School Choice Policies and Market Competition: Implications for the Public Education Sector

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THESIS
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CONTRIBUTION OF AUTHORS

Chapter 1 is an introduction that provides an overview of the thesis. Chapter 2 include an unpublished manuscript for which I am the sole author. Chapter 3 presents a co-authored manuscript with Dr. Benjamin Feigenberg and Dr. Steven Rivkin, and the manuscript is published with the title "Illusory Gains from Chile's Targeted School Voucher Experiment" by Oxford University Press in The Economic Journal, Volume 129, Issue 10, Pages 2805–2832, in 2019. Most of this manuscript was written by Dr. Benjamin Feigenberg and Dr. Steven Rivkin, while I conducted the majority of data analysis and assisted in writing. Lastly, chapter 4 summarizes this dissertation and provides policy implication of my study.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF TABLES (continued)

LIST OF TABLES (continued)

LIST OF FIGURES

LIST OF ABBREVIATIONS

ACT	Scholastic Aptitude Test
CDC	Common Core of Data
CPI	Consumer Price Index
DID	Difference in Differences
DDID	Dynamic Difference in Differences
FRL	Free or Reduced Lunch
FY	Fiscal Year
HEI	Higher Education Institution
SEP	Subvención Escolar Preferencial
SES	Socio Economic Status
SIMCE	Sistema de Medición de la Calidad de la Educación
TPS	Traditional Public Schools

SUMMARY

This dissertation studies the effect of school choice policies with a focus on charter schools and school vouchers. Exploiting the time-varying charter competition driven by the Michigan 2011 cap-lifting policy, the first chapter examines the effect of charter competition on traditional public school districts' cost efficiency in two ways. The first part implements two Difference-in-Differences-based research designs, a standard Difference-in-Differences and a Dynamic Difference-in-Differences, to estimate the effect of the cap-lifting policy on districts' resource allocation. The second part extends the policy analysis to disentangle the separate effects of potential competition and actual competition so that we can understand the dynamic effects of the policy.

Based on an integrated dataset of Michigan traditional public school districts between 2008 and 2014, the first chapter shows that the cap-lifting policy on average pressures school districts to reduce non-instructional expenditure. Specifically, the policy causes salary payment towards non-instructional employees per student to decrease by 1.9 percentage points on average. Meanwhile, the number of non-instructional employee per student decreases by 0.001.

The dynamic analysis indicates that such change in resource allocation occurs immediately after the increase in the potential charter competition and districts try to respond to the policy-driven potential charter competition, possibly deterring future competition and extending sustainability. Further analysis also shows that actual charter competition changes districts' student composition where the percentage of students in the English Language Learner program increases 2.5 percentage points. Little evidence shows that such student sorting results in a significant change in overall academic performance in the short term. The findings suggest that districts attempt to respond to the policy-driven charter competition by prioritizing instruction and reducing cost inefficiency.

The second chapter investigates the effect of a Chilean targeted school voucher program. In 2008, Chile implemented a targeted voucher program that increased funding for disadvantaged students at public and participating private schools by approximately 50%. This reform would be expected to raise average achievement in participating schools and reduce the socioeconomic-status-based achievement gap. Evidence show that disadvantaged students did make substantial fourth-grade test score gains exceeding 0.2 standard deviations. However, focused on contemporaneous changes in family background, as well as limited school input, market competition, and

school switching responses, the analysis raises doubts that a program-induced improvement in school quality accounts for this convergence.

1 INTRODUCTION

With a short history of 20 years, more than 7,000 charter schools are currently serving nearly 3.2 million students in the United States (Ziebarth and Palmer, 2018). The rapid expansion of charter schools across states is fueled by the growing popularity of leveraging competition into the public education sector to achieve market efficiency (Grand, 2009; Epple et al., 2016). In this thriving movement, advocates argue that innovative charter schools offer a better education than Traditional Public Schools (TPS) and pressure the incumbent TPSs to improve and operate efficiently (Hoxby, 2003; Gronberg et al., 2012; Mehta, 2017; Ferreyra and Kosenok, 2018). However, better education quality and more competition might come with great cost. Opponents are worried that charter schools drain away resources from TPSs and leave out disadvantaged students including special-needs or at-risk students with even more scarce resources (Epple et al., 2016). If this problem escalates, as financially distressed states turn to charter schools, charter competition may intensify the disparity of educational resources and devastate the existing TPSs' education quality which still serves the majority of American students.

Researchers are actively seeking empirical evidence regarding the charter school debate, and extensive literature has investigated the effect of charter competition on incumbent TPSs. Unfortunately, various channels from di-

verse contexts have led to mixed conclusions based on the remaining TPS students' test scores (Bettinger, 2005; Bifulco and Ladd, 2006; Sass, 2006; Booker et al., 2008; Ni, 2009; Zimmer and Buddin, 2009; Imberman, 2011; Winters, 2012; Jinnai, 2014; Cordes, 2018). To fully understand the consequence of charter school expansion and provide generalizable evidence to policymakers, instead of taking it as a black box, we need to understand how charter competition can affect districts' resource, teachers, and students (Epple et al., 2016).

This first chapter studies the effect of charter school competition on the cost efficiency of Michigan traditional public school districts, based on a case study of the 2011 Michigan cap-lifting policy. The policy initiated a three-stage roll-out plan for university-authorized charter schools in the state, causing a spontaneous surge in potential charter competition and a gradual increase of actual charter competition. This chapter estimates the average effect of this cap-lifting policy and provides important policy implication on the traditional school districts' response to market competition. It also presents time-varying estimates which suggest that districts actively reduce their non-instructional expenditure while attempting to prioritize instruction, reducing cost inefficiency and deterring future competition.

In addition to the charter competition, the second chapter studies the impact of a targeted school vouch program in Chile. In 2008, the Chilean government implemented a major reform in its existing voucher system, namely

Subvención Escolar Preferencial (SEP), to improve disadvantaged students' access to high-quality schooling. The SEP program is designed to raise the value of school vouchers by 50% for students from the lowest Socio-economic Status (SES) households. With this additional funding from low-SES enrollment, public and private schools participating in this program were required to decrease the achievement gap between SES groups. The second chapter in this dissertation comprehensively examines the SEP program's impact on student sorting, school inputs and quality, market competition, as well as a simultaneous change in family inputs and strategic behaviors. The results provide rich insights in understanding the effect of student-based school voucher and closely investigate the effectiveness of the proclaimed progress.

2 CHARTER COMPETITION AND TRADITIONAL PUBLIC SCHOOL DISTRICTS' RESOURCE ALLOCATION: EVIDENCE FROM MICHIGAN CHARTER SCHOOL CAP-LIFTING

2.1 Introduction

This chapter explores the effect of charter school competition on the cost efficiency of Traditional Public School Districts, henceforth referred to as districts. Considering the nature of public schools' education production function, this chapter particularly examines districts' resource allocation and priority on instruction, in the presence of student sorting. To study how charter competition affects the incumbent districts, the Michigan cap-lifting policy provides a unique opportunity. In December 2011, the state of Michigan approved Senate Bill No.618 and officially terminated the previous cap which allowed a maximum of 150 charter schools authorized by the governing board of state public universities (State of Michigan, 2011a). To replace the old cap, Michigan enacted a three-stage roll-out plan to expand charter schools. The new 2011 legislation lifted the cap by an additional 150, permitting a maximum total number of 300 charters issued by state public universities through December 31, 2011, and 500 through December 31, 2014. After De-

cember 31, 2014, there is no limit on the numbers of university-authorized charter schools (State of Michigan, 2011a).

Interestingly, this three-stage cap-lifting plan causes temporal differences between two types of competition, potential competition and actual competition, that allows me to explore the time-varying dynamics. The potential charter competition immediately surges after the increases in the cap. With the threat of potential charter entry, the incumbent districts are pressured to take actions to reallocate resources and deter future competition (Stiglitz, 1981; Dasgupta and Stiglitz, 1988; Bukowski and Kobus, 2018). As potential competition gradually nurtures actual competition and new charter schools enter the market, the weights on the effect of potential competition and actual competition are likely to change over time. Finally, the dominance of actual competition leads the market to shift to the new equilibrium. In fact, after the decade-long stagnation under the binding cap (Bettinger, 2005), Michigan charter schools, especially university-authorized charter schools, increased by roughly 50 between 2012 and 2014. However, the expansion of actual competition varies greatly by geographic locations. Although the exact proximity between charter schools and their authorizers is not restricted by law, the districts near Higher Education Institutions(HEI) were more likely to experience an increase in charter competition than the ones farther away. The convenience of supervision, the high racial diversity, and the large population of school-age students make the areas close to HEIs desirable for

new charter schools (Bettinger, 2005; Epple et al., 2016). As I demonstrate in section 2.2, the districts within 10 miles of HEIs experienced most of the increase in the charter competition after the cap-lifting policy. More importantly, the time-varying and location-varying increase of charter competition driven by the policy is arguably irrelevant to the districts' resource allocation in the pre-period.

This observation motivates a Difference-in-Differences (DID) research design between districts based on their proximity to HEIs. Considering the districts within 10 miles to any HEIs as the treatment group and the others as the control group, I exploit three versions of DID-based research designs. Firstly, the standard DID combines the impact of both potential competition and actual competition and provide baseline estimates on the average effect of the Michigan cap-lifting policy on districts' cost-efficiency. Secondly, the unique time-lapse from the cap-lifting allows me to disentangle these two types of competition and investigate their time-varying importance on districts' resource allocation. Potential competition may lead to a short-term response by incumbent districts to deter future entry, but actual competition may have different effects on districts because of funding loss (Stiglitz, 1981; Dasgupta and Stiglitz, 1988; Bukowski and Kobus, 2018). To investigate the incumbent districts' response to the three-stage cap-lifting plan, I employ a Dynamic Difference-in-Differences(DDID) framework in addition to the standard DID framework. It closely examines the districts' resource allocation

every year before and after 2011. The results expand the reduced-form estimates on average effect and show that districts concentrate expenditures on instructional activities immediately following the cap-lifting policy but spending tails off after the surge of new charter entry. Lastly, I provide separate estimates of the impact of potential and actual competition to examine the possible deterrent behaviors of the incumbent districts.

Quantifying the effect of charter competition on districts' cost efficiency is one of the key challenges in this research because charter competition affects districts' resource, educators, and students simultaneously (Welsch, 2011; Arsen and Ni, 2012b; Jackson, 2012; Mehta, 2017; Cook, 2018; Cordes, 2018). Simply examining one aspect while controlling for others would lead to bias due to the simultaneous change in all the factors in the education production function. Instead, I investigate the effect of charter competition on a full set of districts' outcomes, thanks to a comprehensive dataset from all Michigan districts with administrative, financial, personnel, and student information between 2008 and 2014. The evidence suggests the cap-lifting policy generally increases districts' percentage of expenditure on instructional employees by an average of 0.6 percentage points, and the increases are 0.5, 1.1, and 1.0 percentage points in the first three years after 2011, respectively. The decomposition results suggest that potential competition explains the majority of this resource allocation and actual competition appears to enhance the effects in the same direction. This concentration of expenditure

on instructional employees is caused by the reduction on the salary of the non-instructional employees in support service, administration, and others. The cap-lifting policy on average decreases the expenditure on these employees per pupil by 1.9 percentage points, and the dynamic effects display deduction of 2.0, 1.5, and 3.2 percentage points every year in the post period. The downward pressure on non-instructional expenditure is likely to decrease the districts' labor demand of non-instructional employees, where the cap-lifting policy significantly decreases the ratio between these employees and student by 0.001. Meanwhile, charter competition shows mixed and insignificant effects on the overall academic performance in the districts, measured by grade-4 math and reading test scores for the elementary education and the composite ACT scores for the secondary education. Additional results indicate this slightly positive effect on ACT scores might correlate with the changes in exam-taking behaviors and grade-retention.

Although the evidence on the districts' priority on instruction-related expenditure and labor demand reveals their attempt to improve instruction quality, such efforts towards cost efficiency can be undermined by cream-skimming caused by charter competition. If charter schools select students based on observable or unobservable characteristics such as motivation, discipline, and/or academic needs, this cream-skimming behavior might offset the districts' efforts in reducing cost inefficiency and eventually lead to a decrease of overall academic performance. This is studied in a growing literature

regarding private competition selecting customers with desirable characteristics (Ni, 2012; Winters, 2012; Zimmer and Guarino, 2013; Epple et al., 2016; Bukowski and Kobus, 2018; Cooper et al., 2018). Besides its adverse effect on the disadvantaged students, this problem adds complexity to the study of cost efficiency. In the presence of a change in student characteristics, the effects on expenditure per student or average test scores are likely to be biased by the change in student composition. To investigate this possible channel of charter competition, I examine the change in the percentage of students in the special education program and English Language Learner (ELL) program. Results provide little evidence of charter schools' cream-skimming behaviors against special-education students. However, the cap-lifting policy leads to a significant increase by 1.0 percentage points of ELL students during my study period, and the sorting appears to start from the second year after the policy which mostly ascribes to the actual competition.

This paper contributes to the limited literature measuring the effect of charter school competition on districts' cost-efficiency. Few studies provide evidence on the effect of charter schools on TPSs' financial outcomes, and the conclusions are fairly mixed (Epple et al., 2016). In order to mitigate the bias caused by endogenous charter entry, one common approach is to utilize school FEs or control for lagged outcome variables (Welsch, 2011; Arsen and Ni, 2012a; Jackson, 2012; Cordes, 2018). This strategy relies on a critical assumption that charter competition is exogenous conditional on school

FEs or past outcomes, while strategic charter penetration is likely to fail this assumption. Additionally, the estimates draw a broad spectrum of heterogeneity where charter competition affects districts via multiple channels including resources, school inputs' productivity, and student sorting(Booker et al., 2012; Jackson, 2012; Epple et al., 2016).

A few recent studies focus on specific sources of charter competition using Instrumental Variables(IV). Common IV options include legislation requirements on the cap of charter schools or enrollment, accountability standards, and location choice (Bettinger, 2005; Singleton, 2017; Cook, 2018). Desirable market conditions such as shares of minority students and available building space have also been explored as IVs for charter competition (Bettinger, 2005; Welsch, 2011; Imberman, 2011). Conceptually, the IV approach isolates the variation of actual competition caused by potential competition. This identification strategy relies on an important exclusion restriction assumption where potential competition has no direct impact on districts' outcomes. Such an assumption is likely to hold when the potential competition is random or its impact on districts' outcome is relatively negligible. However, Dasgupta and Stiglitz (1988) demonstrate an ambiguous relationship between potential competition and actual competition as incumbents take deterrent behaviors as a response to potential competition. Bettinger(2005) also admits that districts are usually aware of the future threat of charter competition. And such information is likely to bias the estimates when dis-

tricts can take actions to respond not only the present, actual charter competition but the future, potential competition. In other words, the direct impact of potential competition on districts is likely to cause the violation of exclusion restriction and lead to a biased estimate from the IV approach.

In a working paper written in parallel with mine, Ridley and Terrier (2018) study Massachusetts's cap-lifting policy on the charter school enrollment cap and find that charter enrollment expansion increases the districts' expenditure on instruction and leads to test score gains. This paper differs from my study in the following two ways. First, Massachusetts and Michigan establish different funding formulas for districts regarding the increasing charter competition. Specifically, Massachusetts provides funding compensation for TPSs which experience heavy enrollment loss, while Michigan has no such financial help for districts. As a result, Massachusetts TPSs may benefit from extra instructional expenditures per student and react differently to the charter competition, while Michigan districts are likely to be pressured to downsizing spending to remain sustainable. Second, Ridley and Terrier (2018) utilize the cap-lifting policy as the instrument for actual charter competition, while my research acknowledges the endogenous relationship between the policy-driven potential charter competition and districts cost efficiency. Without closely investigating this relationship, the potential charter competition, as an omitted variable, is likely to cause a biased estimate of

actual charter competition effect (Dasgupta and Stiglitz, 1988; Pearcy and Savage, 2015).

In addition to the charter school literature, this paper also contributes to the broad understanding of market competition in public sector. The competition in the public sectors like education and health care is increasingly important as it becomes the major approach to control costs and increase market welfare. Different than the common price strategy in private sectors (Brekke et al., 2012; Tenn and Wendling, 2013; Snider and Williams, 2014; Pearcy and Savage, 2015), public schools and not-for-profit hospitals have no option to change their price. Instead, schools and hospitals tend to focus on reducing cost inefficiency and reallocating resources, as well as possibly cream-skimming students or patients for cost control (Card et al., 2010; Bukowski and Kobus, 2018; Cooper et al., 2018). This paper provides evidence on this hypothesis where districts prioritize expenditure on instruction and attempt to operate efficiently, in order to be sustainable in the long run. Such behaviors might be driven from districts' incentive to deter future actual charter competition. These results have important policy implication as states are actively seeking generalizable evidence to support charter schools (Mehta, 2017).

The remainder of the paper is as follows. Section 2.2 describes the institutional details of Michigan charter schools and the cap-lifting policy. Section 2.3 presents a conceptual framework to present different channels of charter

competition effect. Section 2.4 describes the datasets of Michigan districts' financial, personnel, and student academic outcomes. Section 2.5 describes the research design for the standard and dynamic effects of the cap-lifting and section 2.6 shows the corresponding results and provide evidence from the specification test and robustness check. Additionally, section 2.7 describes the research design to disentangle the effects of potential competition and actual competition, and section 2.8 shows the corresponding results. Concluding comments are in section 2.9.

2.2 Institutional Background

Michigan Charter schools, also formally known as Public School Academies, are public-funded K-12 schools operated by one or more persons or entities, regardless whether they are non-profit or private. Since the first charter school from the early 90s, this section has expanded rapidly in Michigan. There are currently 297 operating charter schools serving more than 147,000 students, 10% of the total full-time enrollment among in all Michigan schools in the academic year 2018-2019 (Ziebarth and Palmer, 2018).

To establish a new charter school, the proposing charter school entity needs to provide a detailed application to explain their plan on the education program, grade level, anticipated enrollment, geographic location and available staff (Education Commission of the States, 2018b). This application

needs to be approved by one of the four types of charter school authorizers in Michigan, including the board of a school district, Intermediate School boards(ISD) which provide supervision to multiple school districts in the same region, the board of a community college, and the governing board of a state public university (State of Michigan, 2011; Education Commission of the States, 2018c). The authorizers are responsible for application examination, qualification verification, operation supervision, and funding approval to certain degree. In other words, each authorizer exerts their authorizing jurisdiction based on their district boundaries, except for the governing board of state public universities. Specifically, school districts, Intermediate school boards, and community colleges are only allowed to approve charter schools within their boundary, while the governing board of state public universities can approve and supervise charter schools across the state (State of Michigan, 2010; State of Michigan, 2011).

Generally, charter schools authorized by different authorizers are required to conform to the same state regulation, exemption, evaluation procedure, and funding formula. However, the share of charter schools by their authorizer type differ immensely.

In Michigan, the university-authorized charter schools comprise the majority of charter competition (Bettinger, 2005). Its dominance coincides with historic political encouragement, low local resistance, and broad location options. But, its growth has stagnated in the past decade. In the initial leg-

islation in the pilot period, the State of Michigan capped the total number of university-authorized charter schools at 150 across the state, and the total number of university-authorized charter schools has quickly approached this maximum since the late 1990s, with slight fluctuation from the year-to-year entry and closure (Bettinger, 2005). In 2011, this cap was lifted by Senate Bill No.618 introduced by Senator Pavlov and approved by the Michigan governor (State of Michigan, 2011). This new policy announces a three-stage roll-out plan to encourage new entries of university-authorized charter schools, regulating that the total number of existing charter school contracts issued by all state public universities shall not exceed 300 through December 31, 2012, and 500 through December 31, 2014. After December 31, 2014, there will be no limit on the numbers of this type of charter schools (State of Michigan, 2011) [1].

Upon enactment, this cap-lifting policy resulted in a surge of incentives for more university-authorized charter schools to enter the public education sector. Financially, the university-authorized charter schools have relatively high independence of their expenditure and operation. They function as a local educational agency, also known as school districts, and are allowed to directly receive funding through their authorizers. The charter school

[1] As part of Michigan's Race to the Top plan, the state encouraged the creation of up to 10 new charter schools in 2010. This new quota is only for schools of excellence whose operation entities proves to be effective in improving students' academic performance. This creates a temporary leeway for universities to authorize more charter schools without topping their cap (State of Michigan, 2010)

funding is determined at per-student level, while the amount per student is the less of the following two options, a per-pupil base equivalent to the TPS base funding where the charter schools reside or the state maximum charter school allocation (Mackinac Center for Public Policy, 2017; Summers, 2018; State of Michigan, 2019a; State of Michigan, 2019b) [2]. The threat of charter entry creates great potential charter competition to the districts which are likely to lose their enrollment, as well as the enrollment-based funding, to charter schools.

After the cap-lifting, many new charter schools made their entry decision, and the Michigan public K-12 education sector experienced a drastic increase in the number of university-authorized charter schools, exposing many districts to the active growth of actual charter competition. During a relatively short post-period, the number of university-authorized charter schools increases by about 50, and districts face the challenges brought by the new-level of charter competition.

[2]Besides the base funding, charter schools have the same access to state and federal grants as public school districts, except for 3% of their total funding required to submit to their authorizers for monitoring and administrative expense (Education Commission of the States, 2018a)

2.3 Conceptual Framework

This section provides a conceptual framework to demonstrate the theoretical effects of charter competition on districts' cost efficiency through varied channels including resource allocation, labor demand adjustment, and student sorting. In general, the cap-lifting policy increases potential charter competition which induces future actual competition. Admittedly, distinguishing the two types of competition is a challenge as their magnitudes and importance evolve and are possibly dependent on each other. The relative magnitudes between potential competition and actual competition could also vary by case (Bergman and Rudholm, 2003). For example, the incumbents can be proactive and present sharp responses to the potential competition or ignore the potential competition until they are exposed to an increase in actual competition.

The conceptual framework in this section provides essential guidance for the empirical analysis in this chapter and focus on understanding the effect of potential charter competition and actual charter competition. By utilizing a compare-and-contrast approach, it uncovers districts' behaviors as a response to either potential competition or actual competition. Theoretically, the two types of charter competition might have different effects on districts, and the various channels are summarized in Table I with the detailed discussion below.

TABLE I: THEORETICAL EFFECTS ON AVERAGE DISTRICTS' OUTCOME PER STUDENT

Outcome Variables	Potential Competition	Actual Competition	Total
Total resources	0	-	-
Priority on instruction	+	+	+
Educator effort	+	+	+
Cost based on student composition	0	?	?
Overall academic performance	+	?	?

Notes: The sign of the theoretical effect of charter competition on districts' outcome variable are listed in each cell. 0 indicates no effect, + indicates a positive effect, − indicates a negative effect, and ? indicates an ambiguous effect. Each variable is measured in per-student average.

2.3.1 Resource Allocation

Given districts' limited ability to acquire additional revenue in the short term, one of the most feasible ways for them to change their cost efficiency is cost reduction [3]. When the cap-lifting policy lowers the entry barrier for university-authorized charter schools, the threat of future charter entry im-

[3]In Michigan, individual districts receive the base funding via a fixed schedule at the per-student basis from the state every year. The amount of base funding, also known as foundation allowance, is determined by a step function based on the initial status in FY 1994-1995. The step function went through a few adjustments over the years. Starting from FY 2007-08, the Michigan Legislature reestablished the use of the 2X formula (Wicksall et al., 2018). In addition to this state revenue and a relatively small amount of federal funding, a district's local revenue comes from a fixed tax rate on all non-homestead property within the district boundary (Mackinac Center for Public Policy, 2017). The non-homestead property in a district refers to commercial and industrial property or houses that are not a person's primary residence. This funding context limits districts' ability to acquire additional revenue and leads to the emphasis on cost reduction in this public school setting. Although recent literature documents mixed evidence about the charter competition's impact on districts' local revenue (Cook, 2018), the effect of charter schools on local housing value is less relevant during my short-term study period.

mediately imposes potential competition on districts. Assuming no student leave districts for charter schools before new entry, potential competition has no effect on the total resources available to districts. As shown in the first column in Table I, potential charter competition has zero effect on districts' total resources.

Among the districts facing potential competition, some eventually experiences entries of newly-authorized charter schools. These entries create actual competition close to school district boundary, attracting students and steering the enrollment-based funding away from district to charter schools. As shown in the second column in Table I, actual charter competition has a negative impact on districts' total resources.

Overall, the third column of Table I shows the combined effect of charter competition decreases districts' total resource over a period that districts experience both potential and actual competition.

2.3.2 Labor Demand on Instructional and Other Employees

Conditional on the constraint of total resources, districts have the ability to adjust their resource allocation. Although some research points out that districts could resort to facility construction as comparative advantage over charter schools (Cook, 2018), it is reasonable to assume that Michigan districts are pressured to concentrate resources on instructional activities and

downsize other costs, attempting to retain students and prevent enrollment loss with limited and fixed resource(Mehta, 2017; Cordes, 2018; Bukowski and Kobus, 2018). Theoretically, this incentive exists in both periods when potential competition alerts the districts about the future enrollment loss and actual competition manifests this worry. Even though districts are expected to experience a reduction in total resources in the second period, it is important to acknowledge that they can make further adjustment to compete for enrollment and thus maintain a high priority on instruction at the per-student level. In other words, both types of competition have a positive effect on districts' priority on instruction as shown in Table I. Financially, the priority on instruction leads to resource allocation between instruction and other activities if districts make new decisions to decrease class size, hire high-quality teachers, or invest in educational equipment and facilities (Cook, 2018).

In addition to resource allocation between instruction and other expenditures, districts' priority on instruction can directly increase educator's efforts in both periods when educators are pressured to prevent enrollment loss from districts. A thread of literature has provided empirical evidence on this positive effect with educators' efforts measured by students' test scores (Hoxby, 2003; Card et al., 2010; Epple et al., 2016) or homework efforts (Mehta, 2017) and suggests that district employees have a strong incentive to avoid financial penalty and potential unemployment (Dee and Wyckoff, 2015). In

Table I, both potential competition and actual competition are shown to have a positive effect on educators' effort. Empirically, due to data limitation, this research focuses on districts' attempt to increase educators' efforts by examining the labor demand of instructional employees.

