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Abstract
With the passing of the No Child Left Behind Act (NCLB) has come a wave of economic analyses of education production functions attempting to explain what community and school characteristics affect achievement gaps and yearly growth in pass rates. Using standardized test data from the Illinois State Board of Education over the period of NCLB, I argue that there are ways to empirically re-define growth and student success that more effectively capture NCLB's goals. The results in this paper show inherent differences between the three growth definitions employed and the educational experiences in the grades analyzed.

Keywords
education production function, pass rate growth in Illinois school districts

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An Analysis of Student Achievement and Measures of Growth under *No Child Left Behind*

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May 2015

Abstract: With the passing of the No Child Left Behind Act (NCLB) has come a wave of economic analyses of education production functions attempting to explain what factors affect pass rates and achievement gaps. Recent legislation has also placed an increased emphasis on growth in pass rates from year to year. This paper will examine the extent to which school and community characteristics affect growth in student performance in reading and math in grades 3, 8, and 11 from 2003 to 2012. Using standardized test data from the Illinois State Board of Education over the period of No Child Left Behind, I argue that there are ways to empirically re-define growth and student success that more effectively capture NCLB's goals. The results show that there are inherent differences between the three growth definitions employed in this paper. The results also show that there are inherent differences between grades 3 and 8 and grade 11 – in particular, several community characteristics have reversed effects in grade 11 from in grades 3 and 8.

Keywords: education production function; pass rate growth in Illinois school districts

JEL Classification Codes: H75, I21, I28

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I. Introduction

The No Child Left Behind Act of 2001 is the most recent impactful piece of federal legislation to set a precedent for measuring student success through test scores. Due to the culture of high-stakes testing that has emerged out of a federal emphasis on student achievement, great stress has been placed on standardized testing and growth in test scores, which is the most common metric for student improvement. In the eyes of many educators, political organizations, and even legislators, this has caused serious repercussions for the American system of public education.

Just as student performance has become a prevalent topic in the conversation surrounding education, so, too, have its potential determinants. There exists a very broad literature pertaining to determinants of student achievement. Most believe that a combination of community and school district characteristics contribute to a student's educational performance. Thus, there have been numerous studies aimed at estimating the education production function using an assortment of community characteristics, such as indicators of socio-economic status and the racial makeup of the community, and school characteristics such as expenditures and curricular minutes of instruction. Generally, the output variable in functions of this kind is some measure of educational performance. This paper contributes to the literature on the education production function by using growth in educational performance as the output variable in weighted least squares regressions using data from the Illinois State Board of Education.

When choosing a metric to represent student learning in a school district, one that immediately comes to mind is growth in the percentage of students who meet or exceed standards, known for the duration of this paper as the "pass rate." Though this variable certainly does indicate improvement over time, I argue that there are other empirical definitions of improvement that can be implemented in order to effectively capture the intentions of federal legislation such as No Child Left Behind. Through the above analyses, I hope to answer the question of how growth should be measured to assess educational progress when using district-level pass rates on standardized tests.

The remainder of the paper is organized as follows. Section II details aspects of the No Child Left Behind Act and various econometric studies of determinants of student educational outcomes. Section III outlines the various definitions of growth and variables used in regressions. Sections IV, V summarize identification strategy and results, with concluding remarks in Section V.

II. Review of Literature

A. No Child Left Behind

In January of 2002, President George W. Bush enacted Public Law 107-110, known as the No Child Left Behind Act (NCLB), in order "to ensure that all children have a fair, equal, and significant opportunity to obtain a high-quality education and reach, at a minimum, proficiency on challenging State academic achievement standards and state academic assessments." The Act aimed to do so through creating and enforcing more demanding state standards aligned with "high-quality academic assessments [and] accountability systems…so that students, parents, and administrators can measure progress against common expectations for student academic achievement" (NCLB pp. 15-16). Among NCLB's many goals was also the goal of "closing the achievement gap between high- and low-performing children, especially the achievement gaps between minority and nonminority students, and between disadvantaged children and their more advantaged peers," a goal that has been at the forefront of federal educational legislation for the last half century.

Among the many statutes implemented by NCLB was the notion of "adequate yearly progress," or AYP, by which yearly student improvement was to be measured. Under NCLB, AYP is defined by individual states in a way that would capture the standards enacted, result in "continuous and substantial academic improvement for all students," and measure improvement "based primarily on the academic assessments" administered by state governments (NCLB pg. 22). Each state was then to establish a timeline for AYP that would "ensure that not 12 years after the end of the 2001-2002 school year, all students" in elementary and secondary schools, including those with disabilities, those with limited English proficiency, those who are economically disadvantaged, and those from major racial and ethnic groups must meet or exceed the proficient levels of achievement that states set (NCLB, pg. 23). AYP requirements are typically measured through standardized tests, and failure to meet these requirements by the deadlines would result in the Secretary of Education withholding funds from the state.

