


Difference in differences between students from low and high performing schools, before and after a reform

2007-2008



2008-2009

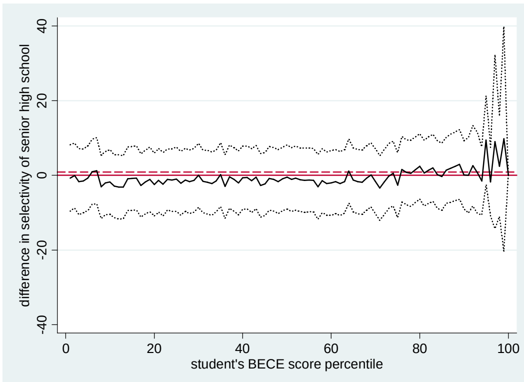


Notes: These figures illustrate results from difference-in-difference regressions estimated with interaction terms for each percentile in the performance distribution. The outcome variable is the average selectivity of schools to which a student applied. The solid line indicates estimates for the individual percentiles (with 95-percent confidence intervals). The dashed line indicates the mean difference. Figures on the left illustrate estimates for the 2007-8 reform. Figures on the right illustrate estimates from 2008-9. The first row indicates coefficients on "high performing junior high school". The second row indicates coefficients on "after reform". The final row indicates coefficients from "after reform*high performing school".

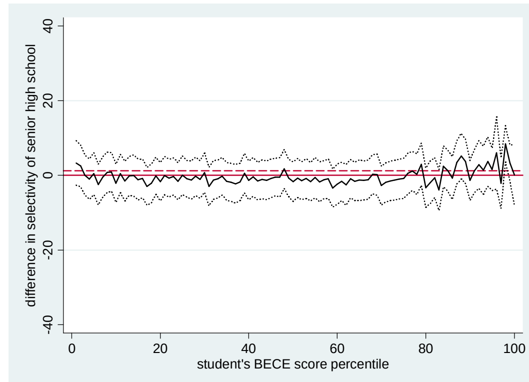
Figure 7: Differences-in-Differences Regression Estimates (Admission Outcomes)