Overall, the combined effect from two types of competition is positive on districts' priority and labor demand on instruction and instructional employees. If potential competition and actual competition occur in the same time period, simply ignoring the effect of potential competition is likely to lead to an upward bias in the estimate of actual competition. More often, the two types of competition happen sequentially, potential competition leading to actual competition. In this sequential case, simply comparing the areas exposed to an increase of actual charter competition and the other areas tends to reach to a downward bias of actual competition as the positive effect on instruction caused by potential competition is ignored for the areas which only experience potential competition but not actual competition. More importantly, assuming the potential competition lifted the entry barriers for actual competition over time, the empirical estimates of actual charter competition may evolve towards zero. Overlooking the positive effect of potential competition on instruction leads to a downward bias in the effect of actual competition, especially in traditional DID research design.

2.3.3 Student Composition and Academic Performance

In lieu of the change in resource allocation and labor demand, charter competition might experience ambiguous effects on districts' overall academic performance due to the simultaneous change in student composition.

In the first period, potential charter competition has no impact on student sorting between districts and charter schools and thus does not change student composition. In the second period, actual charter competition leads to new charter entry and districts lose part of their enrollment to charter schools. More importantly, if charter schools attract disproportionately motivated, disciplined, and high-ability students, actual charter competition does not only decrease districts' enrollment but also change their share of disadvantaged students who requires additional assistance (Imberman, 2011). For example, compared with districts, charter schools with small capacity might have limited seats for the special-education program. Such cream-skimming problem has been documented in many research. Imberman (2011), Ni (2012), Epple et al. (2016), and Ferreyra and Kosenok (2018) find that charter schools, especially in urban areas, tend to have a higher percentage of minority students and a lower percentage of students with special-needs than neighboring TPSs. Without further assumptions, actual charter competition is expected to have ambiguous effect on students composition as shown in Table I.

Although we expect potential charter competition and actual charter competition to reduce districts' cost inefficiency, the ambiguous change in student composition leads to an ambiguous effect on districts' overall academic performance. For instance, in the short term, if districts experience little change in their student composition and exert efforts on instruction, charter competition is likely to increase students' achievement. On the other hand, if the remaining district students are more likely to be at-risk and disadvantaged students, charter competition leads to a negative impact on district students' academic performance. To summarize, Table I shows a zero effect of potential charter competition on the remaining student composition in districts and a positive effect on the overall academic performance. The second column indicates an ambiguous effect of actual charter competition on student composition and an ambiguous effect on academic performance. Therefore, the ambiguity leads to an uncertain reduced-form effect of charter competition on districts' student composition and test scores.

2.3.4 Implication on Empirical Analysis

To facilitate the study, this research highlights the existence of potential competition instead of drawing conclusions on its magnitude. It is designed to capture the average effect of potential competition on districts' cost efficiency, conditional on time and the size of actual competition. Assuming the impact of potential competition and actual competition is separable and additive,

this framework also allows the marginal effect of actual competition to vary by size measured by the number of charter schools or charter enrollment.

2.4 Data

This chapter utilizes various data source regarding Michigan charter school and districts' directory information, expenditure, employee, and student characteristics between the academic year 2007-2008 and 2013-2014. During this study period, Michigan has a uniform measure of districts' standardized test and college readiness, while districts' state funding formula stays consistent [4].

2.4.1 District Information

Districts' expenditure and employment information are collected from the Common Core of Data (CCD), and districts' academic performance data is provided by the Michigan Department of Education between the academic year 2007-2008 and 2013-2014.

CCD is a national database of all public elementary and secondary schools and school districts. Its fiscal survey covers annually aggregated districts'

[4]The amount of state funding in districts depends on their foundation allowance per student. The formula of foundation allowance changed in 2000 and 2007 (Summers, 2018).

expenditure and employment details. By definition, CCD divides total expenditure into current operational expenditure on elementary and secondary education, debt services, and capital outlay (Glander, 2014). Specifically, I define the percentage of current operational expenditure on instruction as the first measure of districts' resource allocation, since it captures the majority of variable cost on instruction such as employee salary payment, utility, and equipment purchase and maintenance. I also include the percentage of salary payment towards instructional employees, including classroom teachers and study aids, among the current operational expenditure as the second measure. From the perspective of resource allocation, it strongly indicates districts' priority on instruction, as instructional employees are the most important school inputs in the educational production function (Jackson, 2012)[5].

Although the salary payment is closely related to the financial incentive for educators' efforts (Welsch, 2011), the relationship between such measures and districts' education quality is ambiguous. The absolute amount of the expenditure on instructional employees per pupil can be driven by multiple factors including the share of high-quality experienced teachers, employees'

[5]In details, the instructional expenditure includes the expenditures on instruction, support services, and others. Among them, instruction expenditures include payments for salaries, employee benefits, supplies, materials, and contractual services for elementary and secondary education. It covers expense on regular, special, and vocational programs offered in the district but excludes any payment to community services and adult education. Expenditure on support services focuses on administration, supervision, maintenance, and students' counseling, transportation, and other services (Allison, 2014)

labor supply choice, or mechanical change to average cost because of enrollment loss (Jackson, 2012). To discover districts' priority on instruction and reveal their trade-off in resource allocation, I simultaneously compare the ratios between instructional employees to student and other employees to student. The divergence between these two ratios shows the districts' input choice between instructional resources and non-instructional resources.

Student sorting is another important aspect that correlates with charter competition and districts' outcomes. It can be driven by both observable characteristics and unobservable characteristics. Considering the data availability, student sorting behavior is measured by the average observable student characteristics in the districts. Specifically, I focus on the percentage of students in the special education program or English Language Learners (ELL) program. The enrollment in those two programs can significantly and directly affect the expenditure per student (Epple et al., 2016).

Other measures of student composition are used as covariates to control their correlation with both charter competition and district resource allocation. Those covariates include the percentage of students eligible for Free or Reduced Lunch (FRL) program, whether districts are located in a city or urban fringe, percentage of black, Hispanic, and white students.

Lastly, districts' academic performance information comes from the Michigan Educational Assessment Program. For elementary-education, I

use district average reading and math test scores for 4th graders which is available between 2008 and 2013. For secondary education, I use district average composite ACT scores including all subjects, as ACT is mandatory for all high-school students during my study period. All the test scores are standardized using the annual state average and $s.d.$ across all the districts and thus comparable across districts and year. Additionally, I examine the ratio between the number of ACT takers and grade-12 enrollment, to approximately check the selective test-taking behavior which is likely to change students' academic performance. Lastly, I use the ratio between the current grade-12 enrollment and the grade-9 enrollment three years ago as the proxy of the grade retention rate between grade-9 and grade-12, to measure the alternative margin of academic progress. If charter competition increases grade retention in districts, the estimates on test score are likely to be upward biased (Greene and Winters, 2007; Schwerdt et al., 2017).

2.4.2 Charter Competition

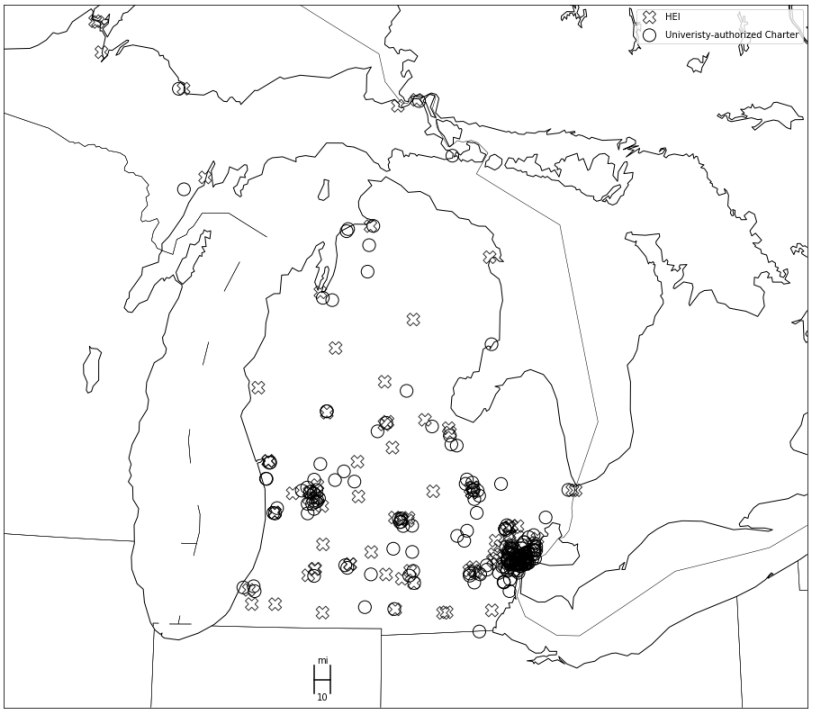
Michigan charter school information is from two major sources. Educational Entity Master Dataset provided by the Center for Education Performance and Information from the Michigan Department of Education specifies charter schools' authorizer information, opening and closing date, authorized grade span, and so forth. Common Core of Data provides charter schools'

operational status, geographic coordinates, enrollment by grade, race, and special programs.

This information allows me to construct potential charter competition and actual charter competition. The aggregated potential charter competition in the state quantifies the total number of potential new charters measured by the difference between the contemporaneous charter school cap and the number of existing charter schools. The local potential charter competition for each district is defined based on districts' proximity to HEIs interacted with the timing of the cap-lifting policy, as such geographic characteristics capture most of the desirable market conditions for new charters. Especially, once the cap-lifting policy permits more charter schools, the districts close to HEIs bears a huge increase of potential competition, as new charter schools are more likely to target at these areas. Figure 1 uses the baseline data in 2011 to demonstrate the clustering of charter schools near HEIs. Although the proximity to HEIs can be based on the varied cut-offs, this chapter mainly uses a 10-mile radius around HEIs as the indicator. Alternative proximity measures ranging from 5 miles to 15 miles are tested in section 2.6.5 for robustness check. The distance between district and HEI is provided by CCD and Integrated Postsecondary Educational Data System.

The aggregated actual charter competition in the state is defined by the total counts of charter schools by authorizers. The unique charter school identifier and their authorizer information help me distinguish university-

Figure 1: Geographic Proximity between HEIs and Charter Schools(2011)

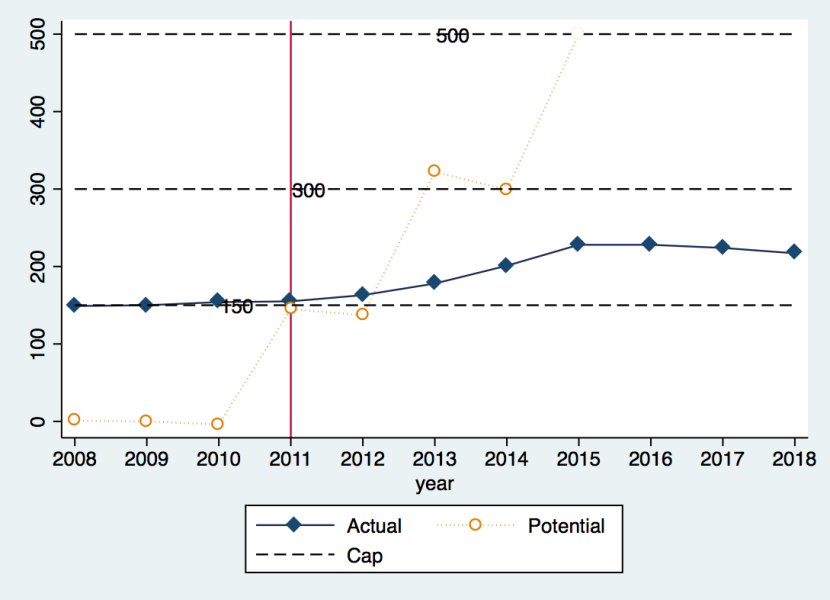


Note: The figure demonstrates the baseline geographic location of university-authorized charter schools in 2011. The cross signs indicate the location of HEIs in Michigan, and the hollow circles are the charter schools in 2011.
Data source: Michigan Department of Education and Common Core of Data.

authorized charter schools from the other types of charter schools. The school counts are calculated using each schools' opening and closing date based on the Michigan fiscal-year/academic-year calendar. Figure 2 provides a state-wise summary of the Michigan charter competition with a focus on the university-authorized charter schools when the aggregated actual competition is measured by the total number of operational charter schools. In Figure 2, the potential charter competition increases instantaneously with the cap-lifting policy in 2011, while actual charter competition slowly increases over time and then tails off after 2015. In the post-period during my study time, the cap-lifting policy leads to a net increase of university-authorized charter schools by roughly 50.

The local actual charter competition is measured in multiple ways. First, since families prefer short commuting distance (Card et al., 2010; Brekke et al., 2012) and few charter schools provide school bus service (Epple et al., 2016), I use adjusted capacity of charter schools within 5 miles of each districts as the summary of relatively exogenous measure of actual competition by markets (Bettinger, 2005; Booker et al., 2008; Zimmer and Buddin, 2009; Cook, 2018). The adjusted capacity is the summation of average charter enrollment imputed by grade, authorizer-type, urbanicity, and county, reversely weighted by the distance squared within 5 miles of each district. Figure 3 demonstrates varied charter competition growth between two groups of district based on their proximity to HEIs. The treatment group includes the

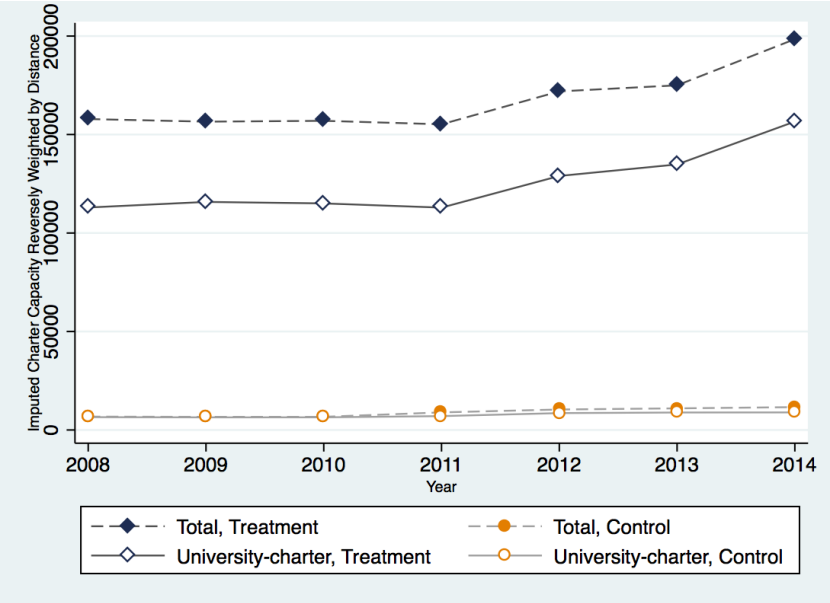
Figure 2: University-authorized Charter Schools in Michigan



Note: The figure shows the total number of university-authorized charter schools in Michigan, before and after the cap-lifting policy between 2008 and 2018. Solid diamond dots show the total number of actual university-authorized charter schools, and hollow circles show the available quota for potential charter entry in the state. The potential charter entry is the difference between the cap and the number of existing university-authorized charter schools. The black dash line represents the time-varying cap due to the policy change.
Data source: Michigan Department of Education.

districts located within 10 miles of HEIs, and the control group includes the others. The figure shows, while the adjusted charter school capacity has been reasonably stable and parallel between two groups before 2011, it gradually increases after the cap-lifting only among the treatment group. Meanwhile, the other types of charter schools are less likely to have simultaneous impacts on districts , since the gap between all the charter schools and university-authorized charter schools remain relatively constant over time.

Figure 3: Actual Charter School Competition within 5 miles of Districts



Note: The figure demonstrates the growth of average actual charter competition within 5 miles of districts in between 2008 and 2014. The actual charter competition is the sum of the total charter capacity weighted by the distance squared between charter schools and districts within 5 miles. The charter capacity is calculated by the average grade-specific enrollment in the charter schools based on counties, urbanicity, and authorizer types.
Data source: Michigan Department of Education and Common Core of Data. Treatment group includes districts within 10 miles of HEIs; control group includes districts farther away.

Secondly, I create a time-varying dummy variable to indicate whether districts experience an increase in actual competition. The dummy variable equals one if districts experience new entry of charter schools and zero otherwise. The new entry is defined based on the opening date of university-authorized charter schools. For example, if a district starts to have new charters authorized by a university starting from 2012, this measure would be one for this district between 2012 and 2014 and zero beforehand.

Thirdly, I use the total number of university-authorized charter schools located within 5 miles of districts and the total number of their enrollment to measure the actual competition. Compared with the time-varying indicator, these two measures are capable of identifying the marginal effect of the additional actual competition and provide straightforward policy implication. Figure 4 pictures the actual competition based on the policy-driven charter entry. It shows that actual competition clusters in a few locations near HEIs, especially near metropolitan and micropolitan areas like Detroit and Grand Rapids. To provide quantitative evidence, Table II summarizes the difference between the treatment and the control groups. On average, compared with the control group, the number of university-authorized charter schools within 5 miles of districts increases by 0.902 after the cap-lifting policy. Although the increase in the number of charter schools do not directly lead to

a significant increase of total charter enrollment, the ratio between charter enrollment and district enrollment significantly increases [6]

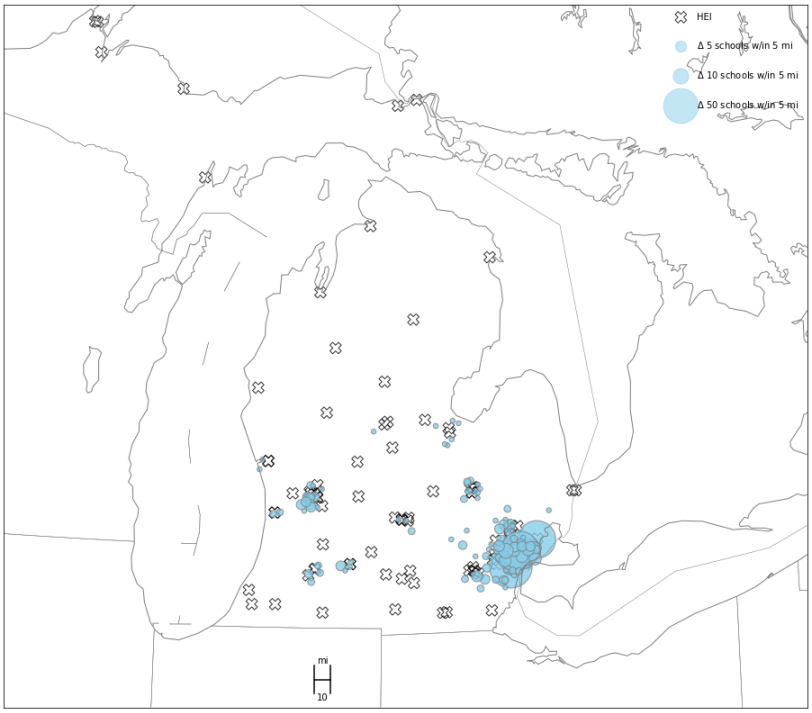
TABLE II: ACTUAL CHARTER COMPETITION BY PROXIMITY TO HEIS

	Near HEIs			Farther Away		
	> 2011	≤ 2011	Difference	> 2011	≤ 2011	Difference
Number of Charters within 5 Miles by Authorizers						
University	3.90	3.00	0.902**	0.17	0.14	0.023
			(0.308)			(0.023)
Community College	1.04	1.00	0.036	0.01	0.01	0.003
			(0.088)			(0.005)
District or ISD	0.81	0.61	0.204*	0.02	0.02	0.007
			(0.085)			(0.008)
Number of Charters Enrollment within 5 Miles by Authorizers						
University	30390	32359	-1968.879	383	313	69.739
			(11497.080)			(90.736)
Community College	4964	5592	-627.996	7	5	1.880
			(1146.692)			(3.404)
District or ISD	3289	2485	803.830	12	5	7.045
			(1175.231)			(5.407)
Ratio between Charter Enrollment and District Enrollment						
University	4.55	3.65	0.898*	0.15	0.12	0.034
			(0.428)			(0.033)
Community College	0.87	0.82	0.051	0.01	0.00	0.002
			(0.087)			(0.003)
District or ISD	0.49	0.27	0.226***	0.01	0.00	0.005
			(0.058)			(0.003)
Observations		2051			1617	

Notes: Being near HEIs is defined by districts located within 10 miles of HEIs; being farther away includes the other districts who are farther away from HEIs. The charter schools authorized by districts or ISDs are considered as part of districts, therefore the district-authorized or ISD-authorized charter enrollment are broadly counted as district enrollment.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

[6] At the district-level enrollment competition in this chapter, the charter schools authorized by districts or ISDs are part of districts. Therefore, their enrollment is counted as district enrollment.

Figure 4: Growth of Actual Charter Competition within 5 miles of Districts



Note: The figure demonstrates the growth of actual charter competition within 5 miles of districts in between 2008 and 2014. Data source: Michigan Department of Education and Common Core of Data.

2.4.3 Baseline Descriptive

The final dataset includes a total of 524 Michigan districts between 2008 and 2014, excluding 29 districts with unbalanced records or extremely low enrollment during this period. Those 524 districts are divided into 293 districts as the treatment group and 231 districts as the control. Table III demonstrates the similar expenditure and student aspects but sheer difference between preferable market condition at the baseline between two groups. For example, Table III shows that, although the average socioeconomic status and the percentage of special-need students are comparable between two types of districts, districts close to HEIs have a much higher share of minority students and are much more likely to be located in an urban area than the control group (Epple et al., 2016). Districts in the treatment group generally have higher expenditure on all types of employees, but the employee-student ratios are similar to each other.

2.5 Research Design I

This chapter leverages the geographic preference of charter schools and exploits the variation of charter competition driven by the cap-lifting policy. As demonstrated in section 2.2 and 2.4, the Michigan cap-lifting policy leads to an immediate surge of potential charter competition near HEI, followed by a gradual increase of actual charter competition after 2011. While dis-

TABLE III: MEAN AND SD OF DISTRICT CHARACTERISTICS (2008-2011)

Variable	Control	Treatment	Total
Resource allocation			
Instruction Expenditure/Total K-12 %	0.63	0.62	0.62
Instructional Employment Salary/Total K-12 %	0.35	0.34	0.34
Labor Demand			
Total K-12 Expenditure Per Pupil	8528	9885	9617
Instruction Expenditure Per Pupil	5325	5930	5811
Salary of Instructional Employees Per Pupil	3368	3821	3731
Salary of Other Employees Per Pupil	1392	1877	1781
Teacher-student Ratio	0.05	0.06	0.06
Aid-student Ratio	0.01	0.01	0.01
Other-student Ratio	0.05	0.05	0.05
Academic performance			
Grade-4 Math	0.01	0.04	0.04
Grade-4 Reading	0.08	0.03	0.04
ACT	-0.01	0.06	0.05
ACT-takers %	0.91	0.89	0.90
12th Graders/ 9th Graders$_{t-3}$	0.92	0.84	0.86
Other district-level characteristics			
Special-Edu Student %	0.14	0.14	0.14
ELL Student %	0.01	0.04	0.03
RFL%	0.39	0.39	0.39
Black %	0.02	0.20	0.17
Hispanic %	0.04	0.05	0.05
White %	0.91	0.68	0.73
City %	0.15	0.79	0.66
Revenue-Property Tax(Millions)	5.80	38.00	32.00
Foundation Allowance	7330	7854	7750
No. District	231	293	524

Notes: District averages between 2008 and 2010 are presented. The treatment group includes districts located within 10 miles of Higher Education Institutions(HEI) in Michigan, and the control group includes the other Michigan districts which are farther away. The distance between districts and HEIs are based on the minimum distance calculated by their geographic coordinates. Average expenditures in districts are weighted by the total enrollment in each district and adjusted based on the 2008 inflation rate. Based on states' formula of foundation allowance, the 1st-tier includes districts whose FA is below 4,200; the 2nd-tier includes districts whose FA is between the minimum, 4200, and basic, 5000; the 3rd-tier includes districts whose FA is higher than 5000. Student composition and district employee information are also weighted by districts' total enrollment. Test scores are weighted by the number of test-takers for each subject. District characteristics, expenditure, employee and test scores are available between 2008 and 2010.

Data source: Financial information and student characteristics are from Common Core of Data. Test score data is from Michigan Department of Education.

tricts close to HEIs experience exposure to potential competition and actual competition, the other districts which are far away from HEIs constitute a reasonably good comparison group. These counter-factual districts barely experience charter competition but are similar in other educational and fiscal aspects as districts close to HEIs.

2.5.1 Assignment of Treatment

Districts' treatment status is assigned based on the proximity to the nearest HEIs. Specifically, if any TPS within the district is within 10 miles of an HEI, the district is considered treated. The districts which are at least 10 miles away from any HEIs are the control group. The geographic distance is calculated based on all Michigan TPSs' coordinates and HEIs' coordinates. HEIs refers to all two-year and four-year educational and research institutions in Michigan. This assignment of the treatment status is fixed during the entire study period between 2008 and 2014.

Although section 2.4 shows that a 10-mile radius is sufficient to capture desirable market condition for charter schools, I implement robustness check using distance cutoff including 5, 8, 12, and 15 miles as the alternative assignment of treatment and status in section 2.6.5.

2.5.2 Regression Specification

First, a standard DID regression as specified in equation 1 provides the baseline estimate about the effect of cap-lifting policy on districts' resource allocation, student composition, and overall academic performance.

$$y_{it} = \alpha + \delta Post_t\{t > 2011\} + \rho Treat_i\{nearHEI\} + \beta Post_t * Treat_i + X_{it}\theta + \epsilon_{it} \tag{1}$$

Here, y_{it} represents the outcomes of district i in year t discussed in section 2.4. On the right-hand side, $Post_t\{t > 2011\}$is a dummy variable that equals one if the time period is after 2011 and zero otherwise. It captures the general variation of districts' outcome between pre and post period. $Treat_i\{nearHEI\}$ is the dummy variable which equals one if a district is located within 10 miles of any HEIs. It captures the time-fixed difference in districts' outcome between the treatment and the control groups. The interaction term $Post_t * Treat_i$ is the product of $Post_t$ and $Treat_i$. It identifies the effect of the cap-lifting policy, combining potential competition and actual competition. To control for other district-by-year factors that may strongly correlate with districts resource allocation, student composition, and academic performance, I include additional covariates to account for schools' average socio-economic composition, including the percentage of students el-

igible for FRL program, the share of black students, Hispanic students, white students, and whether located in metropolitan and micropolitan areas with at least 100,000 population. Section 2.6.5 provide additional specification checks on the effect of these covariates.