There has been widespread opposition to the enactment of NCLB from various sources, and for many reasons. Some oppose the concept of high-stakes testing, in which so much rides on performance on a yearly exam (Guisbond & Neill, 2004; Karp, 2003). There is also some belief that improvement and success is not accurately captured through AYP, and that there are other metrics that can more effectively measure them (Guisbond & Neill, 2004). There has also been much speculation as to how to best get students to reach the high-reaching goals of NCLB from teacher's unions and education agencies. More unease relates to concerns about teaching to the test, inaccurately using AYP to reflect school quality, and the possibility that schools would focus solely on students who are close to achieving minimum requirements on standardized tests, thereby still leaving students behind (Bruning, 2006; Bryant et. al, 2008; Chambers, 2009; Choi et. al, 2007; Guisbond & Neill, 2004; Price, 2010).

B. The Education Production Function

The education production function has been an established interest for economists in concurrence with federal interest in educational reform. In particular, economists have attempted over the years to understand what factors, and at what magnitudes, determine student performance.

Empirical estimates of the education production function commonly include a combination of both school factors and community factors. School factors usually consist of variables like instructional expenditures, teacher experience, teacher education, class size, minutes of instruction, and mobility rates. Community factors include racial makeup of the student body and indicators of socio-economic status, such as average household income or the percent of students who receive free or reduced lunch (Boggess, 1998; Hanushek, 1986; Ferguson and Ladd, 1996; Krueger, 1999; Coates, 2003; Kinnucan, et al. 2006; Balfanz et. al, 2007; Neal and Schanzenbach, 2007; Sander 1993).

Much research over the past decade has been conducted in an attempt to evaluate the effects of NCLB through the lens of an education production function. For example, Price (2010) analyzed whether NCLB's labeling process accurately captures school quality through alternative measures of school quality, standardized testing results, and subgroup test failure. For further examples, see Borg et. al (2007), Neal and Schanzenbach (2007), Steifel et. al. (2007), Dee and Jacob (2011), and Kinnucan, Smith, Zheng and Llanes (2012).

There is plenty of research that indicates little to no relationship between school qualities and student success, and plenty of research that indicates a very significant relationship (Hanushek, 1986; Card and Krueger, 1992; Campbell and Lopez, 2008; Kane et. al, 2010). Economists have tirelessly attempted to estimate a production function that captures relevant determinants of student and school performance. This paper follows the literature by incorporating common school variables such as minutes of instruction, teacher quality, per pupil expenditures, and mobility rates when estimating production functions. Common community characteristics are expressed through variables indicating socioeconomic status (SES), which are seen as the strongest predictor of educational outcomes, along with the racial makeup of the population (Coleman, 1966).

Educational attainment of the adult population is one variable that has rarely been featured as a SES indicator by researchers. However, Gyimah-Brempong and Gyapong (1991) show that the local level of adult educational attainment does play an important role in estimating the relationship between SES characteristics and student performance. It would seem that communities consisting of adults with high levels of educational attainment would encourage their children to aim for high levels of educational attainment and academic achievement as well. Therefore, this variable should be an appropriate component of the education production function, and is included in regressions in this study.

There are a few common output variables used in the education production function. Much of the literature aims to estimate the effects of characteristics on either test scores or pass rates (Lemke, Hoerandner and McMahon, 2006; Primont and Domazlicky, 2006; Flaherty 2013). Some also aim to do so on the achievement gap itself (Chung and Konstantopoulos, 2009). There is a section of the literature that estimates the effects of characteristics on growth in pass rates or test scores (Driscoll, Halcoussis and Svorny, 2006). Some economists question whether test scores are the best measure of student achievement, and use other metrics, such as high school graduation rates, as a reflection of educational output (Boggess, 1998; Goldin, 1998; Chen, 2013; Heckman and LaFonatine, 2012; Iatarola and Reubenstein, 2007; Murnane, 2013). This paper focuses on growth in pass rates. The measures of growth used are explained more fully in the following data section.

III. Data

The analyses in this paper use data from Illinois public school districts of all types (i.e. elementary, middle school, high school, and unit). The data comes from the Illinois State Board of Education (ISBE) for the 2002-2003 and 2011-2012 school years. The ISBE assesses Illinois students using two different standardized tests: the Illinois State Achievement Test (ISAT) and the Prairie State Achievement Examination (PSAE). The ISAT is administered to students in grades 3 through 8, while the PSAE is given to students in grade11. The ISAT tests reading and mathematics in grades 3 through 8 and tests science in grades 4 and 7 (ISBE website). The PSAE includes the ACT plus Writing (for which a student could choose to submit his/her score to colleges), a science assessment developed by the ISBE, and two sections in Reading for Information and Applied Mathematics (ISBE website). Both exams are administered to students in the spring of the academic year. In this paper, I analyze performance on the reading and mathematics sections of the ISAT for third and eighth graders, and of the PSAE for eleventh graders.