Differences between students from low and high performing schools

2007-2008

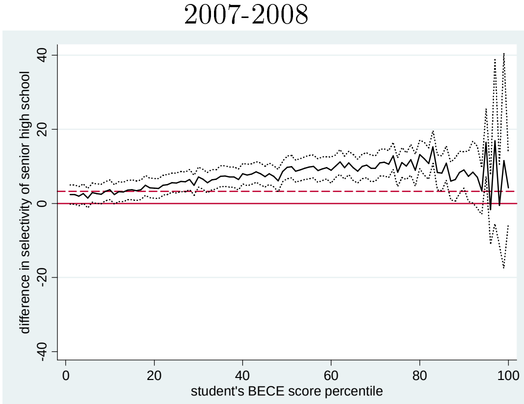


2008-2009

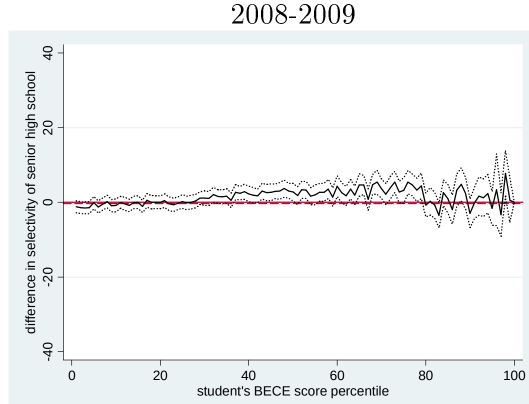


Differences between before and after a reform

2007-2008

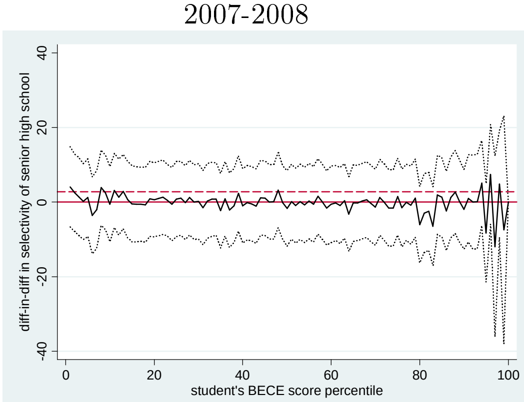


2008-2009

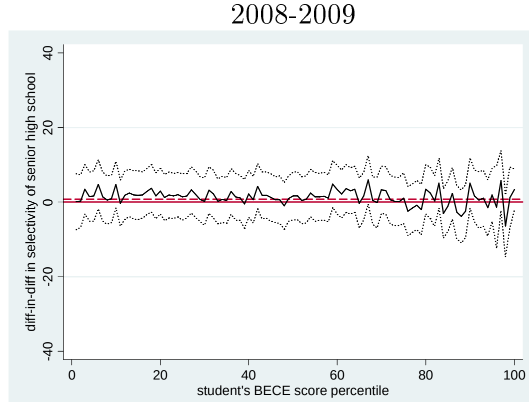


Difference in differences between students from low and high performing schools, before and after a reform

2007-2008



2008-2009



Notes: These figures illustrate results from difference-in-difference regressions estimated with interaction terms for each percentile in the performance distribution. The outcome variable is the selectivity level the senior high school to which a student is admitted. The solid line indicates estimates for the individual percentiles (with 95-percent confidence intervals). The dashed line indicates the mean difference. Figures on the left illustrate estimates for the 2007-8 reform. Figures on the right illustrate estimates from 2008-9. The first row indicates coefficients on “high performing junior high school”. The second row indicates coefficients on “after reform”. The final row indicates coefficients from “after reform*high performing school”.

Box 1: Timeline for School Selection and Placement in Ghana (2005-2008)

1. **Students Submit Choices**
   - **October**: West Africa Exam Council (WAEC) registers students for Basic Education Certification Exam (BECE)
     - Collects students' lists of program choices
     - Provides CSSPS Secretariat with data on student backgrounds and choices
2. **Schools Declare Vacancies**
   - **January**: Ministry of Education supplies CSSPS Secretariat with
     - register of all JHSs
     - register of all SHSs (with numbers of program vacancies)
3. **Student Quality Revealed**
   - **April**: Students take the BECE exams
4. **Students Admitted to Schools**
   - **July/August**: WAEC sends scores to CSSPS Secretariat which then
     - Assigns each student an aggregate score based on performance in 4 core and 2 best subjects
     - Places qualified students in schools according to ranked choices and deferred acceptance algorithm, with priority determined by aggregate BECE scores
   - **A few weeks** after CSSPS Secretariat receives BECE results:
     - Placement results released and displayed in junior and senior high schools or retrieved by text messaging candidate IDs to the CSSPS Secretariat

Box 2: History of School Choice Reforms in Ghana

- 2005: Computerization
  - shift from a manual admission system
  - students can apply to 3 choices anywhere in the country (no longer constrained to apply to three schools in the same region)
  - schools have limited input in admission process
- 2007: Increase in number of permitted choices, from 3 to 4
- 2008: Increase in number of permitted choices, from 4 to 6
- 2009: School categorization reform ("CSSPS Guidelines for Selection of Schools for Placement")
  1. All second cycle institutions have been grouped into categories as follow:
     - Senior High Schools: four (4) categories namely A, B, C, and D depending on available facilities (e.g. single sex, boarding and day, geographical location).
     - Technical Institutes (T).
     - Private Schools (P).
  2. Before making any selection of schools and programmes offered in these schools, parents are advised to note the following:
     - All schools selected (1st to 6th) are considered in the placement of candidates
     - Placement in schools is based on scores obtained by candidates (Merit)
  3. Conditions for Selection of Schools
     - Candidates must choose six schools (1st - 6th choice).
     - Candidates must select programmes and accommodation in each school of choices.
     - Candidates must not choose one school twice.
     - Candidates cannot choose more than one (1) school in category A.
     - Candidates cannot choose more than two (2) schools in category B.
     - Candidates may choose a maximum of 5 schools from category C or D.
  4. Note: Regardless of the categories, candidates must arrange their choices in order of preference.

Appendix

A.1: Student Optimal Stable Matching Mechanism

The CSSPS uses a *deferred-acceptance algorithm* (or Student-Optimal Stable Matching mechanism) for school placement (Gale and Shapley (1962) provide a more detailed description). Under this algorithm, students are placed in schools according to their preferences and priority is determined strictly by academic merit as follows:

- *Step 1*: Each student i proposes to the first school in her ordered list of choices, A_i. Each school s tentatively assigns its seats to proposers one at a time in order of priority determined by students' academic performance (measured by aggregate BECE scores). Each school rejects any remaining proposers once all of its seats are tentatively assigned.