Although the DID specification by equation 1 provides rough estimates of the average effect that combined both potential and actual competition in the post-period, the relative importance between the two types of competition can drive different effects of the cap-lifting policy over time. To understand the dynamic effects, I implement the Dynamic Difference-in-Differences specification in the following equation 2. In the DDID specification, the fully saturated year dummy variables and the treatment dummy variable captures the change of districts' cost efficiency and student composition every year before and after the cap-lifting policy. $\sum_{t=1}^{3} \beta_t \{T = t\} * Treat_{it}$ indicates the effect of the charter competition after the cap-lifting policy and depicts the evolution in 2012, 2013, and 2014, respectively. They capture the combined effects in each year during the post-period. As the potential charter entry evolves into an actual charter entry, the relative strength of actual competition grows over time. This dynamic between potential and actual competition presents the time-varying estimates of the policy effect which facilitate the research on the separate estimates.

$$y_{it} = \alpha + \rho Treat_i\{nearHEI\} + \sum_{t=-3}^{-1} \delta_t + \sum_{t=-3}^{-1} \beta_t\{T = t\} * Treat_i + \sum_{t=1}^{3} \delta_t + \sum_{t=1}^{3} \beta_t\{T = t\} * Treat_t + X_{it}\theta + \epsilon_{it} \quad (2)$$

2.6 Results I

2.6.1 District Resource Allocation

Table IV displays the main results of the effect of cap-lifting on districts' resource allocation based on equation 1 and 2. The measure in this table focuses on the share of all current operational expenditure on instruction-related items and indicate the corresponding financial priority on instruction.

Column (1) shows little effect of charter competition on the percentage of current expenditure on instruction, controlling for students' socio-economic status, racial composition, geographic location, property tax revenue, and base rate per student from the state. While panel A summarizes an increase by 0.3 percentage points for the treatment group after the cap-lifting, panel B indicates an immediate increase of 0.4 percentage points after the cap-lifting policy. Additionally, this positive effect on the percentage of expenditure on

TABLE IV: EFFECT ON INSTRUCTION PRIORITY

	% Instructional Expenditure (1)	% Instructional Employee Salary (2)
Panel A: Basic Difference-in-Differences		
Treat & Post	0.003	0.006
	(0.003)	(0.005)
Panel B: Dynamic Difference-in-Differences		
t = - 3	0.001	0.005
	(0.003)	(0.008)
t = - 2	0.001	0.006
	(0.004)	(0.008)
t = -1	0.001	0.002
	(0.003)	(0.006)
t = 1	0.004	0.005*
	(0.003)	(0.003)
t = 2	0.003	0.012***
	(0.002)	(0.004)
t = 3	0.004	0.011**
	(0.003)	(0.005)
District Characteristics	Yes	Yes
Property Tax	Yes	Yes
Funding Allowance	Yes	Yes
Observations	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating post period and a dummy variable indicating treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of treatment group, and interaction terms for treatment group and a series of years. District characteristics includes percentage of students eligible for free or reduced lunch program, percentage of black students, percentage of Hispanic students, percentage of white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

instruction occurs as a level shift, with similar estimates in all three years after the policy. Although the estimates are not statistically significant, this dynamic decomposition suggests an instantaneous response by districts when cap-lifting policy brings the threat of future competition.

Column (2) shows a significant increase in the percentage of current expenditure on salary payment towards instructional employees including classroom teachers and study aids. Similarly to column (1), although the DID estimate in panel A suggests little average difference between two groups, the DDID estimates in panel B suggests a significant increase in the instructional employees' salary payment, including classroom teachers' salary and study aids' salary. Although the DID estimate in panel A suggests little average difference between two groups before and after the cap-lifting policy, the DDID estimates in panel B suggests a drastic and rapid expenditure concentration on instructional employees' salary payment, starting from 2013. Specifically, the treatment group on average experiences an increase of 0.5 percentage points on the instructional employees' salary in 2012, 1.2 percentage points in two years, and 1.1 percentage points three years later. According to figure 2 and 3, the 1.2-percentage-point increase happens during the first two years after the cap-lifting, when actual charter competition remains relatively stable. In the academic year 2013-2014, when the actual charter competition increases, the increase in the percentage of instructional employees' salary

plateaus at 1.1 percent, suggesting a possible ceiling effect due to the resource constraint.

The results indicate that the cap-lifting policy pressures districts to prioritize expenditures by shifting spending towards instructions. In addition to this overall change, this priority manifests immediately after the policy and before the actual charter penetration. This interesting finding suggests the deterrent behaviors of districts driven by the potential charter competition.

2.6.2 Labor Market of Instructional and Other Employees

Table V dives into the components of district employment and analyzes the change in districts' aggregated labor demand. It provides the estimates on the log value of current K-12 expenditure, instructional expenditure, salary payment towards instructional employees and other employees, at the per-student basis. While the expenditure on instruction-related items has little change, the salary of non-instructional employees per-pupil experiences a relatively sizable decline. This contrast demonstrates the change in the variable labor cost in districts' educational production function and highlights the trade-off between instructional employees and non-instructional employees.

In Table V, the first two columns examine the effect of the cap-lifting policy on log value of K-12 expenditure and instructional expenditure per student by comparing the treatment and control groups before and cap-

TABLE V: EFFECT ON EXPENDITURE PER PUPIL

	K-12 Edu Expenditure Per Pupil (1)	Log of Instructional Expenditure Per Pupil (2)	Instructional Salary Per Pupil (3)	Other Salary Per Pupil (4)
Panel A: Basic Difference-in-Differences				
Treat & Post	-0.003	0.002	0.003	-0.019
	(0.007)	(0.005)	(0.006)	(0.015)
Panel B: Dynamic Difference-in-Differences				
t = - 3	-0.006	-0.006	0.001	-0.006
	(0.011)	(0.009)	(0.007)	(0.018)
t = - 2	-0.006	-0.005	-0.001	-0.003
	(0.011)	(0.006)	(0.006)	(0.016)
t = -1	0.003	0.004	0.004	0.004
	(0.007)	(0.005)	(0.006)	(0.017)
t = 1	-0.008	-0.001	0.003	-0.020
	(0.005)	(0.006)	(0.006)	(0.013)
t = 2	0.002	0.006	0.009	-0.015
	(0.006)	(0.007)	(0.006)	(0.014)
t = 3	-0.010	-0.005	-0.000	-0.032**
	(0.006)	(0.009)	(0.008)	(0.015)
District Characteristics	Yes	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes	Yes
Observations	3668	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating post period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for treatment group and a series of years. District characteristics include the percentage of students eligible for free or reduced lunch program, the percentage of black students, the percentage of Hispanic students, the percentage of white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

lifting policy. Specifically, panel A presents little change in the level change of expenditures per student, and panel B presents an insignificant fluctuation year to year. The results from these two columns provide more details to explain the small change of percentage of expenditure on instruction in Table IV, both current expenditure and expenditure on instruction per student have no change before and after the policy.

Column (3) and (4) analyze the effect on the salary payment to instructional employees and other employees. The dependent variables are also measured at the per-student level and in logarithmic form. Panel A provides indicative evidence that charter competition pressures districts to downsize expenditures on non-instructional employees and prioritize the expenditures on instructional employees. Although most of the estimates are not statistically significant, the reduction on the non-instructional employees is significantly bigger in absolute magnitude than the increase in the instructional employees' salary payment.

Compared to the other three columns, column (4) in panel B shows a sizable decrease in the salary of other employees who provide supervision, administration, food and transportation, and other services (Glander, 2014), starting immediately after the cap-lifting policy. The reduction is 2 percentage points in the first year, 1.5 percentage points in the second year, and up to a statistically significant 3.2 percentage points three years after the policy. These results suggest districts are likely to adjust their employment

on support services, especially those with contracts that are more flexible than teachers to manage operational costs (Jackson, 2012). This adjustment and prioritizing are consistent throughout the post period and sheds light on the possibly deterrent behaviors by districts as a response to potential competition. More important, such possible resource allocation triggered by the policy suggests an upward bias of the estimate on actual charter competition effect on districts' cost efficiency, if the importance of potential charter competition is omitted.

The results in Table VI help us further understand districts' resource allocation behavior, with a focus on the districts' employees, including teacher-student ratio, study-aid-to-student ratio, and other-employee-to-student ratio. In general, the estimates suggest that the charter competition on average has a positive impact on the ratio between instructional employees and students but a negative impact on the other employees.

In detail, column (1) examines the effect of the cap-lifting policy on the teacher-student ratio. Although panel A indicates no empirical effect, panel B shows that a small fluctuation in 2008 might reduce the detectable size of the change. More importantly, the DDID estimates in the post-period indicate that the cap-lifting policy increases the teacher-student ratio by 0.001 by the second year after the cap-lifting policy. A similar pattern occurs to the ratio between study aids and students as shown in column (2). The estimates in panel B suggests that the cap-lifting policy immediately leads

TABLE VI: EFFECT ON SCHOOL EMPLOYEES

	Ratios		
	Teacher-student	Aid-student	Other-student
	(1)	(2)	(3)
Panel A: Basic Difference-in-Differences			
Treat & Post	0.000	0.000	-0.001**
	(0.0004)	(0.0005)	(0.0007)
Panel B: Dynamic Difference-in-Differences			
t = - 3	0.001	0.001	-0.001
	(0.0004)	(0.0005)	(0.0010)
t = - 2	0.000	0.000	-0.000
	(0.0003)	(0.0004)	(0.0008)
t = -1	0.000	0.000*	0.000
	(0.0004)	(0.0002)	(0.0007)
t = 1	0.000	0.001**	-0.001*
	(0.0003)	(0.0002)	(0.0006)
t = 2	0.001**	0.001	-0.001*
	(0.0004)	(0.0004)	(0.0008)
t = 3	0.001**	0.000	-0.002**
	(0.0004)	(0.0005)	(0.0011)
District Characteristics	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes
Observations	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating the post period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

to an increase in study-aid per student by 0.001. Such change may be caused by the employment adjustment of instructional employees or the enrollment loss in the districts, but estimates in column (3) provide additional evidence on districts' resource allocation towards instruction. Panel A shows that the cap-lifting policy on average decreases the ratio between other employees and students by 0.001 during shifting of sources from non-instructional employees to instructional employees. Panel B shows an increased deduction of the other-employee to student ratio over time. Specifically, the ratio between other employees and student significantly decreases by 0.001 in the first two years after the cap-lifting policy, and the decrease magnifies up to 0.002 in the third year. Compared with the small increase in the teacher-student ratio, these negative estimates strongly indicate a relative downsize on the district staff who provide administration, support, and other services. Such finding is consistent with the results from Table IV and V where the salary payment to instructional employees and other employees per student exhibit a divergent trend. This indicates the positive effect of both potential and actual charter competition on districts' priority on instruction and cost efficiency where instructional employees are protected by rigid contracts and the non-instructional employees are usually excluded by collective bargaining.

This finding sheds light on districts' resource allocation in two ways. First, the stable teacher-student ratio is consistent with the literature where market competition does not seem to lead to a downsizing of the instructional

employees. Jackson(2012) finds that charter competition significantly increases the average teacher salary in TPS but only leads to a small change in the teacher turnover rate which is mostly driven by the demand-side. Cordes(2018) suggests that charter entries have little effect on average TPS teacher characteristics such as education level or experience, and Cook(2018) points out that collectively-bargained teacher salaries are unresponsive to charter competition. Second, the positive effect of school competition on districts' expenditure on teacher and instruction has been found in many papers (Welsch, 2011; Hensvik, 2012; Cordes, 2018; Ridley and Terrier). My results suggest that such increase might partially come from the reduction in non-instructional staff whose employment and salary are more flexible than classroom teachers [7].

2.6.3 Student Composition

The results from the previous tables reveal districts' priority on instruction and attempt to increase educators' efforts. Such improvement does not necessarily lead to cost efficiency. If the cap-lifting policy causes serious selection bias based on students' characteristics, the policy-driven charter compe-

[7]Michigan regulates the pay schedule for district classroom teachers based on their highest degree, years of experience, and grades. The other non-instructional district employees share a wide range of hourly wages between a yearly minimum and maximum, depending on their working hours and job grades (Michigan Civil Service Commission, 2019).

tition might impose fiscal challenges on districts, forcing them to operate with a shortage of resources and sacrifice students' academic performance. If such disproportionately sorting is caused by charter schools' cream-skimming, the charter school expansion would severely disrupt the public education section. Admittedly, student sorting can be caused by a variety of observable and unobservable characteristics like socioeconomic status, cognitive skills, behavioral issues, and motivation. Due to data limitation, I focus on the measures of students' academic needs in special education and ELL program which are likely to correlate with districts' cost efficiency. When actual charter competition cream-skim relatively advantaged students and disproportionately leaves out in-need students, the percentage of the special-education students or ELL students are likely to increase in the districts. Table VII presents the estimates of such effects.

In Table VII, column (1) in general shows no effect of cap-lifting policy on the percentage of special-education students in the districts. In detail, panel A shows little average effect before and after 2011, and panel B shows little change in the percentage of special-education students during the first two years after the cap-lifting. In the third year after cap-lifting when relatively more charters enter, the charter competition slightly increases the percentage of special-education students by 0.2 percentage points, although all the estimates are not distinguishable from zero. Meanwhile, column (2) shows a moderate increase in the percentage of ELL students, conditional on

the time-varying racial composition. Panel A summarizes that the cap-lifting policy on average increases the percentage of ELL students by 1.0 percentage points during the study period. Panel B provides more details on the yearly changes. The percentage of ELL students starts with a relatively low time trend in 2008, and this dip might exaggerate the standard DID estimate in panel A because the rest of the pre-period has a relatively higher level of ELL shares. Compared with 2011, the impact on the percentage of ELL students starts by 0.7 percentage points in 2012 and 0.8 percentage points in 2013 when new charter entry entails more student sorting.

Although the empirical evidence of charter schools' cream-skimming behavior has been fairly mixed, the consequential student segregation is one of the major concerns of charter competition. While the heterogeneity of previous charter schools across states results in a big within-sector variation (Cowen and Winters, 2013; Anderson, 2013; Cordes, 2018), literature points out that charter competition tends to intensify districts' concentration of disadvantaged students, such as special-education students, English language learners, or students from low-income families (Ni,2012; Epple et al., 2016; Buerger and Bifulco, 2019). The results in Table VII show a significant increase in the portion of ELL students and suggests that actual competition might disproportionately attract native-speaker students away from districts. The interpretation of the DID estimates requires certain caution, as the time-

trend of the percentage of ELL students in the districts appears to fluctuate during the pre-period.

2.6.4 Overall Academic Performance

The previous analysis has shown mixed results on districts' cost efficiency through various channels. The evidence on districts' resource allocation indicates that districts respond to the cap-lifting policy by prioritizing expenditures on instruction and instructional employees, attempting to improve students' academic performance and overall cost efficiency. Meanwhile, the results on students sorting suggest that the policy-driven charter competition is likely to increase the percentage of ELL students in the districts. If so, the consequential increase in assistance needs is likely to decrease the overall academic performance and undermine districts' efforts in cost efficiency. Considering the simultaneous change via different channels, Table VIII examines the reduced-form effects of cap-lifting policy on average test scores, weighted by the number of exam takers for each subject. The results provide little evidence on a negative effect of cap-lifting policy on district students' academic performance in the short term.

Column (1) examines the effect on standardized grade-4 math test scores. Although panel A shows that the treatment group experiences a differential decrease of 0.028 *s.d.* in math test scores than the control group after 2011,

TABLE VII: EFFECT ON STUDENT COMPOSITION

	Special-Edu% (1)	ELL% (2)
Panel A: Basic Difference-in-Differences		
Treat & Post	0.002	0.010**
	(0.002)	(0.005)
Panel B: Dynamic Difference-in-Differences		
t = - 3	-0.001	-0.013*
	(0.002)	(0.007)
t = - 2	-0.005	-0.004
	(0.004)	(0.006)
t = -1	0.001	-0.003
	(0.001)	(0.004)
t = 1	-0.000	-0.000
	(0.002)	(0.002)
t = 2	0.001	0.007**
	(0.002)	(0.003)
t = 3	0.002	0.008**
	(0.002)	(0.004)
District Characteristics	Yes	Yes
Property Tax	Yes	Yes
Funding Allowance	Yes	Yes
Observations	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating thepost period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

panel B presents a noisy pre-trend of these test scores. Especially, the test scores two years before 2011 are 0.042 and 0.032 *s.d.* higher than the baseline year, 2011, and this leads to the negative DID estimate. Column (2) shows a relatively stable time-trend for the standardized grade-4 reading test scores, as the test scores before and after the policy are very close to each other as presented in panel B. Also, the results are not distinguishable from zero, indicating little change on the overall academic performance. Lastly, column (3) displays a slightly positive effect on the high-school students' ACT scores. Panel A shows that the cap-lifting policy increases the composite ACT scores by 0.024 *s.d.* on average for the treatment group, and panel B suggests a relatively stable pre-trend and highlights a significant and sizable increase in ACT score by 2014.

As the majority of charter competition occurs in elementary education(Epple et al., 2016; Cordes, 2018), the heterogeneity between grade-4 test scores and ACT scores seems to be contradictory with the combined strength of potential and actual charter competition. To examine other channels that might lead to the change in ACT scores, Table IX examines the change in exam-taking behaviors and grade retention rate in districts high-school as a secondary measure for academic progress for district high-schoolers. The exam-taking behavior is approximately measured by the ratio between the number of ACT-takers and grade-12 enrollment; the grade retention is measured by the ratio between grade-12 enrollment and third-lag of grade-9 en-

rollment. Besides being another two measures of academic progress, these variables are also likely to correlate with the test scores and possibly bias the estimates in column (3) in Table VIII (Greene and Winters, 2007; Schwerdt et al., 2017). If charter competition adversely affects district students' college readiness, the students who tend to have a lower ACT score are likely to postpone taking the exam and have a missing test score. This missing test scores could create a upward bias in the empirical analysis in Table VIII. Panel A in column (1) provides a significant DID estimate of a 1.6-percentage-point increase in the ratio between ACT takers and grade-12 enrollment, but panel B suggests that such estimate is mainly driven by the sizable dip in 2008.

Additionally, if charter competition has a positive effect on the grade retention, increasing students' likelihood of repeating a grade, then cap-lifting hurts district students' academic progress. Instead, such adverse effects create an upward bias on the estimate of test scores and draw a misleading conclusion on the overall impact of the cap-lifting policy. Column (2) in Table IX explores the effect of the cap-lifting policy on the ratio between grade-12 enrollment and lagged grade-9 enrollment. Although most of the estimates are not statistically significant, panel A suggests that cap-lifting decreases this ratio by 0.023 and possibly causes a higher probability of grade retention. With some noise, panel B shows that the ratio between grade-12 enrollment and the lagged grade-9 enrollment decreases y 0.013 and 0.026 in 2012 and 2013, respectively. As districts face more and more competition, it

appears that district high-schools tend to have a higher probability of grade retention. Admittedly, this district-by-grade measure only serves as a proxy to the average progress for each cohort, and student sorting by grade might also lead to changes in these measures.

Overall, Table IX indicates that charter competition might lead to adverse outcomes in the secondary schools in the districts, possibly decreasing the probability of ACT-taking and the likelihood of grade retention. Those changes might lead to an upward bias in the estimates of ACT scores which can explain the increase of ACT scores to some extent.

2.6.5 Specification Test

- Test for Common Trend

One of the most important assumptions for this research design requires that the treatment group and the control group follow parallel trends regarding their resource allocation, cost efficiency, and student composition if there is no intervention from the cap-lifting policy. To test this common-trend assumption, Figure 5 to Figure 8 presents the event-study plots corresponding to the regression estimates in Table IV to VII. Specifically, the event-study plots capture the differential change between the two groups every year in the study period. If the two groups follow a parallel time trend before the

TABLE VIII: EFFECT ON DISTRICTS' TEST SCORES

	Grade-4 Math (1)	Grade-4 Reading (2)	ACT scores (3)
Panel A: Basic Difference-in-Differences			
Treat & Post	-0.028	0.013	0.024
	(0.019)	(0.012)	(0.027)
Panel B: Dynamic Difference-in-Differences			
t = - 3	-0.005	0.000	0.028
	(0.027)	(0.018)	(0.036)
t = - 2	0.042*	0.001	0.054
	(0.022)	(0.017)	(0.034)
t = -1	0.032*	0.020	0.005
	(0.018)	(0.015)	(0.031)
t = 1	-0.007	0.017	0.059*
	(0.021)	(0.017)	(0.033)
t = 2	-0.012	0.022	0.018
	(0.023)	(0.018)	(0.040)
t = 3	-	-	0.075**
	-	-	(0.038)
District Characteristics	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes
Observations	3031	3030	3509

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating the post period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE IX: EFFECT ON RETENTION RATE

	Ratios	
	ACT-takers to 12th Graders	12th Graders to Lagged 9th Graders
	(1)	(2)
Panel A: Basic Difference-in-Differences		
Treat & Post	0.016*	-0.023
	(0.008)	(0.024)
Panel B: Dynamic Difference-in-Differences		
t = - 3	-0.054***	0.033
	(0.018)	(0.027)
t = - 2	-0.007	0.043
	(0.019)	(0.028)
t = -1	-0.027	0.031
	(0.019)	(0.029)
t = 1	-0.019	0.050**
	(0.016)	(0.021)
t = 2	0.001	-0.013
	(0.016)	(0.022)
t = 3	-0.000	-0.026
	(0.019)	(0.041)
District Characteristics	Yes	Yes
Property Tax	Yes	Yes
Funding Allowance	Yes	Yes
Observations	3523	3546

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating the post period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

cap-lifting policy, the event-study plot would show a close-to-zero estimate in the pre-trend [8].

Figure 5, 6, and 7 provide evidence on the common trend test regarding districts' resource allocation, and labor demand. The results support the internal validity of both DID estimates and DDID estimates regarding districts' resource allocation behaviors.

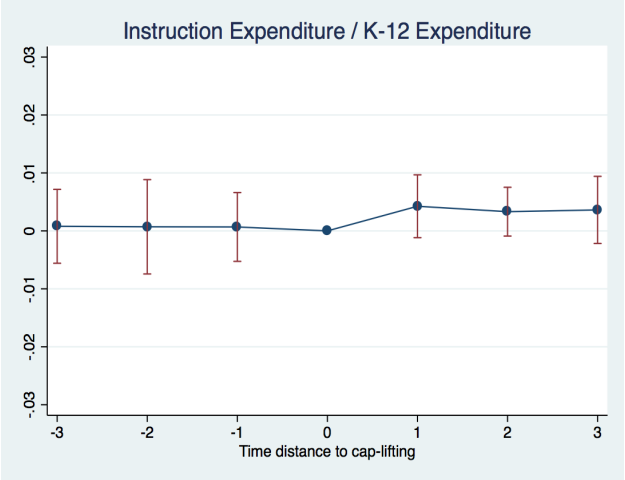
Figure 8 demonstrates the change in student composition over time. Even though there is some fluctuation in the pre-period, the estimates are not distinguishable from zero. The overall pre-trends are relatively flat right before the cap-lifting policy, and it is unlikely the percentage of ELL students endogenously invokes the cap-lifting policy. However, it calls for caution on the estimation interpretation of the charter competition effect on student sorting behaviors.

Figure 9 captures the changes in academic performance. Notably, figure 9a suggests that the negative estimates of the competition effect on grade-4

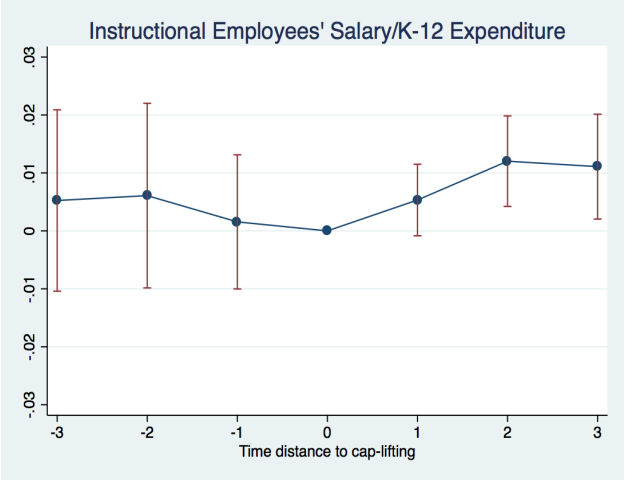
[8]Plotting the pre-trend between two groups can also help verify if other eduction policies might affect districts' resource allocation or academic performance. For example, the Michigan gubernatorial election of 2010 could potentially change the extent of potential charter competition facing many districts. When Republican Governor Rick Snyder replaced Democratic Governer Jennifer Granholm at the end of 2010, districts might become aware of future charter competition as Republicans are known to supportive of charter school competition. If so, the simultaneous political factor can lead to an upward bias of the effect of the cap-lifting policy or a downward bias if proactive districts had taken action before the cap-lifting policy. However, the test for common trend invalidates this possibility since the pre-trend between two groups appear to be parallel before 2011.

Figure 5: Event-study Plot of Resource Allocation

(a) Percentage on Instruction Expenditure



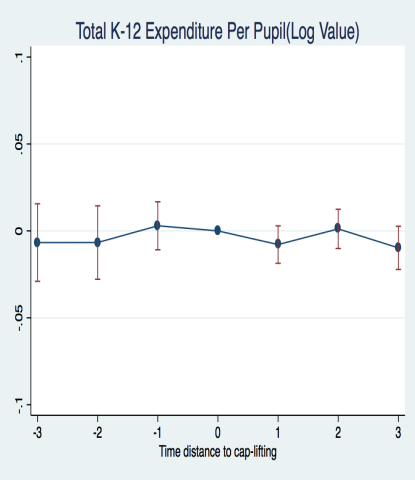
(b) Percentage of Expenditure on Instructional Employees



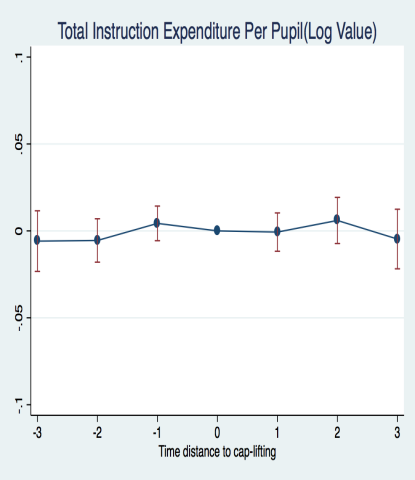
Note: Each plot graphs the estimates based on equation 2. The outcome variables are measures of resource allocation, indicating districts' spending priority. 2011 is the baseline year, i.e. $t = 0$.
Data source: Common Core of Data.

Figure 6: Event-study Plot of Expenditures Per Pupil

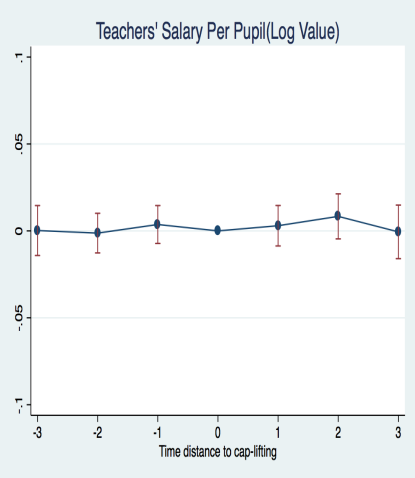
(a) K-12 Expenditure



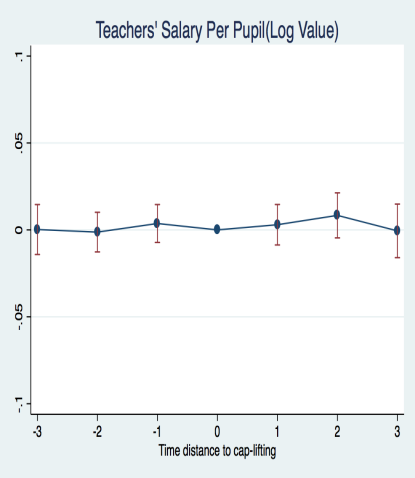
(b) Instruction Expenditure



(c) Salary of Instructional Employees



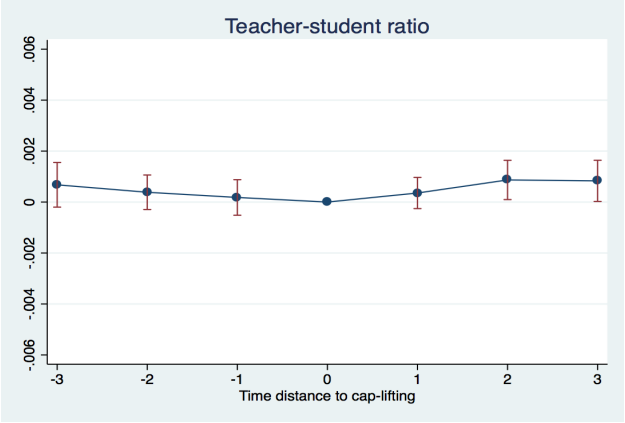
(d) Salary of Other Employees



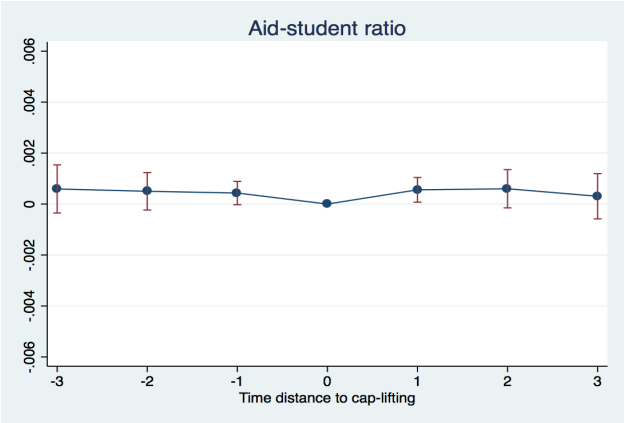
Note: Each plot graphs the estimates based on equation 2. The outcome variables are log values of the inflation-adjusted expenditures per pupil. 2011 is the baseline year, i.e. $t = 0$.
Data source: Common Core of Data.

Figure 7: Event-study Plot of Employees

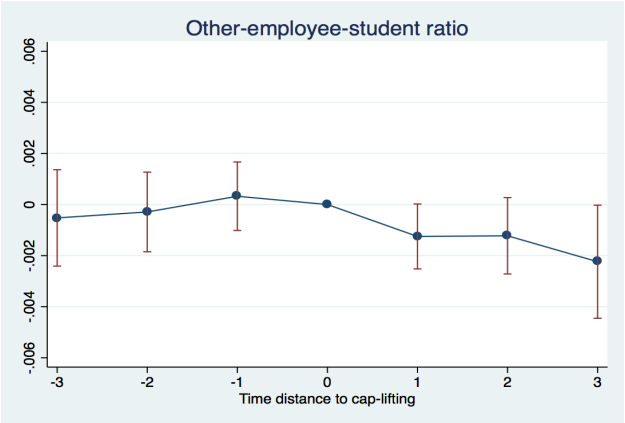
(a) Teacher-student Ratio



(b) Aid-student Ratio



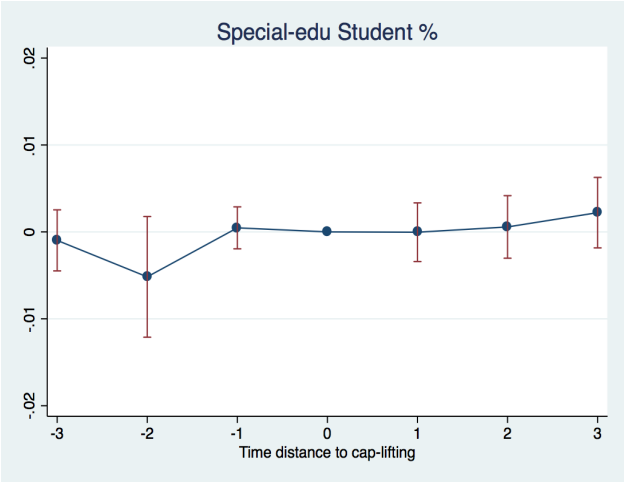
(c) Other-employees-student Ratio



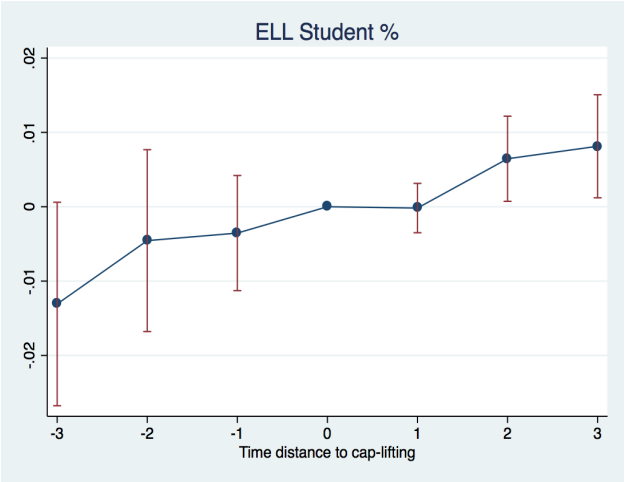
Note: Each plot graphs the estimates based on equation 2. The outcome variables are ratios of district employees to students. 2011 is the baseline year, i.e. $t = 0$. Data source: Common Core of Data.

Figure 8: Event-study Plot of Districts' Student Composition

(a) Special-edu Student %



(b) ELL Student %



Note: Each plot graphs the estimates based on equation 2. The outcome variables present districts' student composition. 2011 is the baseline year, i.e. $t = 0$.
Data source: Common Core of Data.

math test scores might be driven by the positive fluctuation in the pre-period. Meanwhile, the pre-trends of grade-4 reading scores and ACT scores in figure 9b and 9c are relatively parallel between the two groups. Figure 10 depicts little change in the ACT exam-taking behaviors and grade retention before and after the cap-lifting policy. The event-study plot is consistent with the regression estimates in Table IX.

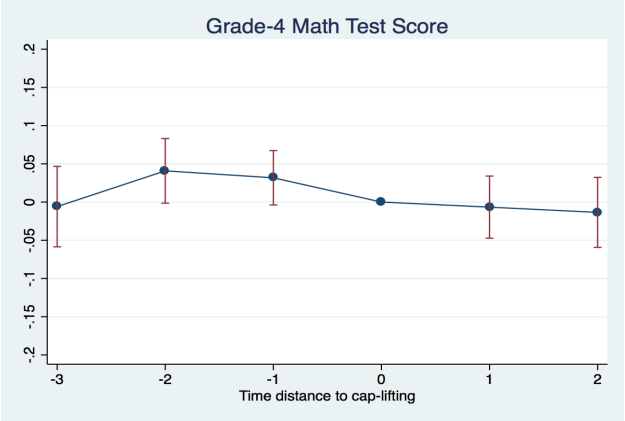
- Controlling for Districts' Revenue Change

Another threat to the research design is possibly simultaneous policies or factors that can change districts' cost efficiency or student composition. If so, the comparison between the treatment group and the control group wrongfully attributes the effect of other policies as the effect of charter competition. Table X provides additional sensitivity check on two important factors, property tax revenue and funding allowance per student, that may affect districts during the study period.

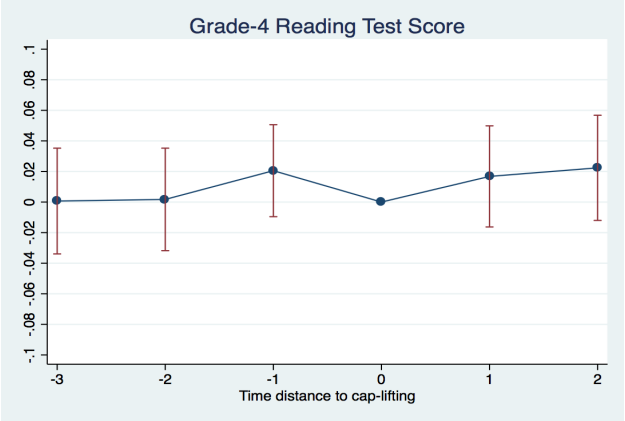
Table X indicates that the estimates on the priority of instructional employees stay consistent across specifications. Column (1) provides the baseline DDID estimates based on equation 2, without controlling for any district covariates. Column (2) adds the time-varying district characteristics to control for the aggregated students' socio-economic status, racial composition, and urbanicity. Compared with column (1), the estimates in column (2) experience slight changes, but the positive effect on the percentage of current

Figure 9: Event-study Plot of Districts' Test Scores

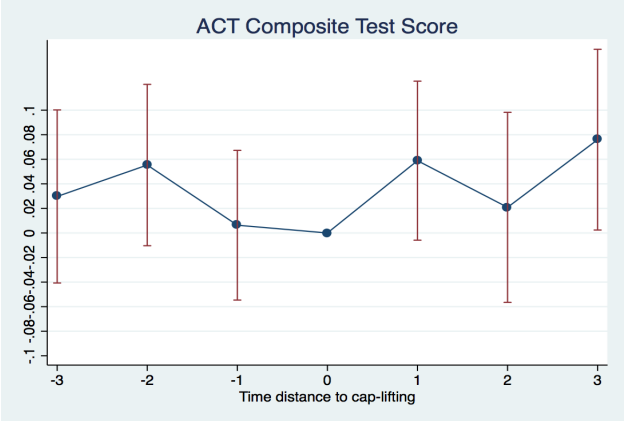
(a) Grade-4 Math Test Scores



(b) Grade-4 Reading Test Scores



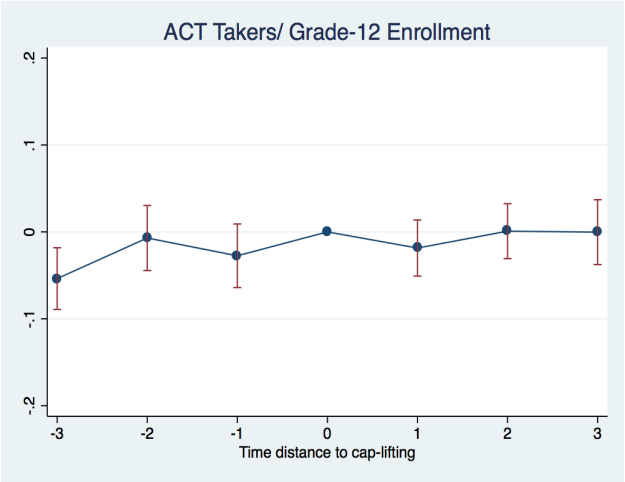
(c) ACT Test Scores



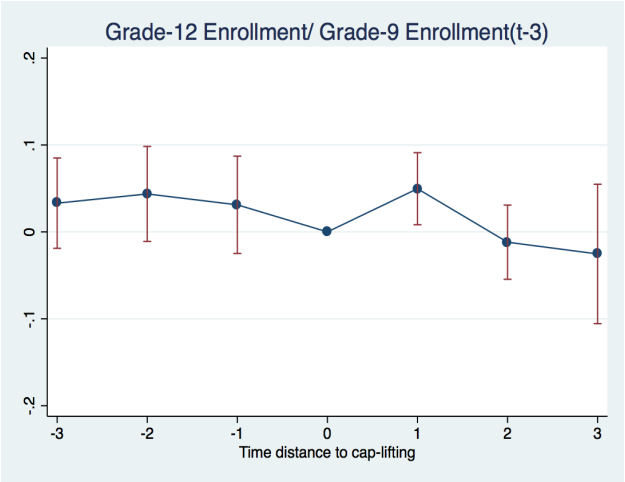
Note: Each plot graphs the estimates based on equation 2. The outcome variables are ratios of districts' average test scores. 2011 is the baseline year, i.e. $t = 0$.
Data source: Common Core of Data.

Figure 10: Event-study Plot of Districts' Retention

(a) ACT Takers %



(b) Retention Rate Grade 9 to 12



Note: Each plot graphs the estimates based on equation 2. The outcome variables are districts' ACT exam-taking rate and retention rate. 2011 is the baseline year, i.e. $t = 0$.

Data source: Common Core of Data.

expenditure on the salary of instructional employees remain robust and significant. On top of the specification in column (2), column (3) and (4) add additional control for the districts' local revenue from property tax and the foundation allowance per student from the state government, respectively. Lastly, column (5) combines all the controls previously mentioned and yields consistent estimates of charter competition effect. It suggests a significant increase in the percentage of current expenditure on the salary payment of instructional employees. This increment occurs in the first two years after the cap-lifting policy, suggesting districts' deterrent behaviors as a response to potential charter competition [9].

2.6.6 Robustness Check

This section provides a robustness check on the treatment assignment based on the proximity to the nearest HEIs. Since the cap-lifting policy does not regulate new charter schools' location, the research design relies on the general desirability of market conditions captured by the proximity to HEIs, mostly dependent on a cutoff of 10 miles within HEIs. Additionally, there is another concern regarding the possible spillover between the treatment and the control groups. If the cap-lifting policy introduces potential or actual competition to the control group in the later stage, the change in the control

[9] The conclusion on other outcomes stay the same, and the additional specification checks on the rest of outcomes can be found in Appendix Table XXIX to XXXII.

TABLE X: SENSITIVITY CHECK ON PERCENTAGE OF EXPENDITURE ON INSTRUCTIONAL EMPLOYEES' SALARY

	% Salary of Instructional Employees				
	(1)	(2)	(3)	(4)	(5)
Panel A: Basic Difference-in-Differences					
Treat & Post	0.006	0.005	0.006	0.006	0.006
	(0.004)	(0.005)	(0.005)	(0.005)	(0.005)
Panel B: Dynamic Difference-in-Differences					
t = - 3	0.006	0.006	0.005	0.006	0.005
	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)
t = - 2	0.007	0.007	0.006	0.007	0.006
	(0.008)	(0.009)	(0.008)	(0.009)	(0.008)
t = -1	0.002	0.002	0.002	0.002	0.002
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
t = 1	0.006*	0.005*	0.005*	0.005*	0.005*
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
t = 2	0.013***	0.012***	0.012***	0.012***	0.012***
	(0.005)	(0.004)	(0.004)	(0.004)	(0.004)
t = 3	0.012**	0.011**	0.011**	0.011**	0.011**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
District Characteristics	No	Yes	Yes	Yes	Yes
Property Tax	No	No	Yes	No	Yes
Funding Allowance	No	No	No	Yes	Yes
Adjusted R^2	0.018	0.153	0.156	0.160	0.163
Observations	3668	3668	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating the post period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

group is likely to attenuate the estimates. Using alternative distance cutoff can provide evidence on the robustness of the estimates.

Table XI presents the DDID estimates on the percentage of expenditure on instructional employees' salary based on equation 5 using alternative distance cutoff including 5, 8, 12, and 15 miles. With reasonable variation, the results suggest a consistently positive effect of charter competition on the priority on instructional employees across varied treatment assignment. The magnitude of the estimates in the first year after the cap-lifting centers around 0.5 percentage points and adds up to 1.6 percentage points three years after the policy change.

2.7 Research Design II

The empirical evidence from the first research design shows the progressive effects of the cap-lifting policy. The time-varying effects suggest interestingly different effects of potential charter competition and actual competition in varied channels, given that the weights between potential competition and actual competition are likely to change and induce different decisions by the districts.

To further understand the effects of two types of competition, I use an alternative research design as in equation 3, to estimate the impact of potential competition and actual competition separately. In the equation, y_{it}

TABLE XI: ROBUSTNESS CHECK ON PERCENTAGE OF EXPENDITURE ON INSTRUCTIONAL EMPLOYEES' SALARY

	% Salary of Instructional Employees				
	5 Miles	8 Miles	10 Miles	12 Miles	15 Miles
	(1)	(2)	(3)	(4)	(5)
Panel A: Basic Difference-in-Differences					
Treat & Post	0.004	0.007	0.006	0.009*	0.004
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
Panel B: Dynamic Difference-in-Differences					
t = - 3	0.008	0.003	0.005	0.007	0.012
	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)
t = - 2	0.005	0.004	0.006	0.007	0.008
	(0.009)	(0.008)	(0.008)	(0.008)	(0.009)
t = -1	0.003	0.000	0.002	0.002	0.001
	(0.007)	(0.006)	(0.006)	(0.006)	(0.006)
t = 1	0.005	0.005*	0.005*	0.007**	0.005
	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)
t = 2	0.011***	0.013***	0.012***	0.016***	0.011**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
t = 3	0.007*	0.008*	0.011**	0.016***	0.011**
	(0.004)	(0.004)	(0.005)	(0.005)	(0.005)
District Characteristics	Yes	Yes	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes	Yes	Yes
Observations	3668	3668	3668	3668	3668
Adjusted R^2	0.163	0.164	0.163	0.162	0.161

Notes: 185 within 5 miles and 339 otherwise; 242 within 8 miles and 282 otherwise; 293 within 10 miles and 231 otherwise; 335 within 12 miles and 189 otherwise; 381 within 15 miles and 143 otherwise.

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating the post period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

represents the outcome variables of district i in year t in resource allocation, labor demand, student sorting, and overall academic performance. On the right-hand side, $Potential_{it}$ is the time-varying dummy variable which equals one if districts are located within 10 miles of HEIs in 2012 and onwards. This definition is equivalent to the interaction term between districts' proximity to HEIs and the timing of cap-lifting policy in equation 1 which is generally able to capture potential competition that facing districts by market conditions.

While the dummy variable, $Potential_{it}$, depicts the average effect of potential competition driven by the cap-lifting policy after 2011, the actual competition, $Actual_{it}$, is measured in three ways. The first measure is a dummy variable that equals one if a district experiences a new entry of university-authorized charter schools within 5 miles after the cap-lifting policy. This estimates the average effect of having a new charter entry within a relatively close radius (Imberman, 2011; Cook, 2018; Cordes, 2018). Second, on the internal margin, I also use a continuous number of new university-authorized charter schools within 5 miles to provide an estimate on the margin effect of one new charter school. Thirdly, I substitute the number of charter schools by the total enrollment in university-authorized charter schools within 5 miles to account for the enrollment-based importance of actual charter competition.

$$y_{it} = \alpha + \beta Potential_{it} + \rho Actual_{it} + X_{it}\theta + \lambda_t + \delta_i + \epsilon_{it} \tag{3}$$

To account for general time trend or across-district variation, I include year Fixed Effects, λ_t, and one dummy variable, δ_i, to capture the average difference between the districts close to HEIs and the others. I also control for the corresponding number or enrollment of charter schools authorized by community-colleges for potential simultaneous charter competition, although section 2.4 provides evidence that the cap-lifting policy only affects charter competition from university-authorized charter schools. Lastly, to control for other district-by-year factors that may strongly correlate with districts' expenditure and test scores, I include covariates to account for schools' average socio-economic composition and school inputs, including the percentage of students eligible for FRL program, the share of black students, Hispanic students, white students, and whether districts' are located in city and suburban city-sprawls with large populations.

2.8 Results II

2.8.1 Resource Allocation

This section presents the average effect of potential competition and actual competition from geographic variation driven by the cap-lifting policy. The potential competition is defined by the interaction term of being located within 10 miles of HEIs and being after 2011, while the actual competition is captured by three measures discussed in section 2.7 in each panel. The first

measure is a time-varying dummy variable which is one if the districts experience new entry of university-authorized charter schools within 5 miles after 2011; the second is the number of charter schools authorized by universities within 5 miles; and the third is the logarithmic value of the total enrollment in the university-authorized charter schools within 5 miles.

First, Table XII panel A shows the average effect of potential and actual charter competition on the districts' priority on instruction in their resource allocation. Although the estimates are not statistically significant, the magnitudes provide interesting perspectives in the decomposition between the two effects. Section 2.6 shows that the combined positive effect of both types of charter competition starts immediately after the cap-lifting policy and grows gradually. Here, Table XII suggests that districts prioritize their expenditure on educational employees and minimize the other expenses to deter future competition. And this incentive of operating efficiently carries on after the actual competition increases. Specifically, column (2) indicates that both potential competition and actual competition increases the percentage of current operational expenditure on salary payment to instructional employees by similar magnitudes, 0.5 and 0.3 percentage points, respectively.

Panel B and C convey a similar conclusion and identify the marginal effect of actual charter competition. The results suggest that the policy-driven potential competition has a bigger effect than the marginal actual competition in the short term. Column (1) in both panels suggests that

potential competition increases the percentage of instructional expenditure by 0.4 percentage points, and column (2) suggests the potential competition increases the share of salary payment towards instructional employees by 0.6-0.7 percentages points. Meanwhile, the actual competition in terms of both the number of charter schools or enrollment has little effect on the resource allocation on instruction-related expenditure in the short term. The little effect of actual competition might be caused by the limited penetration of actual charter competition during a short post-period.

2.8.2 Labor Demand of Instructional and Other Employees

Table XIII takes one step further to understand how the change in districts' resource allocation affects their aggregated labor demand, especially focusing on the weights between instructional and non-instructional employees. By examining districts' financial and educational resources, it reveals the attempts of cost efficiency pressured by charter competition from another point of view. Column (1) and (2) generally suggest little change in current operation expenditure per student and a slightly positive effect on total instructional expenditure per student. Column (3) and (4) show interesting patterns of the change in the decomposition of instructional expenditures. For instance, panel A of column (3) indicates that actual competition increases the salary payment on instructional expenditure per student by 0.9 percentage points. In contrast, panel A of column (4) shows that potential

TABLE XII: EFFECT ON INSTRUCTION PRIORITY

	% Instructional Expenditure (1)	% Instructional Employee Salary (2)
Panel A: Entry of New University-authorized Charters		
Potential	0.002	0.005
	(0.003)	(0.004)
Actual	0.004	0.003
	(0.006)	(0.007)
Panel B: Number of University-authorized Charters		
Potential	0.004	0.007*
	(0.003)	(0.004)
Number of Charter Schools	-0.000	-0.000
	(0.001)	(0.001)
Panel C: Log of Enrollment in the University-authorized Charters		
Potential	0.004	0.006
	(0.003)	(0.005)
Charter Enrollment	0.001	0.001
	(0.001)	(0.001)
District Characteristics	Yes	Yes
Property Tax	Yes	Yes
Funding Allowance	Yes	Yes
Observations	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All the regression are based on the specification in equation 3. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

competition decreases the expenditure on other employees by 1.9 percentage points and the actual competition decreases it by 0.6 percentage points [10].

On top of the average effect shown in panel A, panel B and C provides more details on the marginal effect of the number of charter schools and charter enrollment. Using the number of charter schools as the second measure of actual competition, the estimates in panel B suggest that there is little effect of the actual competition driven by the cap-lifting policy. This might result from a short period during my study period, as charter schools need a much longer time period to stabilize their quality and increase their competitiveness (Hannushek et. al., 2007).

Alternatively, the effects of actual charter competition might matter at the enrollment level, and the number of charter schools cannot fully capture the enrollment-based funding competition. Therefore, panel C studies the effect of actual competition measured by the actual enrollment in the charter schools within 5 miles. Specifically, panel C of column (3) suggests that the potential competition generally increases the salary payment to instructional employees per student. When the charter enrollment within 5 miles increases by 1 %, the salary payment to instructional employees per student increases

[10]The similar decomposition can be achieved by alternative practice where Dynamic DID regressions are applied to a restricted sample with only the districts within 10 miles of HEIs but did not experience an increase of actual competition. Although the results are not presented here, it would reach a similar conclusion regarding the relative weights between potential and actual competition.

by about 0.004 percentage points. Lastly, column (4) suggests that potential competition leads to a sizable deduction on the percentage of expenditure on other employees across all three panels. This finding is consistent with Cook(2018) where he finds that actual charter competition leads districts to shift resources from instruction to facility and other expenses. Although this observation presents interesting patterns, the district-level analysis does not draw a statistically significant conclusion.

These findings are also consistent with the results in Table XII where there is an increase in the percentage of expenditure on salary payment to instructional employees. Two possible channels can explain resource concentration. First, when charter competition increases, districts have incentives to downsize the labor demand on non-instructional employees to minimize the cost and remain sustainable in the long term. They are also likely to be pressured to hire high-quality instructors to help students and improve instructional quality. Alternatively, the positive estimates from the new charter entry might result from the differential rigidity of employment contracts, when districts attempt to change their labor demand. For example, as the actual charter competition attracts away enrollment, the districts are not flexible to decrease their labor demand of instructors. As a result, the remaining district students might benefit from an increase in instruction-related expenditure per student.