In general, at

- *Step k*: Each student who was rejected in a previous round proposes to his or her kth choice school. Each school compares the set of students it has been holding with the set of new proposers. It tentatively assigns its seats to these students one at a time in order of students' academic performance and rejects remaining proposers once all of its seats are tentatively assigned.

The algorithm terminates when no spaces remain. Each student is then assigned to his or her final tentative assignment. Rejected students remain unassigned. The mechanism has been shown to be stable and strategy proof. It is not Pareto efficient, however, it is Pareto optimal relative to all other stable matching algorithms (Haeringer and Klijn (2009)).

Note that academic performance is the ultimate determinant of school assignment in the CSSPS and no preferential treatment is given to students for listing a school as a first choice. Thus, there is no penalty for ranking schools in true preference order within the set of listed choices. This contrasts with the *Boston mechanism* (formerly used by Boston public schools and several other school districts in the United States) which assigns students based on their first choices in the same way but then keeps these initial assignments for all subsequent rounds and does not allow higher priority students to displace students already assigned to a school in a preceding round. There are clear incentives for making a strategic first choice under the *Boston mechanism* which do not apply under the *deferred-acceptance algorithm*. The CSSPS technical working committee produced a handbook outlining a set of "Guidelines for Selection and Admission into Senior Secondary Schools and Technical/Vocational Institutes" (MOES, 2005). The publication highlights the issue of "Displacement of 1st choice candidates and 2nd choice candidates as a matter of merit or better performance" and emphasizes the notion that placement priority is based on "merit not choice". (p.4)

The *deferred-acceptance algorithm* has several desirable properties when students are allowed to rank all schools - it is student optimal, strategy proof and eliminates "justified envy"[12] (Gale and Shapley (1962); and Abdulkadiroğlu and Sönmez (2003)). The attractiveness of this mechanism decreases only slightly when students are forced to make a constrained choice with an opportunity to rank only a limited number of schools (Abdulkadiroğlu, Pathak and Roth, 2008, p.30). However, the CSSPS's merit-based priority may create incentives for strategic behavior because students are encouraged to select schools according to their anticipated BECE scores and expected admission chances.

A.2: Measures of Decision-Making Quality

I do not observe students' expected admission chances in the data, but I do observe school selectivity, given by the performance distribution of students admitted to the school in previous years. Noting that admission chances (p_{is}) are inversely correlated with school selectivity (q_s), I use six measures to evaluate the quality of students' decision making:

1. $q_{i1} > q_{i2} > \ldots > q_{iN}$: choices are strictly ranked in order of selectivity
2. $q_{i1} \geq q_{i2} \geq \ldots \geq q_{iN}$: choices are weakly ranked in order of selectivity
3. $q_{i1} + 10 \geq q_{i2},\ q_{i2} + 10 \geq q_{i3}, \ldots \geq q_{iN}$: choices are weakly ranked in order of selectivity, allowing for a band of 10 percentile points around the selectivity level of each school
4. $q_{i1} + 20 \geq q_{i2},\ q_{i2} + 20 \geq q_{i3} \ldots \geq q_{iN}$: choices are weakly ranked in order of selectivity, allowing for a band of 20 percentile points around the selectivity level of each school
5. $q_{i1} \geq q_{i2}, \ldots q_{iN}$ and $q_{iN} \geq q_{iN-1}, \ldots q_1$: the highest-ranked choice is the most selective school and the lowest-ranked choice is least selective
6. $q_{i1} \geq q_{iN}$: the highest-ranked choice is weakly more selective than the lowest-ranked choice

Finally, I also construct a decision-making index which assigns a value of 6 to students who satisfy condition (1), a value of 5 to those who satisfy condition (2), and so on, assigning a value of 1 to students who satisfy condition (6) and a value of 0 to those who fail to satisfy any of the six conditions. The final row in each panel of Table 6 indicates the share of students who satisfy each condition in a given year. For the most part of my analysis, I use condition (6) as my preferred measure of decision-making quality since it predicts the largest change in the selectivity of senior high schools to which students gain admission.

[12] This requires that there should be no unmatched student-school pair (i, s) where student i prefers school s to her final assignment and has higher priority than another student who is assigned to school s.