TABLE XIII: EFFECT ON EXPENDITURE PER PUPIL

	Log of			
	K-12 Edu Expenditure Per Pupil	Instructional Expenditure Per Pupil	Instructional Salary Per Pupil	Other Salary Per Pupil
	(1)	(2)	(3)	(4)
Panel A: Entry of New University-authorized Charters				
Potential	-0.002	0.001	-0.001	-0.019
	(0.005)	(0.006)	(0.007)	(0.017)
Actual	-0.002	0.003	0.009	-0.006
	(0.012)	(0.011)	(0.012)	(0.027)
Panel B: Number of University-authorized Charters				
Potential	-0.005	0.000	0.002	-0.024
	(0.005)	(0.006)	(0.007)	(0.015)
Number of Charter Schools	0.000	-0.000	-0.000	-0.001
	(0.002)	(0.001)	(0.001)	(0.003)
Panel C: Log of Enrollment in the University-authorized Charters				
Potential	-0.003	0.002	0.003	-0.026*
	(0.007)	(0.005)	(0.006)	(0.015)
Charter Enrollment	0.001	0.003	0.004**	0.002
	(0.001)	(0.002)	(0.002)	(0.003)
District Characteristics	Yes	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes	Yes
Observations	3668	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All the regressions are based on the specification in equation 3. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

One way to test these two hypotheses is to examine districts' labor demand on instructional and other employees. Table XIV displays the change in the ratios between district employees and enrollment. The first two columns focus on the ratio between instructional employees and students, including the teacher-student ratio and the study-aid to student ratio. The third column shows the contemporaneous change in the ratio between other employees and students in the districts. In panel A, column (1) shows that both potential competition and actual competition have no impact on the teacher-student ratio, and column (2) draws the same conclusion for the number of study-aids available per student. Meanwhile, column (3) indicates actual competition significantly decreases the number of other employees per pupil by 0.003, while potential competition has no impact. Although panel B captures no impact of actual competition measured by the number of charter schools, panel C suggests, besides the zero effect on instructional employees available per student, charter competition decreases the number of other employees per student. Specifically, column (3) shows that, while potential competition on average decreases the ratio between other employees and students by 0.001, an increase of enrollment in university-authorized charter schools by 1%, the ratio between other employees and total district enrollment decreases by 0.001.

The combined findings from Table XIII and XIV provides evidence on districts' attempt to increase instruction efforts and improve cost efficiency

[11]. Given that neither potential competition or actual competition changes the teacher-student ratio, the rigid district labor demand is less likely to contribute to a mechanical increase in the salary payment to instructional employees per student in Table XIII. On the other hand, the concentration of expenditure on instructional employees tends to be caused by a purposeful decision of districts to face charter competition. This finding is consistent with the conclusion from Jackson(2012) where he claims that charter competition may force districts to increase salary to retain high-quality teachers. On the other hand, the negative effect on the ratio between other employees and district enrollment verifies that the reduction on the salary payment towards other employees is caused by the non-instructional employees.

2.8.3 Student Composition

Table XV highlight the direct impact of actual charter competition on students' sorting behaviors, especially through a change in the average student characteristics. The previous results in Table XIII and XIV reveals districts' attempt to prioritize instruction and improve cost efficiency, and this table shows that the actual competition tends to have an opposite effect on districts' instruction when charter schools cream skim students based on their academic needs. Table XV analyzes the effect of potential and actual

[11]The auxiliary analysis on the average salary per district employee is available in Appendix Tables XXVIII and XXXIII.

TABLE XIV: EFFECT ON SCHOOL EMPLOYEES

	Ratios		
	Teacher-student	Aid-student	Other-student
	(1)	(2)	(3)
Panel A: Entry of New University-authorized Charters			
Potential	0.000	0.000	0.000
	(0.0003)	(0.0005)	(0.0008)
Actual	-0.000	-0.001	-0.003**
	(0.0006)	(0.0008)	(0.0014)
Panel B: Number of University-authorized Charters			
Potential	0.000	0.000	-0.000
	(0.0003)	(0.0004)	(0.0008)
Number of Charter Schools	0.000	-0.000	-0.000
	(0.0001)	(0.0001)	(0.0003)
Panel C: Log of Enrollment in University-authorized Charters			
Potential	0.000	0.000	-0.001**
	(0.0004)	(0.0005)	(0.0007)
Charter Enrollment	-0.000	-0.000	-0.001**
	(0.0001)	(0.0001)	(0.0002)
District Characteristics	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes
Observations	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All the regressions are based on the specification in equation 3. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

competition on districts' percentage of students in the special-education program and ELL program. The first column across three panels shows little impact of charter competition on the percentage of special-education students, although panel C suggests an increase of charter enrollment by 1% leads to an increase in the districts' share of special-education students by 0.1 percentage point.

Additionally, the second column shows that the districts facing actual charter competition experience a significant increase of ELL students by 2.5 percentage points. This self-selection could be due to two reasons. First, the ELL students might prefer districts over charter schools with a diverse student body and good English-learning programs. Second, it can reflect different accessibility of charter schools between native speakers and ELL students. If charter schools limit ELL enrollment, due to the cost of English-learning assistance, this student-sorting behavior would result in the worrying financial burden on districts in the long term. However, such an effect on percent of ELL students is also noisy across panel A, B, and C. Its fluctuation between the pre- and the post- periods in figure 8 calls for caution on this interpretation.

TABLE XV: EFFECT ON STUDENT COMPOSITION

	Special-Edu%	ELL%
	(1)	(2)
Panel A: Entry of New University-authorized Charters		
Potential	0.002	-0.001
	(0.002)	(0.003)
Actual	0.002	0.025**
	(0.003)	(0.010)
Panel B: Number of University-authorized Charters		
Potential	0.003	0.004
	(0.002)	(0.002)
Number of Charter Schools	-0.001	0.003
	(0.000)	(0.002)
Panel C: Log of Enrollment in the University-authorized Charters		
Potential	0.002	0.009**
	(0.002)	(0.004)
Charter Enrollment	0.001**	0.001
	(0.000)	(0.001)
District Characteristics	Yes	Yes
Property Tax	Yes	Yes
Funding Allowance	Yes	Yes
Observations	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All the regressions are based on the specification in equation 3. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

2.8.4 Overall Academic Performance

Theoretically, the effect of charter competition from districts' priority on instruction and student sorting leads to an ambiguous effect on districts' efficiency and quality. The finding on resource allocation reveals districts' efforts towards efficiency, but the concentration of disadvantaged students with academic needs makes it difficult for districts to improve overall academic achievement without additional resources. To further investigate the effect of charter competition on districts' overall academic performance, Table XVI examines the change in the districts' grade-4 test scores and ACT scores. Considering that the majority of charter schools focus on elementary-level education, I use the standardized grade-4 math and reading test scores to study the overall academic performance in districts' elementary education, conditional on districts' student socio-economic status, racial characteristics, urbanicity, and family inputs measured by the property tax.

Column (1) shows that potential charter competition decreases districts' grade-4 math test scores by 0.032 *s.d.* but actual charter competition increases it by an additional 0.015 *s.d.*. As the negative effect is likely to be caused by the slightly noisy upward trend before the cap-lifting policy as discussed in section 2.6, the positive effect from actual competition suggests educators' attempt to improve instruction efforts and students' academic

performance [12]. However, it only reflects a short-term effect where the districts only experience an increase of potential and actual competition for up to three years. This conclusion can also be found in column (2) where potential and actual competition on average increases the grade-4 reading test scores by 0.011 and 0.008 *s.d.*. Additionally, column (3) in panel C provides evidence on the improvement on ACT scores, where potential competition increases the district composite ACT scores by 0.025 *s.d.* and one more university-authorized charter school within 5 miles leads to an increase in composite ACT scores by 0.011 s.d.. Although most of the estimates are not distinguishable from zero, the positive estimates suggest the positive effect of charter competition on districts' priority on instruction and cost efficiency even with an increase in the percentage of ELL students.

In addition to the unobservable pressure of increasing instructional quality caused by actual competition, the increase in ACT scores might also be affected by other omitted variables. For instance, if charter schools lead to repeated exam-taking, the repeaters might achieve higher scores than the first takers and cause an upward bias. Alternatively, if charter schools affect the students' progress and increase the retention rate among students, it would also lead to an upward bias in the effect on ACT scores. To examine these

[12]The endogenous penetration of actual competition might bias the estimates of actual competition if actual competition after cap-lifting is correlated with districts' baseline academic performance. Although not shown here, little evidence suggests that districts' standardized grade-4 test scores are strongly predictive of actual competition

TABLE XVI: EFFECT ON DISTRICTS' TEST SCORES

	Grade-4 Math (1)	Grade-4 Reading (2)	ACT scores (3)
Panel A: Entry of New University-authorized Charters			
Potential	-0.032	0.011	0.024
	(0.020)	(0.014)	(0.029)
Actual	0.015	0.008	0.011
	(0.025)	(0.018)	(0.041)
Panel A: Number of University-authorized Charters			
Potential	-0.022	0.019	0.027
	(0.018)	(0.013)	(0.027)
Number of Charter Schools	0.004	0.001	0.011**
	(0.003)	(0.002)	(0.005)
Panel B: Log of Enrollment in the University-authorized Charters			
Potential	-0.021	0.018	0.039
	(0.019)	(0.012)	(0.027)
Charter Enrollment	-0.002	-0.002	0.003
	(0.004)	(0.002)	(0.006)
District Characteristics	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes
Observations	3031	3030	3509

Notes: Standard errors in parenthesis are clustered at the district level. Each regression is weighted by the number of exam takers in each subject. Observations are at the district-year level. Each column reports results from a separate regression. All the regressions are based on the specification in equation 3. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

two possible channels, Table XVII investigates the effect of charter competition on districts' overall academic performance by examining the students' ACT-taking behaviors and grade retention rate. These two factors are more than alternative measures of students' academic progress.

Column (1) panel A in Table XVII shows that potential competition increases the ratio between ACT-takers and grade-12 enrollment by 0.021, and panel B and C suggest similar findings. Column (2) suggests that potential competition increases grade retention by decreasing the ratio between grade-12 enrollment and lagged grade-9 enrollment by 0.048. Meanwhile, actual charter competition decreases grade retention by increasing this ratio by 0.059. The opposite effects of potential competition and actual competition can be found in both panel B and panel C. However, as shown in section 2.6, the pre-trends of ACT-taking behavior and grade-retention are quite noisy, as the pre-trend estimates differ much from the baseline year 2011.

In addition to the effect on existing district students' progress, charter competition might cause such change by student sorting. For example, when students with high motivation and college readiness decide to leave districts for charter schools, it would also show that districts' ACT-taking rate decreases and grade retention increases. My analysis focuses on the combined effect from either channel and does not distinguish between them. If actual charter competition increases the retention rate in each cohort, the estimate

on the positive effect of actual competition on ACT score in able XVI provides a suggestive upper-bound.

TABLE XVII: EFFECT ON RETENTION RATE

	Ratios	
	ACT-takers to 12th Graders	12th Graders to Lagged 9th Graders
	(1)	(2)
Panel A: Entry of New University-authorized Charters		
Potential	0.021**	-0.048
	(0.010)	(0.034)
Actual	-0.012	0.059
	(0.012)	(0.039)
Panel B: Number of University-authorized Charters		
Potential	0.024**	-0.043
	(0.010)	(0.040)
Number of Charter Schools	-0.002*	0.007
	(0.002)	(0.007)
Panel C: Log of Enrollment in the University-authorized Charters		
Potential	0.017**	-0.025
	(0.008)	(0.025)
Charter Enrollment	0.000	-0.003
	(0.001)	(0.003)
District Characteristics	Yes	Yes
Property Tax	Yes	Yes
Funding Allowance	Yes	Yes
Observations	3523	3546

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All the regressions are based on the specification in equation 3. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

2.9 Conclusion and Discussion

This chapter investigates the effect of charter competition on districts' cost efficiency. Based on a case study in Michigan, I find that Michigan cap-lifting policy increases both potential charter competition and actual charter competition which trigger traditional public school districts to re-allocate their resources. Compared with the other Michigan districts, the policy leads the districts within 10 miles of HEIs, where charter schools desire to enter, increases their shares of current operational expenditure on instruction by 0.6 percentage points, decrease the average salary of non-instructional employees per student by 1.9 percentage points, and the number of non-instructional employees per student by 0.001. The finding on the change of instruction-related expenditure or salary payment towards instructors agrees with the latest literature in Michigan (Arsen and Ni, 2012). But, instead of no or positive effect on support service and administration (Arsen and Ni, 2012), I find that the policy-driven charter competition pressures districts to get leaner in their non-instruction expenditure and place a priority on instruction(Cordes, 2018; Ridley and Terrier, 2018)

More importantly, relying on a Dynamic Difference-in-Differences framework, this chapter investigates the time-varying effects of the cap-lifting policy and lays a foundation for further analysis to disentangle potential competition and actual competition. The results provide interesting insights for

various channels where potential and actual competition have impacts on districts. The reduction in the salary payment towards non-instructional employees, as well as their employment, follows immediately after the cap-lifting policy. Meanwhile, the change in student composition and test scores, which is mostly attributed to the actual competition, occurs two or three years later than the change in resource allocation. The analysis of potential and actual competition also confirms this pattern, where the potential competition accounts for most of the change in expenditures but actual competition has a dominating impact on the percentage of ELL students and test scores.

The evidence provided in this chapter reveals districts' priority on instruction, as they face an surge of potential charter competition and the consequential growth in actual charter competition. As they allocate resources to deter potential charter competition and remain sustainable in the long term, the market-wide cost inefficiency among the public schools is likely to decrease. Therefore, the studies relying heavily on the variation caused by actual competition might ignore its direct impact on traditional public schools' instruction and tend to reach a conclusion on biased results.

On the other hand, this study also reveals the possible cream-skimming by charter schools for ELL students and the grade-retention in districts. These problems illustrate the concerns about the impacts of the rapid expansion of charter schools in the long run.

Broadly, this chapter provides important policy implications regarding the effect of competition in the public education sector. Up to the academic year of 2017-2018, out of 42 states and District of Columbia, 21 states have various caps on their charter school sector(Ziebarth and Palmer, 2018). The cap facilitates the quality supervision of charter schools and prevents the financial distress imposed on districts. On the downside, the cap-type regulation on charter schools would limit charter schools and suppress positive competition effect on TPSs (Mehta, 2017). My study sheds light on the market-wide impact of such policies. In addition to the policy-driven charter growth, the policy itself directly pressures the incumbent districts to decrease inefficiency, improve instruction quality, deter future competition, and remain sustainable. This leads to lower new charter entry and mitigates the concerns about charter schools draining resources away from districts.

Although the evidence indicates that the charter competition increases districts' cost efficiency, the definition of cost efficiency in this paper is limited in two ways. First, it heavily relies on the linearity assumption between inputs and outputs in the aggregated educational production function. For example, given the same-level test scores, the deduction in the expenditure is considered as a decrease in cost inefficiency. Second, it focuses on the observable cognitive skills, especially relying on using test scores as the sole outputs from the education production functions. Although academic performance is one of the most important factors that drive school choices for each family,

the possible impact of charter competition on districts' supportive service is likely to be ignored in this paper. As charter competition pressures districts to be leaner in the non-instructional expenditures and school inputs, the consequence of such trade-off behaviors in districts needs further analysis and understanding.

3 ILLUSORY GAINS FROM CHILE'S TARGETED SCHOOL VOUCHER EXPERIMENT

(Previously published as Benjamin Feigenberg, Rui Yan, Steven Rivkin, Illusory Gains from Chile's Targeted School Voucher Experiment, The Economic Journal, Volume 129, Issue 623, October 2019, Pages 2805–2832.)

3.1 Introduction

Residential segregation, local public financing of schools, and difficulties attracting and retaining educators are among the factors that tend to lower the quality of education received by economically disadvantaged children, and myriad policies have been implemented to elevate the quality of instruction and reduce the school-quality gap. Broadly speaking, these policies can be divided between those that raise resources and those that provide greater choice, and there is not strong evidence in favor of either approach. Chile, a country with a long-standing voucher program in which roughly half of all children attend private school, implemented a major reform in 2008 that works through both channels and was designed to improve disadvantaged students' access to high-quality schooling.[13] The Subvención Escolar

[13]Early research on Chile's voucher system, including McEwan (2001) and Hsieh and Urquiola (2006), concludes that gains associated with increased market competition were small and did not differentially benefit poorer students. More recent work, including Hanushek et al. (2012), Bravo et al. (2010), and Gallego (2013), identifies more substantial gains associated with voucher program-induced competition but does not provide evidence

Preferencial (SEP) raised the value of school vouchers used to fund private and public schools by 50% for students from the lowest-socioeconomic status (SES) households. In order to receive these additional revenues, both public and private voucher schools were required to sign contracts with the Chilean Ministry of Education that defined anticipated test score gains over the subsequent years, required detailed accounting of SEP program expenditures, eliminated screening of SEP-eligible students based on past academic performance or family background, and prohibited schools from charging SEP-eligible students additional tuition or fees (Correa et al., 2014).

The targeted voucher would be expected to increase the quality of instruction and achievement for low-income students through a number of channels. First, schools participating in the SEP program would receive additional revenue for each enrolled low-income student that could be used to reduce class size, improve technology, or purchase other resources; initially, the law did not permit schools to use the program revenue to raise teacher pay.[14] Second, the higher revenue provides schools an incentive to become more attractive to low-income families, and raising the quality of instruction could be one

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of any significant convergence in academic achievement based on student socioeconomic status.

[14]As discussed in more detail in Section 2.2, the law was amended in October 2011 to provide school administrators with greater control over expenditures.

component of any such effort.[15] Third, the expansion of the set of schools in which low-SES students could enroll at no cost and without the possibility of rejection based on background would be expected to induce some SEP-eligible students to switch to higher-quality schools (with higher-achieving peers) that were previously not available.

In this paper we investigate the impact of SEP on the achievement deficit of low-SES students, the relative gains of all students in schools that participated in the SEP program, and the contributions of specific channels to observed changes. Our analysis of the effect of SEP on the achievement gap begins with a simple multi-year difference-in-differences research design that compares low- and high-SES students' fourth grade test scores before and after the SEP reform and identifies a greater than 0.2 standard deviation improvement in the relative performance of low-SES students in the period after SEP was introduced. This closing of the gap reproduces findings from a growing body of work that attributes a significant reduction in inequality to SEP. Neilson (2013) and Correa et al. (2014) argue that achievement gains among disadvantaged students can be explained primarily by school quality improvements based largely on the absence of extensive movement to private or initially higher-quality schools. Navarro-Palau (2017) also finds a significant though more modest effect of SEP on the achievement gap, and

[15]Work including Hoxby (2000), Card et al. (2010), and Lavy (2010) highlights the potential benefits associated with increased market competitiveness in alternative settings.

concludes based on a regression discontinuity design analysis that the positive program impact was driven by public school improvements. The findings in Murnane et al. (2016) also point to the combination of increased school funding and greater accountability as the primary mechanisms through which SEP raised achievement.

Yet although we replicate the large decline in the achievement gap, we believe that the body of evidence as a whole provides little support for the belief that the SEP reform led to a large reduction in the achievement gap or substantial achievement gains in participating schools. Rather, the improvements for low-SES students attributable to the SEP program appear to be largely illusory. We base these conclusions on a decomposition of gains into between- and within- school components, the sensitivity of gains to the inclusion of family background controls, and detailed investigations of the primary channels through which SEP would have been expected to raise the quality of instruction.

The distribution of gains and convergence in family background characteristics suggest that changes in the family backgrounds of test-takers account for much of the decline in the achievement gap. First, school-by-year fixed effects estimates show that two-thirds of the gain occurs within schools during a period in which within-school differences in parental education between disadvantaged and non-disadvantaged test-takers also declined substantially. Comparisons with trends from national surveys suggest that roughly half of

the family background improvement resulted from changes in the pool of test-takers.[16] Second, controlling crudely for family background, program-eligible students made virtually no achievement gain at a time when the SES-based achievement gap declined by over 0.15 standard deviations. Third, although the achievement differential between students in SEP-participating and non-participating schools declined by 0.18 standard deviations following program implementation, inclusion of the same family background controls reduces the convergence to less than 0.05 standard deviations.

Moreover, there is little evidence that SEP differentially increased inputs in schools attended by low-SES children, induced many children to switch to higher-quality schools, or raised the equality of instruction by strengthening competition. Despite the 50% increase in the voucher value for disadvantaged students at participating schools, there was only a modest reduction in class size at participating schools and results suggest that teacher characteristics became relatively less positive following program implementation. An audit showed that many schools were not using the additional revenues for permitted expenditures, and estimates that exploit a discontinuity in the revenues allocated to schools show little or no evidence of a positive effect of allocated

[16] As we describe in more detail in Section 1, parental education and household income data is based on a household survey that is only conducted among test-takers. Using data on maternal educational attainment from the Chilean Encuesta de Caracterización Socioeconómica Nacional, we find that roughly half of the convergence measured using SIMCE data is attributable to selective test taking, while the other half appears to reflect decreasing inequality in the maternal education distribution for all children.

funds on achievement growth. In addition, similar to Navarro-Palau (2017), we find limited evidence that disadvantaged students transitioned to higher quality schools during the period of large achievement gains for low-SES students. Finally, although difficult to measure, there is little direct evidence of a competitive or incentive effect on school quality.

3.2 Educational Data

We draw from a number of sources to assemble a rich database that tracks primary school students across schools and years for the 2005-2014 study period. These include administrative records on matriculation, academic performance, family background, school and teacher characteristics, and SEP eligibility and program participation. Unique school and student identifiers make it possible to track students over time and across schools and merge information from the various data sets.

The restricted-access administrative records provided by the Chilean Ministry of Education for all grade levels for the years 2005-2014 include matriculation and academic performance data. The matriculation records contain information on school attended, grade, attendance rate, and part-time enrollment, and the supplementary academic performance data includes grade point average in each year (on a one-to-seven scale), as well as indicators for grade progression, transfer status, academic probation and dropping out.

Test score data contain results from the Sistema de Medición de la Calidad de la Educación (SIMCE). The SIMCE battery of exams provides national standardised test scores in math and Spanish for grade four in every year between 2005 and 2014 and for grade eight in the years 2007, 2009, 2011, 2013, and 2014. Based on the existing literature, we exploit the comparability of the SIMCE test across years (Neilson, 2013). We are able to match SIMCE test score data to matriculation records using the unique student identifiers provided. Throughout the analysis, we follow the existing literature in normalizing grade four SIMCE math and Spanish test scores by the corresponding means and standard deviations from 2005 (Neilson, 2013; Navarro-Palau, 2017). In the analysis, we focus on the average of these two normalised scores, and we ignore tests conducted in other subjects that are irregularly administered.

Information on household income and parental educational attainment is available only for students who take the SIMCE examinations. Household income is reported as a categorical variable with thirteen to fifteen values in each year, while mother's and father's education levels are categorical variables that are mapped to completed years of schooling based on documentation provided by the Ministry of Education. We use mother's education to determine socioeconomic status. Specifically, we rank students in each grade four cohort based on mother's education and categorise the 40% of students with the lowest levels of mother's education as low SES.

The remaining 60% of students in each cohort are characterised as high-SES students. This dichotomy is based on the structure of the SEP program, which provides targeted vouchers to the 40% of students in each cohort at the bottom of the socioeconomic distribution.[17]

The Ministry of Education provides data on all schools and teachers. We use information on teacher's educational attainment, contract status, and years of experience in the analysis.

Finally, the Ministry also provides data on SEP program eligibility and participation starting with 2008 when the program was first introduced. In addition, the data report whether the student qualified for SEP program participation based on (1) household enrollment in the Chile Solidario social program, (2) the household being identified as among the one-third of most vulnerable households in the Ficha de Protección social safety net program and/or being in Group A of the FONASA public health insurance program, or (3) the household reporting sufficiently low income, low parental education, rural residency status, and/or the child living in a municipality with a high local poverty rate. In addition, SEP files identify all participating schools in each year.

[17]Given discrete levels of educational attainment, we randomly assign students with the same maternal education to the low-SES and high-SES groupings to ensure that precisely 40% of students are classified as low SES in each year. While this approach may attenuate the measured achievement gap at baseline, it should not bias estimated year-on-year changes in the achievement gap.

3.3 Institutional Details

This section provides an overview of the Chilean education system and describes the SEP program. Chile has a large private schooling sector, but students from economically-disadvantaged families potentially face a number of impediments in voucher-funded schooling markets that can limit the benefits of competition. There may be a positive association between family income and the academic and social skills that schools value. In addition, more limited family resources may elevate the costs of operating schools and geographical segregation may constrain competitive pressures. If private schools are able to charge tuition above the value of a voucher and selectively admit applicants, disadvantaged students may have limited options.

3.3.1 The Chilean Education System

Influenced by Friedman (1962), Chile's military government adopted a national school voucher program in 1981. Supporters of the voucher program argued that increased competition in the market for primary and secondary education would lead to improved academic achievement across the distribution (Bettinger, 2011). Given the unique scale of Chile's voucher program, it has attracted substantial academic attention (Correa et al., 2014). Evidence on the efficacy of Chile's voucher program, however, has been mixed, and dis-

tributional analyses suggest that the voucher program may have exacerbated stratification based on socioeconomic status (Hsieh and Urquiola, 2006).

Over the past 35 years school funding has primarily been a function of enrollment levels and the annual value of the grade-specific nationwide voucher that goes to public and private voucher schools. Since 1994, private voucher schools in Chile have been permitted to charge tuitions up to three times the value of the nationwide school voucher and to impose their own eligibility criterion in the admissions process. In contrast, public schools have not been allowed to turn away students unless oversubscribed or to charge tuition over and above the school voucher (Urquiola, 2016). The result of this policy regime has been substantial inter-school stratification based on socioeconomic status: as of the mid 2000s, 69% of low-SES students but only 35% of higher-SES students attended public schools.

3.3.2 The SEP Program

To address the large, persistent gap in achievement based on background, the Chilean Ministry of Education launched the SEP program in 2008. It was designed to improve educational outcomes for SEP-eligible priority students by increasing resources, expanding opportunities to attend private schools, and strengthening incentives to raise achievement. Schools were allocated the product of approximately an additional 50% of the baseline voucher pay-

ment for each enrolled priority student multiplied by the student's lagged three-month attendance rate (defined to take on a value between zero and one). In addition, schools received supplementary revenue as a function of the lagged share of priority students enrolled in the school and students' average attendance rate. For pre-kindergarten through grade four, for example, schools received up to an additional 9.8% of the standardised national voucher payment unit if between 15% and 30% of enrolled students were classified as priority. This multiplier increased to 16.8% for enrollment rates between 30% and 45%, to 22.4% for enrollment rates between 45% and 60%, and to 25.2% for priority enrollment rates above 60%.[18] In all cases, the supplementary funding was based on the product of the formula-based multiplier and the average lagged three-month attendance rate of students in the relevant grades.

In exchange for receiving these additional funds, participating schools had to sign contracts that ensured that SEP funds would be spent appropriately and that all expenditures would be documented. Appropriate expenditures categories included additional personnel and school resources, while increased salaries, bonuses and other expenditure categories (debt repayments, school celebrations, etc.) were excluded. The School Improvement Plans submitted by SEP participants outlined planned expenditures and anticipated test score

[18]For comparison, in 2008, primary schools received 275% of the standardised national voucher payment unit for each full-time student enrolled. This corresponded to approximately $92 USD per month.

gains over subsequent years, with a required focus on activities intended to improve the performance of low-SES students. Subsequent financial autonomy was tied to test score performance for fourth graders, adjusted for the socioeconomic composition of the student body. Participating private schools were also required to significantly alter admissions and student retention systems. Specifically, schools could no longer charge tuition or fees to priority students in excess of the voucher revenues received by schools, schools could not selectively admit priority students based on past educational achievement or family background, and schools could not expel priority students for failing a grade before allowing them at least one opportunity to repeat each grade level (SEP, 2008).[19] Although we investigate the possibility that schools' SEP participation improved outcomes for students regardless of socioeconomic background, these institutional features of the SEP program make clear that the program was designed explicitly to improve outcomes for disadvantaged (i.e., priority) students.

In preparation for the introduction of the SEP program in 2008, the Ministry of Education engaged in an information campaign to make school administrators aware of the key features of the program, including additional revenues and requirements for program participants. The SEP enrollment period for schools was shortened for the 2008 school year; nevertheless, 51

[19]In October 2011, the SEP legislation was amended to increase SEP voucher values by 21% and to eliminate some restrictions on the use of funds, including on teacher salary increases.

percent of private voucher and 99 percent of public schools enrolled in the program in the inaugural year. The private voucher schools that elected to participate in the SEP program in 2008 or subsequent years charged lower prices at baseline (in 2005), attracted students with lower levels of maternal education, and had lower test scores conditional on student characteristics than non-participants. These findings are in line with those presented in Aguirre (2017). It appears that foregone revenues are a key factor that prevented universal participation: while 92% of private voucher schools charging under $5 USD per month chose to participate in the program, fewer than 18% of those charging more than $50 USD per month did so.

In 2008, participating schools were eligible to receive funding for all priority students in pre-kindergarten through grade four. During subsequent school years, cohorts maintained eligibility as they progressed through school, while incoming pre-kindergarten students were added to the program. As a result, students in pre-kindergarten through eighth grade were eligible by 2012. In 2008, the SEP program enrolled approximately two-thirds of the number of students that were enrolled in subsequent school years. This lower initial enrollment rate was due primarily to a lower share of students being classified as SEP-eligible.[20] The share of all students in grades one through

[20]The Chilean government utilised a socioeconomic ranking score to determine SEP eligibility (although other pathways to eligibility were also available). An increase over time in the coverage of the survey used to assign this socioeconomic ranking score, which occurred as part of a larger overhaul intended to reduce strategic survey responses, explains

four who received SEP funding increased from 26.9% in 2008 to 41.9% in 2009 and remained stable thereafter.[21]

3.4 Academic Achievement Gap

This section describes differences in family and school characteristics by SEP eligibility and then illustrates changes over time in the achievement gap. SEP is designed to cover the bottom two quintiles of the SES distribution, but prior to program implementation in 2008 there is no measure of eligibility. Therefore, we use maternal education as a proxy for SES and eligibility status but also compare achievement gap trends based on this proxy with those based on actual priority designation during the reform period.

In Table XVIII we report summary statistics for achievement, family background variables and school sector by time period (pre- or post-reform) and disadvantaged status. Across both definitions of disadvantage, Table XVIII shows that disadvantaged students have lower levels of parental education and household income, lower grade point averages, and lower SIMCE test scores in both time periods. In addition, these students are more likely to be enrolled in public schools and are less likely to be enrolled in private

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the finding that the share of SEP-eligible students increased somewhat during the years after SEP's introduction. This finding is discussed in more detail in Neilson (2013).

[21]The share of participating voucher private schools also increased to 61% by 2009 and continued to increase in the following years.

voucher schools. Although priority students appear to be slightly less disadvantaged than those classified as low SES, the SIMCE and GPA deficits are quite similar for the two measures of disadvantage. Note that, as discussed in more detail in Section 5, family background measures are only available for test-takers.

TABLE XVIII: VARIABLE MEANS BEFORE AND AFTER THE SEP REFORM, BY SES AND PRIORITY STATUS

	(1) Mother's Education (Years)	(2) Father's Education (Years)	(3) Household Income (Pesos)	(4) GPA (1-7 Scale)	(5) Normalised SIMCE Score	(6) Public School	(7) Voucher Private School	(8) Observations
Panel A: Pre-SEP program (2005-2007)								
Low-SES	7.46	8.68	149,378	5.68	-0.36	0.67	0.31	252,007
High-SES	13.56	12.92	439,105	5.99	0.25	0.35	0.54	378,012
Panel B: SEP program in place (2008-2014)								
Low-SES	8.25	9.27	173,694	5.72	-0.11	0.58	0.41	530,297
High-SES	13.91	13.27	497,280	5.97	0.38	0.28	0.60	795,452
Priority	10.05	10.02	189,036	5.68	-0.04	0.55	0.44	785,645
Non-Priority	12.81	12.86	499,383	5.91	0.32	0.31	0.56	944,418

Notes: Table displays mean values over relevant years for fourth grade students. Household Income measures monthly household income in 2005 Chilean Pesos, higher GPA values reflect better academic performance.

The top two rows of Panels A and B also show the sizable decline in the SIMCE test-score gap following the introduction of the SEP program, as the average differential between high- and low-SES students declines from 0.61 standard deviations in the pre-reform period to 0.49 standard deviations post-reform. The same comparison across cohorts identifies large relative gains in the parental education levels of tested low-SES students, previewing the subsequent analysis that identifies changing student demographics as an

important driver of the decline in the measured achievement gap during the post-SEP period.

To formally characterise the yearly change in relative test performance based on socioeconomic status, we estimate multi-year difference-in-differences models using alternative measures of disadvantage. The first specifications use the low-SES indicator available throughout the relevant period, while the second set of specifications use an indicator for SEP priority status available from 2008 forward. Estimating equations are as follows:

$$Testscore_{ijt} = \sum_{t=2005}^{2014} (LowSES_{ijt} \cdot \gamma_t)\delta_{1t} + \lambda_{jt} + \epsilon_{ijt} \tag{4}$$

$$Testscore_{ijt} = \sum_{t=2008}^{2014} (Priority_{ijt} \cdot \gamma_t)\delta_{1t} + \lambda_{jt} + \epsilon_{ijt} \tag{5}$$

In the equations above, $Testscore_{ijt}$ represents the normalised test score of student i in school j year t, λ_{jt} represent school-by-year fixed effects, and disadvantage is an indicator variable defined two different ways. In one set of specifications it equals one for low-SES children based on SIMCE survey

responses, and in the other it equals one for SEP priority students as classified by the Ministry of Education.[22]

Table XIX reports estimates based on both measures of disadvantage from specifications with either year fixed effects or school-by-year fixed effects and, in the case of the priority status specifications, with and without family background controls. Column (1) shows average gains for low-SES students that appear similar to previous estimates, including those presented in Neilsen (2013). Between 2007, the year prior to the introduction of the SEP program, and 2014, low-SES students increased their relative test scores by 0.2 standard deviations. Note that 80% of these gains gains occurred by 2011.[23] Column (2) shows that the addition of school-by-year fixed effects reduces the relative gains by only one-third, meaning that most of the convergence occurred within schools and was not due to higher overall school quality for low-SES students.

Columns 3 to 6 use SEP eligibility as the measure of disadvantage and only cover the period in which the SEP program is in effect. Nevertheless, the estimates in Column 1 show a substantial reduction in the SES-based gap

[22]The sample is restricted to include only test-takers with non-missing scores for both the math and Spanish exams, although results appear similar if we include all non-missing test score observations in the analysis sample.

[23]This pattern of test score gains suggests that the increase in voucher values and the relaxation of expenditure restrictions, which affected test-takers in 2012 and subsequent years, did not significantly improve the relative performance of disadvantaged students.

during this period, a pattern that also emerges in Column 3. Yet regardless of whether the specification includes school-by-year fixed effects, the addition of controls for parental education and household income virtually eliminates any test-score convergence between priority and non-priority students. In fact, only the 2011 coefficient of 0.022 is significantly greater than zero in Column 5, and the 2014 coefficient is actually negative and significant.

TABLE XIX: ESTIMATED ACHIEVEMENT DEFICITS FOR DISADVANTAGED STUDENTS, BY YEAR

	(1) SIMCE Score	(2) SIMCE Score	(3) SIMCE Score	(4) SIMCE Score	(5) SIMCE Score	(6) SIMCE Score
Disadvantaged	-0.618***	-0.282***	-0.469***	-0.153***	-0.080***	-0.068***
	(0.004)	(0.004)	(0.004)	(0.004)	(0.005)	(0.005)
Disadvantaged·2006	0.008	-0.003				
	(0.005)	(0.006)				
Disadvantaged·2007	0.008	0.012*				
	(0.006)	(0.006)				
Disadvantaged·2008	0.034***	0.046***				
	(0.005)	(0.006)				
Disadvantaged·2009	0.030***	0.043***	0.023***	0.032***	-0.005	0.019***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
Disadvantaged·2010	0.093***	0.062***	0.083***	0.044***	0.010	0.023***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.007)	(0.007)
Disadvantaged·2011	0.168***	0.103***	0.138***	0.064***	0.022***	0.033***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.007)	(0.007)
Disadvantaged·2012	0.181***	0.116***	0.134***	0.060***	0.005	0.021***
	(0.005)	(0.006)	(0.005)	(0.006)	(0.007)	(0.007)
Disadvantaged·2013	0.185***	0.119***	0.106***	0.054***	0.008	0.023***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.007)	(0.007)
Disadvantaged·2014	0.209***	0.137***	0.116***	0.049***	-0.016**	0.006
	(0.005)	(0.006)	(0.005)	(0.006)	(0.007)	(0.007)
School-by-Year Fixed Effects		X		X		X
Additional Controls					X	X
Disadvantage Measure Used	Low SES	Low SES	Priority	Priority	Priority	Priority
Observations	1,955,768	1,955,768	1,508,726	1,508,726	1,213,679	1,213,679

Notes: Robust standard errors are in parentheses and all specifications include year fixed effects. The dependent variable is the normalised fourth grade test score (normalised by 2005 mean and standard deviation). The low socioeconomic status indicator is based on mother's years of education as measured by SIMCE parental surveys from the years 2005-2014. The priority status of a student is designated by the Ministry of Education. Additional controls include interactions between year and each of the following: mother's years of education, father's years of education, and log household income.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

Although Table XIX raises doubts that the SEP program substantially reduced the gap in school quality, the focus on the achievement differential may understate the program effect to the extent that the benefits of SEP accrue to all students in a school and not just those eligible for the program. To assess program effects on average school quality we estimate a series of difference-in-differences models of the following form:

$$Testscore_{ijt} = \gamma_t + \sum_{t=2005}^{2014} (SEP_{jt} \cdot \gamma_t)\delta_{1t} + X_{ijt}\beta + \epsilon_{ijt} \tag{6}$$

Here, SEP_{jt} is an indicator for whether school j participated in the SEP program by the end of the sample period (2014). We focus on a measure of whether each school ever participated in the SEP program because of the significant achievement differences by timing of program entry shown below. X_{ijt} includes controls for the following student-level covariates, interacted separately with year: mother's educational attainment (in years), father's educational attainment and log household income. Remaining terms are defined as in Equation 4.

Table XX reports estimates of Equation 6 for specifications without (Column 1) and with (Column 2) family background controls. While Column (1) reveals that students in SEP-participating schools improved their relative test score performance by 0.18 standard deviations between 2007 and 2014, Col-

umn (2) shows the crude demographic controls explain almost three-quarters of these gains. These estimates suggest that any SEP effects above and beyond those differentially benefitting low-SES students are modest, but ignoring the timing of program entry could attenuate SEP effects if the benefits rise with duration in the program. In Figure 11, we plot the time series of average test scores by the year of initial SEP participation. There is little evidence that test score gains align with the timing of SEP entry or grow with program duration, providing additional support for the finding of small benefits to participating schools.

3.5 Potential Channels of SEP Program Effects

In this section we seek to provide additional evidence on the effects of the SEP reform by examining the primary channels through which the reform would have been expected to raise the quality of instruction. First, we assess the effects of SEP on the quantity of school inputs. Second, we investigate the effects of SEP on the distribution of students among schools to assess the possibility that the program led to extensive quality upgrading for low-SES students. Third, we assess whether the evidence is consistent with the notion that increased competition to attract low-SES children raised achievement.

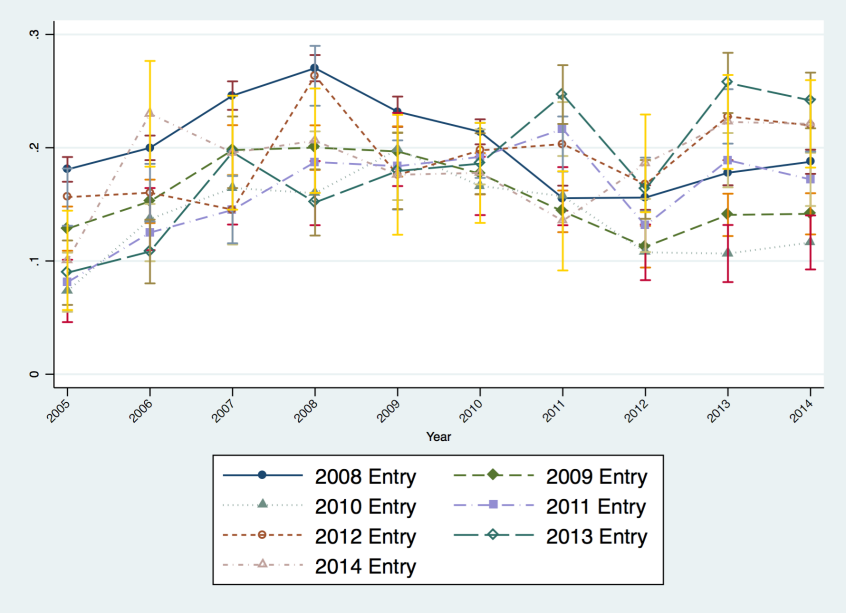
TABLE XX: ESTIMATED ACHIEVEMENT DEFICITS FOR SCHOOLS THAT EVER PARTICIPATE IN THE SEP PROGRAM, BY YEAR

	(1) SIMCE Score	(2) SIMCE Score
SEP School	-0.639***	-0.168***
	(0.005)	(0.005)
SEP School·2006	-0.001	-0.023***
	(0.006)	(0.007)
SEP School·2007	-0.046***	-0.067***
	(0.007)	(0.008)
SEP School·2008	-0.048***	-0.088***
	(0.006)	(0.008)
SEP School·2009	-0.022***	-0.057***
	(0.007)	(0.008)
SEP School·2010	0.046***	-0.043***
	(0.007)	(0.007)
SEP School·2011	0.125***	-0.001
	(0.006)	(0.008)
SEP School·2012	0.148***	0.016**
	(0.006)	(0.007)
SEP School·2013	0.128***	-0.012
	(0.006)	(0.007)
SEP School·2014	0.135***	-0.018**
	(0.006)	(0.007)
Additional Controls		X
Sample	All Students	All Students
Observations	1,955,768	1,803,820

Notes: Robust standard errors are in parentheses and all specifications include year fixed effects. The dependent variable is the normalised fourth grade test score (normalised by 2005 mean and standard deviation). SEP School status is determined by whether a school participated in the SEP program by 2014. Additional controls include interactions between year and each of the following: mother's years of education, father's years of education, and log household income.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

Figure 11: Trends over Time in SIMCE Test Score Gaps Relative to Non-SEP Schools, by Initial Year of SEP Participation



Notes: This figure presents magnitudes of year-by-SEP entry year coefficients from a student-level regression of test scores on the full set of interactions between year and year of school SEP entry. The regression also includes controls for interactions between year and each of the following: mother's years of education, father's years of education, and log household income.

3.5.1 SEP Effects on School Inputs

1. School expenditures

   To investigate the extent of SEP-induced increases in school inputs we examine alternative sources of variation in school revenues and expenditures. First, we present findings from an audit study conducted by the Chilean Comptroller's Office (Comptroller's Office, 2012) that compared SEP funding inflows for the 2008-2011 period to documented SEP expenditures by municipal authorities for 77 of Chile's 346 municipalities.[24] On average, only 65% of received funds designated for public schools could be linked to validated expenditures during the audit period. Moreover, municipality-level regressions of test score changes on funds spent reveal little or no evidence of a substantial effect of SEP spending on municipality-level test score gains or the within-municipality achievement gap (Table XXI, Columns 1 and 2), and subsequent regressions also provide no evidence that students within public schools benefitted from increased SEP spending (Table XXI, Columns 3 and 4).[25]

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[24]Although 77 municipalities were included in the audit, estimated expenditures were not provided in the audit report for four of these municipalities.

[25]Although municipality administrators determined the share of SEP funds to spend within the set of permitted categories, failing to spend SEP funds appropriately was in direct violation of SEP regulations and could potentially limit future inflows. Thus, it seems likely that schools/municipalities which failed to spend SEP funds were, if anything,

TABLE XXI: OLS ESTIMATED EFFECTS OF SEP PROGRAM EXPENDITURE ON SIMCE SCORE GAINS

	(1)	(2)	(3)	(4)
Panel A: 2008-2011 Aggregate Municipality-level Test Score Gains				
% SEP Funds Spent	0.029	-0.022	0.009	-0.039
	(0.091)	(0.063)	(0.091)	(0.101)
Additional Controls		X		X
Sample	All School Types	All School Types	Public Schools Only	Public Schools Only
Observations	73	73	73	73
Panel B: 2008-2011 Municipality-level Test Score Gains by SES Status				
% SEP Funds Spent	0.022	0.002	-0.028	-0.057
	(0.076)	(0.061)	(0.110)	(0.118)
% SEP Funds Spent·Low SES	-0.069	-0.069	-0.005	-0.005
	(0.048)	(0.048)	(0.079)	(0.080)
Additional Controls		X		X
Sample	All School Types	All School Types	Public Schools Only	Public Schools Only
Observations	146	146	146	146

Notes: Robust standard errors are shown in parenthesis in Panel A and standard errors are clustered at the municipality level and shown in parentheses in Panel B. In Panel A, the dependent variable is the change in municipality-level average normalised test scores over the 2008-2011 period and one observation is included per municipality. In Panel B, the dependent variable is the change in municipality-level average normalised test scores over the 2008-2011 period with the municipality·SES group as the unit of observation. Column (1)-(4) specifications include those municipalities that were audited in 2012 (observations are weighted by the 2008 number of fourth grade students in the municipality). In Columns (2) and (4), regressions control for municipality-level log number of students and fraction low-SES students.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

Of course these estimates do not capture causal effects, but the structure of the SEP funding formula discussed in detail in Section 2 enables the use of regression discontinuity methods to identify the causal effects of additional revenue. Specifically, funding increases discontinuously with the share of disadvantaged students. Equation 7 presents the relationship between test scores and share disadvantaged used to estimate the regression discontinuity design intent-to-treat effects[26]:

relatively less efficient than those that did spend funds as required. This would in turn suggest that our estimates likely provide upper bounds of the effect of funding on test score gains.

[26]Implicitly, the first-stage dependent variable is $Bonus_{st}$, the value of concentration bonus funds received as a fraction of non-bonus SEP funds allocated to school s in year t. Since we impute bonus funds based on the concentration bonus formula, there is me-

$$Testscore_{st} = \alpha + \beta_j Threshold_{j,st} + \tau f(Priority_{st}) + \epsilon_{ist} \quad (7)$$

In this specification, $Threshold_{j,st}$ is defined as an indicator variable for whether school s passes concentration formula threshold j in year t, $Priority_{st}$ is the lagged school-level share of priority students in SEP-eligible grade levels (the basis for the concentration formula), and $f(Priority_{st})$ represents a local linear polynomial that is estimated separately on each side of the relevant threshold. To provide a better sense of the underlying variation in the data, Figure 12 presents a histogram of school-level priority shares and graphs the predicted bonus funding measure as well as student test scores and mother's years of education as a function of priority student share for the first concentration bonus threshold.

We estimate separate RD specifications around each threshold with samples restricted to schools with values of $Priority_{st}$ share within 0.075 of the relevant cutoff. Table XXII estimates are based on data from 2012-2014, the subset of years for which the precise monthly attendance data necessary to construct school-level shares of priority students is available. We present estimates for the remaining years, based on annual attendance data, in Appendix Table XXXIV (the overall

chanically a sharp discontinuity in this measure at each of the bonus thresholds. Crossing bonus thresholds one through four is associated with funding increases of 44, 12, 8 and 3 percentage points, respectively.

pattern of test score findings is unchanged).[27] Column (1) of Table XXII reports the reduced form effects on test scores. These estimates provide no evidence that additional SEP funding leads to significant test score improvements. In Column (2), mother's years of education replaces student test score as the dependent variable, and we find little evidence of a discontinuity in this student-level characteristic around the relevant thresholds, indicating that sorting cannot likely explain the lack of test score impacts. Columns (3) and (4) re-produce Columns (1) and (2) specifications for the subsample of priority students in SEP schools, and findings are comparable.[28] Finally, Column (5) presents results from a school-level specification that tests for manipulation (i.e. bunching) around each cutoff. The test, based on McCrary (2008), reveals evidence of manipulation only at the fourth threshold included in Appendix Table XXXIV. Although estimates of test score effects at threshold four should consequently be interpreted with caution, the estimates based on the three other thresholds provide consistent evidence that there is little return to additional SEP revenues during the study period. Moreover, the fourth threshold corresponds to the small-

[27]While special education students can also be classified as priority students, we find that very few special education students are classified as priority students before 2011 and so exclude these students when constructing school-level priority shares in Appendix Table XXXIV specifications. We also exclude 2009 from the RDD sample as pre-kindergarten students are not consistently included in the matriculation records for 2008.

[28]Across RDD specifications, results are not sensitive to the choice of bandwidth.

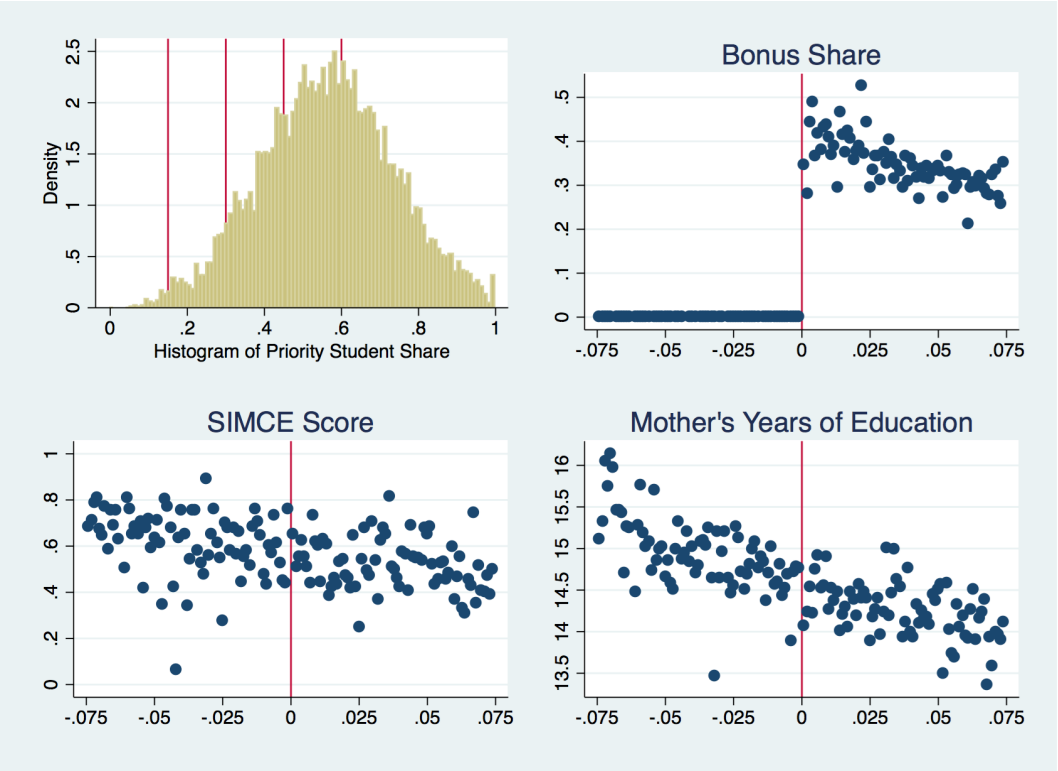
est jump in bonus funding. To the extent that the return to additional funds is not increasing as funds rise, we would expect to see larger effects at the lower thresholds, where differences in test scores are not statistically significant.

TABLE XXII: RDD SPECIFICATION CHECKS AND ESTIMATED EFFECTS OF SEP FUNDING ON SIMCE SCORES BY PRIORITY STATUS (2012-2014)

	(1)	(2)	(3)	(4)	(5)
	SEP School Students		*Priority Students*		
	SIMCE Score	Mother's Education (Years)	SIMCE Score	Mother's Education (Years)	Density Test
Threshold 1	-0.035	-0.170	-0.021	-0.925	0.275
	(0.246)	(0.607)	(0.232)	(0.609)	*(0.28)*
Threshold 2	-0.003	-0.065	0.057	0.072	-0.057
	(0.059)	(0.132)	(0.077)	(0.204)	*(0.60)*
Threshold 3	-0.007	-0.120	0.003	-0.086	-0.028
	(0.035)	(0.130)	(0.039)	(0.145)	*(0.63)*
Threshold 4	0.042	0.064	0.049	0.077	0.058
	(0.044)	(0.132)	(0.046)	(0.163)	*(0.21)*
Observations	342,509	317,927	178,280	165,238	16,228

Notes: The dependent variable in Columns (1), (3) is the student's normalised fourth grade test score (normalised by 2005 mean and standard deviation) and the dependent variable in Columns (2), (4) is mother's years of education. Columns (1)-(4) specifications are estimated at the student level and include data from the years 2012-2014. Each threshold refers to a given Concentration Bonus discontinuity. Specifications in Columns (1)-(4) are estimated separately for each threshold and include a local linear polynomial in Priority share that is estimated separately on each side of the relevant concentration formula threshold. For each regression estimated in Columns (1)-(4), the sample is limited to include schools with a Priority share within 0.075 of the cutoff and standard errors are clustered on the running variable. Column (5) presents discontinuity estimates and corresponding p-values from school-level tests for manipulation (i.e. bunching) around each cutoff.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

Figure 12: RDD Priority Share Density and Plots of Bonus Share, SIMCE Score and Mother's Years of Education Against the Share of Priority Students in the School



Notes: The figure displays a histogram of school-level priority shares and presents plots of concentration bonus funding, student test scores, and mother's years of education as a function of the share of priority students in the school. Except in the histogram, the first concentration bonus threshold is normalised to 0 in each panel and only data points within 0.075 priority share of the cutoff are included. In specifications examining bonus shares, SIMCE scores and maternal education, each data point characterises the average of the dependent variable within a 0.01 priority share bin. Bonus shares are calculated for June 2012, the first month for which lagged monthly attendance data and lagged annual priority share (based on monthly attendance data) are available.

2. Class size and teacher characteristics

To bring additional evidence to bear on SEP-induced changes in school inputs and teacher quality we now describe differential changes in class size and teacher characteristics for students in SEP-participating schools.[29] The estimates reported in Table XXIII reveal declines in relative class size for students in SEP-participating schools of 1.5 students per class between 2007 and 2014 (Column 5). However the results suggest that, in general, teacher characteristics for students in SEP-participating schools became relatively less positive following program implementation. Aside from a small increase in the fraction of teachers with a college degree (1-2 percentage points), there is a 4-5 percentage point increase in the share of inexperienced teachers (defined as teachers with fewer than two years of teaching experience) and a significant increase in the share of teachers who work part time. Together the results suggest schools reduced class size primarily by hiring part-time teachers who are marginally less experienced than those already on staff. Even ignoring any decline in teacher quality, existing evidence suggests that a class size reduction of this magnitude would have only a small effect on achievement (Rivkin et al., 2005; Krueger, 1999). In combination

[29]We restrict the sample to instructors whose primary role is "Classroom Teacher." Since data on grade level taught is not available until 2011, we construct averages based on all primary school teachers in a given school and year. Teachers are only asked about degree status beginning in 2011, so educational attainment is missing for those teachers who do not appear in the data file in 2011 or later.

with the findings on expenditure effects, these patterns indicate that this channel almost certainly plays a minor role in explaining observed gains for low-SES students and SEP schools.[30] Importantly, the initial prohibition on using SEP funds to raise teacher salaries may have dampened program impacts.

3.5.2 School Upgrading

We next test the hypothesis that the SEP program improved test scores for disadvantaged students by raising the quality of the schools attended. Previous research using RDD methods has found that post-SEP period changes in enrollment patterns were limited among students at the eligibility boundary (Navarro-Palau, 2017). We address this question by estimating changes in the school quality gap in terms of 2005 test scores, i.e., school quality prior to the adoption of SEP. This approach ensures that program-induced school improvement is excluded, and only changes in the distribution of students among schools affects the school quality gap as measured by 2005 test scores.

[30]Corresponding estimates for low-SES students are presented in Appendix Table XXXV. Results there reveal positive changes in relative class size for low-SES students during the post-SEP period. This pattern is explained by small annual declines in the share of low-SES students enrolled in rural schools (which have significantly smaller classes than urban schools). In Column 6 of Appendix Table XXXV, we show that increases in relative class size for low-SES students are explained entirely by the inclusion of rural school-by-year fixed effects.

TABLE XXIII: ESTIMATED DIFFERENCES IN CLASS SIZE AND TEACHER CHARACTERISTICS, BY SCHOOL SEP PARTICIPATION AND YEAR

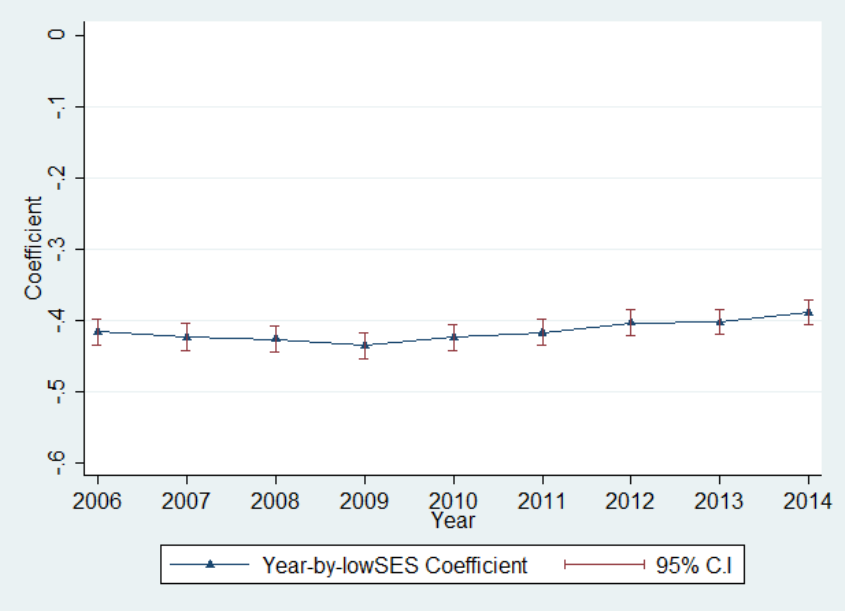
	(1)	(2)	(3)	(4)	(5)
	Percentage of Teachers with:				
	College Degree	$\leq$ 1 Year Experience	$\leq$ 20 Contract Hours	Employment in Multiple Schools	Class Size (# Students)
SEP School	-0.038***	-0.035***	-0.042***	0.009	1.107***
	(0.005)	(0.005)	(0.005)	(0.006)	(0.334)
SEP School ·2006	0.003	0.006	0.006**	-0.004	-0.346*
	(0.002)	(0.004)	(0.003)	(0.003)	(0.200)
SEP School ·2007	-0.002	0.005	0.016***	-0.001	-0.367
	(0.003)	(0.006)	(0.004)	(0.004)	(0.259)
SEP School ·2008	0.005*	0.030***	0.020***	0.004	-0.750***
	(0.003)	(0.006)	(0.004)	(0.004)	(0.224)
SEP School ·2009	0.007**	0.043***	0.028***	0.009**	-1.071***
	(0.003)	(0.006)	(0.004)	(0.005)	(0.241)
SEP School ·2010	0.010***	0.041***	0.031***	0.003	-0.899***
	(0.003)	(0.006)	(0.004)	(0.005)	(0.249)
SEP School ·2011	0.009**	0.023***	0.036***	0.000	-1.570***
	(0.003)	(0.008)	(0.004)	(0.005)	(0.264)
SEP School ·2012	0.010***	0.028***	0.038***	0.003	-1.723***
	(0.004)	(0.009)	(0.005)	(0.005)	(0.274)
SEP School ·2013	0.017***	0.063***	0.044***	0.004	-1.865***
	(0.004)	(0.007)	(0.005)	(0.005)	(0.271)
SEP School ·2014	0.015***	0.057***	0.040***	-0.001	-1.749***
	(0.004)	(0.007)	(0.005)	(0.005)	(0.281)
Observations	1,931,971	1,937,236	1,937,236	1,937,236	1,887,014

Notes: Standard errors are clustered at the school level and shown in parentheses. All specifications are estimated at the student-level and include data from the years 2005-2014 as well as year fixed effects. SEP School status is determined by whether a school participated in the SEP program by 2014.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

In Figure 13, we plot coefficients and confidence intervals from a regression that re-estimates the specification employed in Table XIX but replaces the dependent variable with the average 2005 normalised fourth grade test score of the school in which a student is enrolled. Figure 13 shows that there is a modest (0.035 SD) relative increase in the average baseline test scores of schools attended by low-SES students between 2007 and 2014, with virtually all of these gains taking place after 2011.

Figure 13: Estimated SES Deficit in Average School Quality as Measured in 2005, by Year



Notes: The figure presents point estimates and confidence intervals constructed from a regression in which the dependent variable is the average 2005 normalised fourth grade test score of the school in which a student is enrolled in a given year. The included regressors are the full set of interactions between year and low-SES dummy variables.

3.5.3 SEP Effects on Competition

The third channel we investigate is whether the evidence is consistent with the hypothesis that SEP reduced the achievement gap by fostering competition for low-SES students. An increase in the voucher value associated with socioeconomically disadvantaged students increases the return to enrolling and retaining these students and should lead to greater competition. If socioeconomically disadvantaged students are informed participants in the primary school market and have multiple primary schools in their choice set, this should in turn incentivise schools that desire to enroll low-SES students to improve. Prior research on the Chilean education market suggests that the magnitude of such competitive pressure may be limited, however, given schools' market power, which is driven in part by strong parental preferences for primary schools in close proximity to their homes (Chumacero et al., 2011; Feigenberg, 2016).

We investigate the role of competition under the alternative assumptions that either 1) the benefits of competition for low-SES children would be expected to be stronger in more densely populated municipalities; or 2) the benefits would be expected to be larger in municipalities with the largest decline in concentration in the schooling market after SEP's introduction. Given that municipalities with lower population density have schools that are more geographically dispersed, which likely limits the potential benefits

of competition, we test for heterogeneity in SEP impacts based on whether a student resides in a municipality that is above the 50th percentile in population density. Next, we construct municipality-level Herfindahl Indices based on fourth graders' enrollment patterns in 2005 and 2014. We then compare test score gains in municipalities with below-median differences in 2014 versus 2005 Herfindahl Index values to those with above-median differences (below-median differences correspond to larger declines in market concentration). Any decline in concentration results from endogenous changes in enrollment patterns, and these could result from many factors that could be directly related to achievement. Therefore it is likely that the relationship between the achievement gain and change in concentration provides an upwardly-biased estimate of competition effects. Nevertheless, across Table XXIV specifications, we find little or no evidence of differences by level of competition in the gains made by disadvantaged students regardless of the measure.[31]

3.6 Alternative Explanations for the Closing of the Gap

We now consider alternative explanations for the test score gains of disadvantaged students, focusing on non-school inputs and strategic behavior by

[31]In Appendix Table XXXVI, we present alternative specifications based on Herfindahl Indices constructed separately by gender and by year. Across these alternative specifications, we find little evidence of differential gains based on market competitiveness.

TABLE XXIV: ESTIMATED ACHIEVEMENT DEFICITS FOR LOW-SES STUDENTS, BY INTENSITY OF SCHOOL COMPETITION, MEASURE OF COMPETITION, AND YEAR

	(1)	(2)	(3)	(4)
	Population Density		Δ Herfindahl Index	
	Above Median	Below Median	Below Median	Above Median
LowSES	-0.650***	-0.570***	-0.618***	-0.619***
	(0.006)	(0.005)	(0.005)	(0.005)
LowSES·2006	-0.006	0.007	-0.020***	0.033***
	(0.008)	(0.007)	(0.008)	(0.008)
LowSES·2007	-0.026***	0.015*	-0.011	0.022***
	(0.009)	(0.008)	(0.008)	(0.008)
LowSES·2008	0.016*	0.043***	0.010	0.058***
	(0.008)	(0.008)	(0.008)	(0.008)
LowSES·2009	0.008	0.041***	0.013	0.046***
	(0.009)	(0.008)	(0.008)	(0.008)
LowSES·2010	0.090***	0.086***	0.074***	0.114***
	(0.008)	(0.007)	(0.008)	(0.008)
LowSES·2011	0.163***	0.158***	0.151***	0.186***
	(0.008)	(0.007)	(0.008)	(0.008)
LowSES·2012	0.189***	0.158***	0.169***	0.195***
	(0.008)	(0.008)	(0.008)	(0.008)
LowSES·2013	0.179***	0.178***	0.173***	0.199***
	(0.008)	(0.008)	(0.008)	(0.008)
LowSES·2014	0.204***	0.202***	0.190***	0.232***
	(0.008)	(0.008)	(0.008)	(0.008)
Observations	965,790	989,352	1,019,588	935,574

Notes: Robust standard errors are in parentheses and all specifications are estimated at the student-level. The dependent variable is the student's normalised fourth grade test score (normalised by 2005 mean and standard deviation). Δ Herfindahl Index is calculated as the difference between the 2014 municipality-level index and the 2005 municipality-level index. Population density is based on 2002 Chilean Census data. Low socioeconomic status is based on mother's years of education as measured by SIMCE parental surveys in 2005-2014.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

schools. There is widespread agreement on the importance of families in the acquisition of human capital, and public programs including income supports (for which most priority students in this setting are eligible) have also been shown to influence academic outcomes (Dahl and Lochner, 2012). Because the bottom 40 percent of the SES distribution was designated as low-SES regardless of the absolute level of parental education or income, parental education and household income differentials may have changed substantially over time. In addition, there is extensive evidence of opportunistic behavior on the part of schools in response to high-stakes testing requirements and accountability pressures (Cullen and Reback, 2006). The requirement to meet achievement targets in order to qualify for unconditional renewal of SEP funding may lead schools to attempt to raise achievement through selective test-taking, teaching to the test or even outright cheating.

3.6.1 Student Demographics

Table XXV describes the timing of changes in parental education and log household income for SIMCE test-takers using the same difference-in-differences approach used above but replacing SIMCE score with father's educational attainment (in years) in Column (1), with mother's educational attainment in Column (3), and with log household income in Column (5). Point estimates reveal that parental education levels increased significantly for socioeconomically disadvantaged test-takers (relative to their higher-

socioeconomic status counterparts) during the post-2007 period. In contrast, we find more limited convergence in log income between the start and end of the post-SEP period. The even-numbered columns of Table XXV re-estimate changes in parental education and household income in specifications that include school-by-year fixed effects. Estimates are similar to those in odd-numbered columns for parental education, suggesting that differences across schools do not account for the observed changes along these margins for tested students. Importantly, the finding that low-SES socio-demographic characteristics improve in relative terms both overall and within schools is consistent with our earlier finding that the majority of the test score gains made by low-SES students occur within schools.[32]

To assess the degree to which measured changes in the parental characteristics of test takers are driven by selective test taking versus genuine changes in the underlying distributions of parental characteristics, we employ nationally-representative data on maternal educational attainment from the Chilean Encuesta de Caracterización Socioeconómica Nacional (CASEN). We focus on maternal education since paternal education is only reported when the father is present in the household in the CASEN data (whereas it is reported regardless of household composition in the SIMCE). Using the

[32]Corresponding socio-demographic changes for priority students are presented in Appendix Table XXXVII. However, changes in rural residency status of priority students and in whether they rank among the lowest 40% of the population based on reported mother's education complicate year-on-year comparisons based on priority status.

CASEN, we categorise the 40% of 4th grade students with the lowest levels of maternal education in each year as low SES and then compare education differentials in the four years for which CASEN data are available (2006, 2009, 2011, and 2013). We calculate that average maternal education for low-SES students is 5.75 years lower than that of their high-SES counterparts in 2006 (the corresponding estimate from the SIMCE is 6.10 years). The CASEN-based gap declines by 0.07 years, 0.31 years and 0.29 years between 2006 and each of the three subsequent survey waves (all estimates are significant at the 1% confidence level). This suggests that roughly 50% of the observed convergence in the SIMCE data is attributable to selective test taking, while the remaining 50% appears to reflect genuine convergence in the maternal education distribution.

3.6.2 Strategic Behavior

The SEP program provides strong incentives to raise 4th-grade SIMCE scores, and this may lead schools to engage in strategic behaviors such as teaching to the test, selective test-taking or even cheating. An examination of low-stakes outcomes with respect to SEP, including GPA and 8th grade SIMCE scores, can provide context within which to interpret the patterns of 4th grade SIMCE scores. The GPA data can also be used to learn more about the degree of selective test-taking and its contribution to the closing of the 4th grade SIMCE score gap.

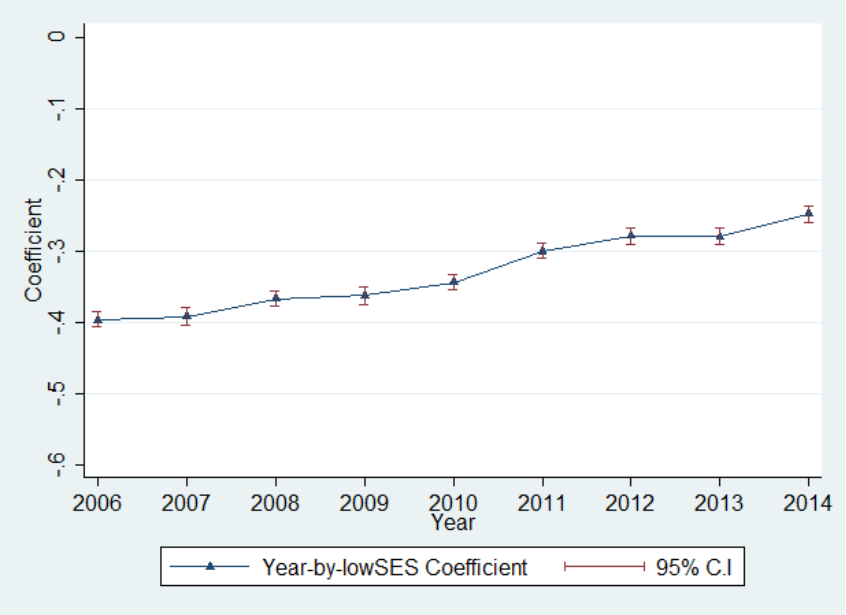
TABLE XXV: AVERAGE DEFICITS IN PARENTAL EDUCATION AND HOUSEHOLD INCOME FOR LOW-SES STUDENTS, BY YEAR

	(1) Father's Education (Years)	(2) Father's Education (Years)	(3) Mother's Education (Years)	(4) Mother's Education (Years)	(5) Log Household Income (Pesos)	(6) Log Household Income (Pesos)
LowSES	-4.27***	-2.29***	-6.15***	-5.05***	-0.93***	-0.36***
	(0.014)	(0.016)	(0.009)	(0.010)	(0.004)	(0.003)
LowSES ·2006	0.03	0.02	0.05***	0.04***	0.00	0.00
	(0.020)	(0.022)	(0.013)	(0.014)	(0.005)	(0.005)
LowSES ·2007	0.08***	0.05**	0.12***	0.12***	0.02***	0.01
	(0.021)	(0.024)	(0.014)	(0.015)	(0.005)	(0.005)
LowSES ·2008	0.02	0.06**	0.17***	0.21***	0.01**	0.01
	(0.021)	(0.023)	(0.014)	(0.014)	(0.005)	(0.005)
LowSES ·2009	0.05**	0.15***	0.27***	0.37***	-0.02***	0.00
	(0.023)	(0.025)	(0.015)	(0.015)	(0.005)	(0.005)
LowSES ·2010	0.17***	0.18***	0.39***	0.48***	0.00	0.01*
	(0.021)	(0.023)	(0.014)	(0.014)	(0.005)	(0.005)
LowSES ·2011	0.28***	0.26***	0.48***	0.60***	0.01	0.01**
	(0.021)	(0.023)	(0.015)	(0.015)	(0.005)	(0.005)
LowSES ·2012	0.39***	0.30***	0.58***	0.67***	0.03***	0.01***
	(0.021)	(0.023)	(0.015)	(0.015)	(0.005)	(0.005)
LowSES ·2013	0.44***	0.32***	0.64***	0.73***	0.06***	0.03***
	(0.021)	(0.023)	(0.015)	(0.015)	(0.005)	(0.005)
LowSES ·2014	0.57***	0.36***	0.87***	0.93***	0.12***	0.04***
	(0.021)	(0.023)	(0.015)	(0.015)	(0.005)	(0.005)
School-by-Year Fixed Effects		X		X		X
Observations	1,831,696	1,831,696	1,955,768	1,955,768	1,924,139	1,924,139

Notes: Robust standard errors are in parentheses and all specifications are estimated at the student-level and include year fixed effects. Low socioeconomic status is based on mother's years of education as measured by SIMCE parental surveys. All six columns include data from the years 2005-2014.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

Because of the difficulty interpreting between school and year differences in GPA, we focus on within school and year differences by SES, where GPA is normalised by school and year. Figure 14 shows GPA gains of 0.14 SD for disadvantaged students. This sizable gain reflects a convergence in academic performance, though it is somewhat smaller than the gain in 4th grade SIMCE scores. This may emanate from a greater focus on cognitive skills or teaching to the test in response to the high stakes placed on the 4th grade test.

Figure 14: Estimated GPA Deficits for Low-SES Students, by Year



Notes: The figure presents point estimates and confidence intervals constructed from a regression in which the dependent variable is the student's GPA (normalised at the school-by-year level). The included regressors are the full set of interactions between year and low-SES dummy variables as well as school-by-year fixed effects.

In order to learn more about the sources of the 4th grade test score gain, we next compare gains on the high-stakes 4th and lower-stakes 8th grade SIMCE tests for untreated and treated cohorts. Because only students in grades four and below were treated in 2008, the first treated cohort reached 8th grade in 2012. Therefore a comparison of 8th grade scores in 2011 (4th grade in 2007) with those in subsequent years illustrates test score changes following exposure to SEP, and differences between these changes and those experienced by the same students on the higher-stakes 4th grade SIMCE test provides evidence on the extent to which schools focused narrowly on those tests. In order to illuminate differences among grades, we restrict the sample to students who progress through school one grade per year and remain in the same school; relaxing these restrictions has virtually no effect on the estimates.

The pattern of gains in Table XXVI provides support for the notion that teaching to the test moderately inflated 4th grade SIMCE gains for low-SES students (Columns 1 to 4). Regardless of whether specifications include school-by-year fixed effects, the estimated gains made by either the 2009 or 2010 4th grade cohorts for which 8th grade scores are available are somewhat smaller for the 8th grade test than for the 4th grade test. In contrast, although the 8th grade deficit for SEP schools is larger for the pretreatment cohort than the 4th grade deficit (-0.31 versus -0.27), Columns (5) and (6) show that the gains for subsequent cohorts are at least as large on the 8th

grade test as on the 4th grade test.[33] In combination with the results for GPA, we conclude that 4th grade gains largely reflect real learning, rather than resulting primarily from increased teaching to the higher-stakes 4th grade SIMCE test.

TABLE XXVI: ESTIMATED FOURTH AND EIGHTH GRADE SIMCE TEST SCORE DEFICITS FOR LOW-SES CHILDREN AND CHILDREN IN SEP-PARTICIPATING SCHOOLS, BY YEAR OF FOURTH GRADE ATTENDANCE

	(1) SIMCE (Grade 4)	(2) SIMCE (Grade 8)	(3) SIMCE (Grade 4)	(4) SIMCE (Grade 8)	(5) SIMCE (Grade 4)	(6) SIMCE (Grade 8)
Disadvantaged (2007)	-0.540***	-0.536***	-0.185***	-0.179***	-0.272***	-0.314***
	(0.006)	(0.006)	(0.006)	(0.006)	(0.008)	(0.008)
Disadvantaged ·2009	0.005	0.009	0.021**	0.016*	0.007	0.037***
	(0.008)	(0.009)	(0.009)	(0.009)	(0.012)	(0.011)
Disadvantaged ·2010	0.068***	0.000	0.035***	0.016**	0.037***	0.021*
	(0.008)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)
Measure of Disadvantage	Low SES	Low SES	Low SES	Low SES	SEP School	SEP School
Grade 4 School-by-Year FE			X	X		
Additional Controls					X	X
Observations	285,985	285,985	285,985	285,985	258,664	258,664

Notes: Robust standard errors are presented in parentheses. All specifications are estimated at the student-level and year reflects year of fourth grade enrollment. The sample is restricted to students with non-missing fourth and eighth grade test scores who transitioned from fourth to eighth grade in four years and remained in the same school. Additional controls include interactions between year and each of the following: mother's years of education, father's years of education, and log household income.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

The much larger convergence in family background characteristics among test-takers than the population as a whole shown above suggests that selective test-taking contributed to the 4th grade gains, and we now make use

[33]To the extent that students' test score gains are a function of years of exposure to SEP, we would expect that 8th grade gains should be larger than 4th grade gains for post-treatment cohorts.

of the availability of GPA information for all students to examine the role of such selection. Because its impact depends upon changes in both the incidence and composition of students with missing tests, it is important to consider both. Therefore we use GPA information to impute missing SIMCE scores and estimate the contribution of missing scores to the closing of the gap. Importantly, information on SES is not available for those with missing scores. Therefore we use attendance at a public school as a proxy for low-SES status. The public-private school difference provides a noisy proxy for the difference by SES, but the comparison between trends based on all students and those based on students with non-missing scores will provide information on the contribution of missing data to the observed decline in the achievement gap. The first column in Table XXVII reports coefficients on interactions between public school and year from a linear probability model that regresses an indicator for missing score on year dummies, a public school dummy and their interactions. The coefficients show an increase in the missing rate in public schools relative to private schools following the SEP reform that ranges between three and six percentage points following the first year of the program. We next impute test scores for all students using school-specific estimates of the linear relationship between SIMCE score and GPA for those with non-missing scores (school-specific estimates are constructed using data from 2007, the year before the SEP reform). Changes over time in the achievement gap for the sample of students with non-missing scores can then be compared with changes for the full sample of students.

Column 2 reports coefficients on the interactions between public school and year dummies from a regression of SIMCE score on a public dummy, year dummies and their interactions for the sample of students with non-missing data, while Column 3 reports the same coefficients from a regression over all students that uses imputed SIMCE score as the dependent variable. A comparison of the coefficients in Column 2 with the smaller coefficients in Column 3 suggests that nearly half of the relative gains observed for public school students can be explained by changes in the composition of test-takers. This finding mirrors our earlier conclusion, based on a comparison of trends in family background characteristics using SIMCE and CASEN survey data, that roughly one-half of the observed convergence in background characteristics among SIMCE test-takers is explained by selective test-taking.

3.7 Conclusion

Although the SES-based fourth grade SIMCE test score gap decreased by roughly 0.2 standard deviations following the implementation of the SEP program, our analysis does not support the belief that the SEP program had a substantial impact on the corresponding school-quality gap. First, the bulk of the decline in the test score gap occurred within schools at a time when inequality within schools in family background declined substantially. Second, the limited information on family background appears to explain most of the test-score convergence between SEP-participating and non-participating

TABLE XXVII: DIFFERENCES IN THE RATE OF MISSING TEST SCORES AND ESTIMATED ACHIEVEMENT DEFICITS FOR STUDENTS IN PUBLIC SCHOOLS, BY TREATMENT OF MISSING SCORES AND YEAR

	(1) Missing SIMCE(0/1)	(2) Actual SIMCE	(3) Imputed SIMCE
Public School	0.03***	-0.46***	-0.48***
	(0.001)	(0.004)	(0.004)
Public School·2006	-0.00	0.02***	0.02***
	(0.002)	(0.005)	(0.005)
Public School·2007	-0.00***	-0.03***	-0.03***
	(0.001)	(0.005)	(0.005)
Public School·2008	0.01***	-0.03***	-0.03***
	(0.001)	(0.005)	(0.005)
Public School·2009	0.07***	-0.01**	-0.04***
	(0.002)	(0.005)	(0.005)
Public School·2010	0.02***	0.03***	-0.00
	(0.002)	(0.005)	(0.005)
Public School·2011	0.04***	0.10***	0.05***
	(0.002)	(0.005)	(0.005)
Public School·2012	0.03***	0.09***	0.05***
	(0.002)	(0.005)	(0.005)
Public School·2013	0.03***	0.08***	0.04***
	(0.002)	(0.005)	(0.005)
Public School·2014	0.06***	0.07***	0.03***
	(0.002)	(0.005)	(0.005)
Observations	2,541,194	2,185,871	2,425,129

Notes: Standard errors clustered at the school level are presented in parentheses. All specifications are estimated at the student level. All columns include data from the years 2005-2014. Imputed test scores in Column (3) are predicted for missing observations based on student GPA and a school-specific estimate of the linear relationship between GPA and test scores.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

schools. Moreover, neither increases in school expenditures, enhanced competition, nor school quality upgrading appear to explain much of the apparent gains for low-SES students.

The crucial questions for policy concern the lack of impact of the SEP reform. Specifically, it is critical to understand the relative importance of: (1) the lack of integrity of the policy implementation which caused the increase in validated school expenditures to be far smaller than the increase in revenues; and (2) the failure of the performance incentives to alter behavior in ways that improved the quality of instruction and learning for disadvantaged students.

Alternative explanations come to the forefront, and their divergent implications for policy highlights the importance of gaining a clear understanding of their contributions. First, program rules may have dampened the benefits. These include an initial prohibition on using the SEP funds to raise teacher salaries to attract and retain more effective educators. The adverse effects of these and other deficiencies in program structure may have been amplified by weak monitoring and enforcement.

Alternatively, it is possible that such a major reform requires time to take effect, as found in a study of Texas charter-school reforms (Baude et al., 2014). Consistent with this possibility, movement of low-SES children towards higher-quality schools does emerge at the end of the period. However, the limited market entry of new voucher schools serving low-income

areas even five years after program implementation raises doubts that the program will have a large effect over the longer-term. An alternative explanation emphasised in Feigenberg (2016) suggests that the market power enjoyed by schools in a system in which many parents seem unwilling or unable to respond to differences in school quality is likely to dampen the benefits of programs designed to raise school competition for disadvantaged children.

In sum, our findings indicate that the Chilean SEP experiment was not nearly as promising as it appears based on the convergence in 4th grade SIMCE scores and that additional evidence is needed on the question of whether targeted voucher policies can effectively serve those students most in need. Understanding the extent to which the price mechanism can be employed within educational markets like Chile's in order to mitigate adverse features of these markets remains an open question in the academic literature and one that is of first-order importance to educational policymakers who seek to identify interventions and policies that raise the quality of instruction for disadvantaged children including those that strengthen the positive forces of competition.

4 CONCLUSION

This dissertation studies the effect of school choices policies, with a focus on charter schools and school vouchers. To leverage competition to improve the quality of public education, school choice policies such as charter schools and school vouchers have experienced a rapid expansion both in the United States and worldwide (Cooper et al., 2018). This dissertation intends to comprehensively examine the effect of such policies and understand the consequential changes brought upon schools, teachers, and students.

This first chapter studies the effect of charter school competition on the cost efficiency of Michigan traditional public school districts, based on a case study of the 2011 Michigan cap-lifting policy. The policy initiated a three-stage roll-out plan for university-authorized charter schools in the state, eventually resulting in a great variation of charter competition by districts' proximity to HEIs. Evidence suggests the cap-lifting policy generally increases districts' percentage of expenditure on instructional employees. Facing charter competition, districts decrease their salary payment to non-instructional employees by 1.9 percentage points and the number of non-instructional employees per student by 0.001. Further analysis based on these estimates suggests that a great extent of the impact on districts' resource allocation is caused by policy-driven potential competition, while such a market-wide effect has been ignored in literature. This finding calls for caution in pre-

vious literature where potential competition has been commonly used as an instrument for actual competition, as it results in the violation of exclusion restriction and biased estimates.

The first chapter also provides evidence on charter schools' cream-skimming behaviors and sheds light on the long-term risk of disparity in education resources among students. The results show that charter competition leads to an increase in districts' share of ELL students, although other evidence suggests an attempt to reduce cost inefficiency. If actual charter competition leads to a disproportional increase in disadvantaged students among districts, such cost efficiency is hardly sustainable in the long term. Eventually, districts might face financial distress and thus struggle to provide high-quality education to public school students.

The second chapter of this dissertation studies the effect of a targeted school voucher program in Chile. In 2008, the Chilean government implemented a major reform in its existing voucher system to raise the value of school vouchers by 50% for students from the lowest socioeconomic status (SES) households. With this additional funding from low-SES enrollment, public and private schools participating in this program were required to decrease the achievement gap between SES groups. Literature shows that the SES-based fourth-grade SIMCE test score gap decreased by roughly 0.2 standard deviations following the implementation of the SEP program. But via an investigation in various channels that can attribute to students' academic

achievement, the study finds little evidence on change in school expenditure, competition, or quality. Instead, there is a significant change in students' family backgrounds where family inputs might explain the convergence of the achievement gap. The finding in this chapter also highlights the complex channels of school voucher programs where schools, students, and markets simultaneously change over time. Overall, this dissertation sheds light on controversial topics regarding the school choice policies and provide policy lessons intended to facilitate the design of such programs in the future.

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APPENDICIES

APPENDIX A. TABLES FOR CHAPTER ONE

TABLE XXVIII: AVERAGE SALARY PER DISTRICT EMPLOYEE I

	Log Value of Avg Salary		
	Per Teacher	Per Aid	Per Other Employee
	(1)	(2)	(3)
Panel A: Basic Difference-in-Differences			
Treat & Post	-0.005	-0.025	0.008
	(0.007)	(0.038)	(0.017)
Panel B: Dynamic Difference-in-Differences			
t = - 3	-0.006	-0.059	0.005
	(0.011)	(0.065)	(0.022)
t = - 2	-0.003	-0.011	-0.010
	(0.010)	(0.037)	(0.021)
t = -1	-0.001	0.015	0.003
	(0.008)	(0.024)	(0.015)
t = 1	-0.001	-0.072*	0.003
	(0.006)	(0.037)	(0.012)
t = 2	-0.006	-0.026	0.012
	(0.006)	(0.044)	(0.016)
t = 3	-0.016**	-0.017	0.006
	(0.007)	(0.050)	(0.019)
District Characteristics	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes
Observations	3668	3414	3604

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating thepost period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXIX: SENSITIVITY CHECK ON LOG OF SALARY ON INSTRUCTIONAL EMPLOYEES

	% Salary of Instructional Employees				
	(1)	(2)	(3)	(4)	(5)
Panel A: Basic Difference-in-Differences					
Treat & Post	-0.010	-0.010*	-0.002	-0.004	0.003
	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Panel B: Dynamic Difference-in-Differences					
t = - 3	0.016*	0.017**	0.004	0.013*	0.001
	(0.008)	(0.007)	(0.007)	(0.007)	(0.007)
t = - 2	0.011	0.012	0.001	0.009	-0.001
	(0.009)	(0.008)	(0.006)	(0.008)	(0.006)
t = -1	0.010	0.011*	0.006	0.009	0.004
	(0.006)	(0.007)	(0.006)	(0.006)	(0.006)
t = 1	0.004	0.005	0.003	0.004	0.003
	(0.007)	(0.008)	(0.006)	(0.008)	(0.006)
t = 2	0.002	0.003	0.004	0.008	0.009
	(0.006)	(0.007)	(0.006)	(0.007)	(0.006)
t = 3	-0.007	-0.008	-0.007	-0.000	-0.000
	(0.008)	(0.009)	(0.008)	(0.008)	(0.008)
District Characteristics	No	Yes	Yes	Yes	Yes
Property Tax	No	No	Yes	No	Yes
Funding Allowance	No	No	No	Yes	Yes
Adjusted R^2	0.180	0.385	0.442	0.574	0.622
Observations	3668	3668	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating thepost period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXX: SENSITIVITY CHECK ON LOG OF SALARY ON NON-INSTRUCTIONAL EMPLOYEES

	Log of Salary of Non-instructional Employees				
	(1)	(2)	(3)	(4)	(5)
Treat & Post	-0.044***	-0.039**	-0.027*	-0.030**	-0.019
	(0.016)	(0.015)	(0.015)	(0.015)	(0.015)
t = - 3	0.021	0.017	-0.002	0.012	-0.006
	(0.016)	(0.016)	(0.018)	(0.016)	(0.018)
t = - 2	0.019	0.015	-0.001	0.012	-0.003
	(0.014)	(0.014)	(0.016)	(0.014)	(0.016)
t = -1	0.017	0.015	0.007	0.012	0.004
	(0.014)	(0.015)	(0.016)	(0.015)	(0.017)
t = 1	-0.018	-0.017*	-0.019	-0.018*	-0.020
	(0.012)	(0.010)	(0.012)	(0.010)	(0.013)
t = 2	-0.028**	-0.024	-0.022	-0.017	-0.015
	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)
t = 3	-0.045***	-0.042***	-0.041***	-0.032**	-0.032**
	(0.015)	(0.016)	(0.015)	(0.015)	(0.015)
District Characteristics	No	Yes	Yes	Yes	Yes
Property Tax	No	No	Yes	No	Yes
Funding Allowance	No	No	No	Yes	Yes
Adjusted R^2	0.246	0.465	0.497	0.552	0.580
Observations	3668	3668	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating thepost period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXXI: SENSITIVITY CHECK ON TEACHER-STUDENT RATIO

	Teacher-student ratio				
	(1)	(2)	(3)	(4)	(5)
Treat & Post	0.000	0.000	0.000	0.000	0.000
	(0.0003)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
t = - 3	0.001**	0.001**	0.001*	0.001*	0.001
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
t = - 2	0.001*	0.001	0.000	0.000	0.000
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
t = -1	0.000	0.000	0.000	0.000	0.000
	(0.0003)	(0.0004)	(0.0004)	(0.0003)	(0.0004)
t = 1	0.000	0.000	0.000	0.000	0.000
	(0.0003)	(0.0003)	(0.0003)	(0.0003)	(0.0003)
t = 2	0.001*	0.001*	0.001*	0.001**	0.001**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
t = 3	0.001*	0.001	0.001	0.001*	0.001**
	(0.0004)	(0.0004)	(0.0004)	(0.0004)	(0.0004)
District Characteristics	No	Yes	Yes	Yes	Yes
Property Tax	No	No	Yes	No	Yes
Funding Allowance	No	No	No	Yes	Yes
Adjusted R^2	0.014	0.221	0.225	0.298	0.300
Observations	3668	3668	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating thepost period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXXII: SENSITIVITY CHECK ON OTHER-EMPLOYEE-STUDENT RATIO

	Other-employee to student ratio				
	(1)	(2)	(3)	(4)	(5)
Treat & Post	-0.002**	-0.002**	-0.002**	-0.002**	-0.001**
	(0.0008)	(0.0009)	(0.0008)	(0.0008)	(0.0007)
t = - 3	0.000	0.000	-0.000	-0.000	-0.001
	(0.0012)	(0.0012)	(0.0010)	(0.0012)	(0.0010)
t = - 2	0.000	0.000	-0.000	0.000	-0.000
	(0.0010)	(0.0011)	(0.0008)	(0.0010)	(0.0008)
t = -1	0.001	0.001	0.000	0.001	0.000
	(0.0007)	(0.0009)	(0.0007)	(0.0008)	(0.0007)
t = 1	-0.001*	-0.001*	-0.001*	-0.001**	-0.001*
	(0.0006)	(0.0006)	(0.0006)	(0.0006)	(0.0006)
t = 2	-0.002**	-0.002*	-0.001*	-0.001*	-0.001*
	(0.0007)	(0.0008)	(0.0008)	(0.0008)	(0.0008)
t = 3	-0.002**	-0.003**	-0.002**	-0.002**	-0.002**
	(0.0012)	(0.0012)	(0.0012)	(0.0012)	(0.0011)
District Characteristics	No	Yes	Yes	Yes	Yes
Property Tax	No	No	Yes	No	Yes
Funding Allowance	No	No	No	Yes	Yes
Adjusted R^2	0.030	0.147	0.159	0.170	0.181
Observations	3668	3668	3668	3668	3668

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating thepost period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXXIII: AVERAGE SALARY PER DISTRICT EMPLOYEE II

	Log Value of Avg Salary		
	Per Teacher	Per Aid	Per Other Employee
	(1)	(2)	(3)
Panel A: Entry of New University-authorized Charters			
Potential	-0.011	-0.050	-0.018
	(0.0074)	(0.0448)	(0.0202)
Actual	0.013	0.058	0.058**
	(0.0156)	(0.0486)	(0.0284)
Panel B: Number of University-authorized Charters			
Potential	-0.003	-0.037	-0.014
	(0.0074)	(0.0396)	(0.0173)
Number of Charter Schools	-0.001	0.005	0.006*
	(0.0015)	(0.0045)	(0.0037)
Panel C: Log of Enrollment in University-authorized Charters			
Potential	-0.006	-0.024	0.003
	(0.0068)	(0.0387)	(0.0175)
Charter Enrollment	0.006***	0.002	0.011***
	(0.0016)	(0.0052)	(0.0042)
District Characteristics	Yes	Yes	Yes
Property Tax	Yes	Yes	Yes
Funding Allowance	Yes	Yes	Yes
Observations	3668	3414	3604

Notes: Standard errors in parenthesis are clustered at the district level. All regressions are weighted by enrollment. Observations are district-years. Each column reports results from a separate regression. All basic DID models are based on equation 1 with a dummy variable indicating thepost period and a dummy variable indicating the treatment group. All dynamic DID models are based on equation 2 with a fully saturated year dummy, a dummy variable of the treatment group, and interaction terms for the treatment group and a series of years. District characteristics include percentages of students eligible for free or reduced lunch program, black students, Hispanic students, white students, and a dummy variable of being located in city or city fringe. Property tax is the log value of districts' local revenue from property tax, adjusted by the 2008 inflation rate. The funding allowance is a time-varying base rate per student specified by the state of Michigan for each district.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

APPENDIX B. TABLES FOR CHAPTER TWO

TABLE XXXIV: RDD SPECIFICATION CHECKS AND ESTIMATED EFFECTS OF SEP FUNDING ON SIMCE SCORES BY PRIORITY STATUS (2010-2011)

	(1)	(2)	(3)	(4)	(5)
	SEP School Students		Priority Students		
	SIMCE Score	Mother's Education (Years)	SIMCE Score	Mother's Education (Years)	Density Test
Threshold 1	-0.010	0.703*	0.140	1.764**	0.230
	(0.099)	(0.406)	(0.223)	(0.822)	*(0.41)*
Threshold 2	-0.022	-0.185	-0.027	0.155	0.016
	(0.117)	(0.265)	(0.119)	(0.174)	*(0.88)*
Threshold 3	0.033	-0.037	0.029	0.182	0.024
	(0.059)	(0.156)	(0.063)	(0.124)	*(0.74)*
Threshold 4	-0.061	-0.036	0.018	0.004	0.125
	(0.075)	(0.135)	(0.042)	(0.114)	*(0.02)*
Observations	227,372	208,093	104,921	95,232	12,551

Notes: The dependent variable in Columns (1), (3) is the student's normalised fourth grade test score (normalised by 2005 mean and standard deviation) and the dependent variable in Columns (2), (4) is mother's years of education. Columns (1)-(4) specifications are estimated at the student level and include data from the years 2010-2011. Each threshold refers to a given Concentration Bonus discontinuity. Specifications in Columns (1)-(4) are estimated separately for each threshold and include a local linear polynomial in Priority share that is estimated separately on each side of the relevant concentration formula threshold. For each regression estimated in Columns (1)-(4), the sample is limited to include schools with a Priority share within 0.075 of the cutoff and standard errors are clustered on the running variable. Column (5) presents discontinuity estimates and corresponding p-values from school-level tests for manipulation (i.e. bunching) around each cutoff.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXXV: ESTIMATED DIFFERENCES IN CLASS SIZE AND TEACHER CHARACTERISTICS FOR LOW-SES STUDENTS, BY YEAR

	(1)	(2)	(3)	(4)	(5)	(6)
	Percentage of Teachers with:					
	College Degree	$\leq$ 1 Year Experience	$\leq$ 20 Contract Hours	Employment in Multiple Schools	Class Size (# Students)	Class Size (# Students)
LowSES	-0.013***	-0.013***	-0.020***	0.001	-3.189***	-1.154***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.130)	(0.130)
LowSES ·2006	-0.001	0.001	0.005***	-0.001	0.063	0.044
	(0.001)	(0.002)	(0.001)	(0.002)	(0.103)	(0.099)
LowSES ·2007	-0.002	-0.004*	0.007***	0.005**	0.167	0.109
	(0.002)	(0.002)	(0.002)	(0.002)	(0.123)	(0.119)
LowSES ·2008	0.001	0.008***	0.009***	0.008***	0.140	-0.026
	(0.001)	(0.002)	(0.002)	(0.002)	(0.114)	(0.111)
LowSES ·2009	0.000	0.018***	0.013***	0.010***	0.207*	-0.082
	(0.002)	(0.002)	(0.002)	(0.002)	(0.120)	(0.117)
LowSES ·2010	-0.001	0.011***	0.016***	0.010***	0.424***	0.052
	(0.002)	(0.002)	(0.002)	(0.002)	(0.121)	(0.118)
LowSES ·2011	-0.001	0.005	0.020***	0.010***	0.431***	-0.092
	(0.002)	(0.003)	(0.002)	(0.002)	(0.128)	(0.128)
LowSES ·2012	0.000	0.009***	0.024***	0.013***	0.461***	-0.083
	(0.002)	(0.003)	(0.002)	(0.002)	(0.128)	(0.132)
LowSES ·2013	0.002	0.023***	0.027***	0.015***	0.560***	-0.091
	(0.002)	(0.003)	(0.002)	(0.002)	(0.129)	(0.131)
LowSES ·2014	-0.001	0.020***	0.023***	0.009***	0.915***	0.011
	(0.002)	(0.003)	(0.002)	(0.002)	(0.135)	(0.132)
Rural-by-Year Fixed Effects						X
Observations	1,931,971	1,937,236	1,937,236	1,937,236	1,887,014	1,887,014

Notes: Standard errors are clustered at the school level and shown in parentheses. All specifications are estimated at the student-level and include data from the years 2005-2014 as well as year fixed effects. Low socioeconomic status is based on mother's years of education as measured by SIMCE parental surveys.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXXVI: ESTIMATED ACHIEVEMENT DEFICITS FOR LOW-SES STUDENTS, BY MEASURE OF SCHOOL COMPETITION, GENDER-SPECIFIC INTENSITY OF SCHOOL COMPETITION AND YEAR

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Herfindahl Index (2005 School Choice)		Herfindahl Index (2014 School Choice)		Δ Herfindahl Index (Male)		Δ Herfindahl Index (Female)	
	Below Median	Above Median	Below Median	Above Median	Below Median	Above Median	Below Median	Above Median
LowSES	-0.643***	-0.587***	-0.642***	-0.588***	-0.607***	-0.631***	-0.621***	-0.613***
	(0.006)	(0.005)	(0.006)	(0.005)	(0.008)	(0.008)	(0.007)	(0.008)
LowSES·2006	-0.003	0.010	-0.007	0.015**				
	(0.008)	(0.007)	(0.008)	(0.007)				
LowSES·2007	-0.009	0.016*	-0.004	0.013	0.002	-0.004	-0.006	0.032***
	(0.009)	(0.008)	(0.009)	(0.008)	(0.012)	(0.012)	(0.011)	(0.011)
LowSES·2008	0.017**	0.042***	0.015*	0.044***	0.009	0.044***	0.023**	0.060***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
LowSES·2009	0.022**	0.033***	0.024***	0.029***	0.019	0.028**	0.017	0.055***
	(0.009)	(0.008)	(0.009)	(0.008)	(0.012)	(0.012)	(0.011)	(0.011)
LowSES·2010	0.099***	0.080***	0.100***	0.083***	0.081***	0.086***	0.077***	0.128***
	(0.008)	(0.007)	(0.008)	(0.007)	(0.011)	(0.011)	(0.010)	(0.011)
LowSES·2011	0.172***	0.157***	0.177***	0.154***	0.155***	0.175***	0.148***	0.194***
	(0.008)	(0.007)	(0.008)	(0.007)	(0.011)	(0.011)	(0.010)	(0.011)
LowSES·2012	0.197***	0.161***	0.202***	0.157***	0.169***	0.174***	0.185***	0.198***
	(0.008)	(0.007)	(0.008)	(0.007)	(0.011)	(0.011)	(0.011)	(0.011)
LowSES·2013	0.200***	0.168***	0.203***	0.169***	0.171***	0.195***	0.178***	0.202***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
LowSES·2014	0.225***	0.193***	0.231***	0.191***	0.200***	0.218***	0.192***	0.234***
	(0.008)	(0.008)	(0.008)	(0.008)	(0.011)	(0.011)	(0.011)	(0.011)
Observations	972,037	983,671	975,470	979,812	446,127	417,101	452,103	405,989

Notes: Robust standard errors are in parentheses and all specifications are estimated at the student-level. The dependent variable is the student's normalised fourth grade test score (normalised by 2005 mean and standard deviation). In Columns 1-2, the Herfindahl Index is calculated at the municipality-level in 2005 and in Columns 3-4, the Herfindahl Index is calculated at the municipality-level in 2014. In Columns 5-8, Δ Herfindahl Index is calculated as the difference between the 2014 municipality-level index and the 2005 municipality-level index, separately by gender (including only male students in Columns 5-6 and only female students in Columns 7-8). Student gender is nearly always missing in 2006, so gender-specific specifications exclude this year. Low socioeconomic status is based on mother's years of education as measured by SIMCE parental surveys in 2005-2014.

* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

TABLE XXXVII: AVERAGE DIFFERENCES IN PARENTAL, STUDENT, AND SCHOOL CHARACTERISTICS FOR PRIORITY STUDENTS, BY YEAR

	(1) Father's Education (Years)	(2) Father's Education (Years)	(3) Mother's Education (Years)	(4) Mother's Education (Years)	(5) Log Household Income (Pesos)	(6) Log Household Income (Pesos)	(7) LowSES	(8) Attend Rural School
Priority	-3.32***	-1.26***	-3.26***	-1.37***	-0.89***	-0.35***	0.38***	0.15***
	(0.017)	(0.018)	(0.016)	(0.017)	(0.004)	(0.004)	(0.002)	(0.002)
Priority ·2009	0.19***	0.27***	0.22***	0.27***	-0.03***	-0.00	-0.04***	-0.03***
	(0.025)	(0.026)	(0.023)	(0.024)	(0.005)	(0.005)	(0.003)	(0.002)
Priority ·2010	0.43***	0.34***	0.40***	0.30***	0.02***	0.02***	-0.06***	-0.04***
	(0.024)	(0.024)	(0.022)	(0.022)	(0.005)	(0.005)	(0.003)	(0.002)
Priority ·2011	0.52***	0.34***	0.61***	0.47***	0.03***	0.02***	-0.09***	-0.05***
	(0.024)	(0.024)	(0.022)	(0.023)	(0.005)	(0.005)	(0.003)	(0.002)
Priority ·2012	0.68***	0.47***	0.68***	0.49***	0.07***	0.05***	-0.10***	-0.05***
	(0.024)	(0.024)	(0.022)	(0.023)	(0.005)	(0.005)	(0.003)	(0.002)
Priority ·2013	0.37***	0.32***	0.39***	0.32***	0.01	0.03***	-0.08***	-0.05***
	(0.024)	(0.025)	(0.022)	(0.023)	(0.005)	(0.005)	(0.003)	(0.002)
Priority ·2014	0.63***	0.47***	0.68***	0.50***	0.10***	0.07***	-0.11***	-0.07***
	(0.024)	(0.024)	(0.022)	(0.023)	(0.005)	(0.005)	(0.003)	(0.002)
School-by-Year Fixed Effects		X		X		X		
Observations	1,257,482	1,257,482	1,325,749	1,325,749	1,357,199	1,357,199	1,325,749	1,508,682

Notes: Robust standard errors are in parentheses and all specifications are estimated at the student-level and include year fixed effects. Priority student status is determined by the Ministry of Education for the years 2008-2014.
* significant at 10 percent level ** significant at 5 percent level *** significant at 1 percent level.

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Working Papers

"Charter Competition and Traditional Public School Districts' Resource Allocation: Evidence from Michigan Charter School Cap-lifting" (2019)

"Illusory Gains from Chile's Targeted School Voucher Experiment" with Benjamin Feigenberg and Steven Rivkin, The Economic Journal (2019, October)

"The Long-Term Effect of Fertility Choice on American Parents' Financial and Health Outcomes" (2018)

Research Experience

Graduate Research Assistant 2014 - 2016
Advised by Benjamin Feigenberg and Steven Rivkin, University of Illinois at Chicago
Research Assistant 2011 - 2013
Advised by Xianyu Wu and Alice Y. Ouyang, Central University of Finance and Economics

Professional Experience

Summer Intern PricewaterhouseCoopers Zhong Tian LLP 2011

Teaching Experience

Teaching Assistant 2013 - 2019

Development economics(graduate)

Environmental Economics(undergraduate)

Introduction to Urban Real Estate(undergraduate)

Econometrics (undergraduate)

Behavioral Economics (undergraduate)

Principle of Macroeconomics (undergraduate)

Presentations, Conferences, & Workshops

Illinois Economics Association Annual Conference, 2018

University of Illinois at Chicago Econ Active Research Lunch, 2018

$\hat{E}$STIMATE Econometrics Workshop, Michigan State University, 2017
University of Illinois at Chicago Econ Active Research Lunch, 2016

Awards & Achievements

Travel Award for $\hat{E}$STIMATE Econometrics Workshop, University of Illinois at Chicago, 2017

Academic Excellence Scholarship, Central University of Finance and Economics, 2011

Miscellaneous

Skills: Stata, Python, ArcGIS, R, LaTeX, SQL, Linux, SPSS.

Languages: English, Mandarin.