Data for this paper was assembled from a few sources. The first is the Illinois State Report Cards for the 2002-2003 and 2011-2012 school years, which the Illinois State Board of Education produced under mandate from NCLB. The second is the United States Census Bureau's American Community Survey, which provides a five-year estimate from 2008 for the percent of adults in each school district with a bachelor's degree (from now on referred to as the local BA rate). While most of the data reported in the Illinois state report cards is given at the state, district, and school level, expenditure data is only given at the state and district level. Due to this, and because the local BA rate is also given at the district level, I found a district-level analysis most appropriate.

This analysis uses data from every district in Illinois in the 2002-2003 and 2011-2012 school years, with a few exceptions. Most notably, the Chicago Public School (CPS) district is not included. The CPS is much larger than any other district in Illinois, as over twenty percent of Illinois' population resides in Chicago. Also, the demographic information about the residents of the district makes it very different from every other district in Illinois, and the presence of these differences make it logical not to include CPS in the analyses in this paper.

For various reasons, a handful of school districts closed or were created over the period in question. Sometimes districts merged or consolidated with others; other times, districts that closed were not replaced at all. Those districts in the latter category are not included in this analysis. Of the districts that closed, only those that existed in 2003 and could be traced to a district that existed in 2012 were included.

After excluding the various categories of districts as noted above, and outlying districts with extremely small (under 100) or large (over 100,000) enrollments, there are 758 districts remaining to analyze. 320 of these are elementary districts that serve kindergarten through eighth grade; 93 are high school districts; and 345 are unit districts that serve kindergarten through twelfth grade. In total, 114 districts are located in rural areas, 621 in suburban areas, and 23 are in major metropolitan areas (excluding Chicago). There is potential that the school districts that closed over the period had relatively low pass rates, which could lead to a biased selection of districts. However, this does not appear to be the case, since the average pass rates of the full sample and the sample excluding the aforementioned districts show little differences.

The most commonly used measure of AYP is the percent of students in a district who meet or exceed state-determined standards (i.e. the district's pass rate). Illinois State Report Cards categorize test scores into four categories: exceeds standards, meets standards, below standards, or academic warning. The former two groups signify "passing the test," while the latter two denote "failing the test." The pass rate, therefore, reflects the percent of students who "pass the test." This paper reports pass rate data for the entire student body, and the white, black, and Hispanic subgroups.

According to NCLB, states determine an "*n* size," or a threshold for the number of students in various subgroups that would require districts to incorporate them into their data. The worry was that calculating AYP for very small groups could fluctuate and therefore be unreliable due to changes in student composition every year. Most states used an *n* size of 30 to 40 students as a minimum threshold for factoring subgroups into AYP calculations. The *n* size in Illinois during the period in question was 45 students (Dept of Ed Accountability under NCLB: Final Report). Thus, in Illinois, 137 and 155 districts were required to report results for their black and Hispanic students in grade 3 respectively in both years. Likewise, 140 and 142 districts reported grade 8 test results for their black and Hispanic students respectively, while 86 and 94 districts reported grade 11 test results for their black and Hispanic students respectively. Overall, pass rates for Illinois school districts increased for all students from 2002-2003 to 2011-2012, and for white, black, and Hispanic subgroups of students in reading and math in grades 3 and 8. The pass rates decreased in grade 11 for all students and all subgroups except for Hispanic students in math. Table 1 displays all of these trends.

Additional trends also emerge from this data. In general, pass rates for white students in both 2003 and 2012 exceeded those for black and Hispanic students. Although the pass rates of the black and Hispanic subgroups never exceed those of the white students, the black and Hispanic subgroups typically experience greater margins of change in pass rates.

In order to confirm that the 2012 pass rates are statistically different from those in 2003, I conducted paired t-tests on the pass rates for both years. Reading and mathematics pass rates are different with 1 percent statistical significance in 2012 from their 2003 values in all races, grade levels, and subjects, except for grade 11 white students in math and grade 11 Hispanic students in reading (see Table 1).

Along with closing the achievement gap between subsets of students, an objective of NCLB was to improve educational output for all students, ideally to 100 percent proficiency on standardized tests in all districts. Thus, although Table 1 includes pass rates in 2003 and 2012, the analysis in the paper is primarily focused on *growth* in those pass rates. The existence of growth in student performance, reflected by growth in pass rates, more consistently follows the objectives of NCLB, and is thus the metric under analysis here. The question that remains, though, is how to most effectively define growth while staying true to the ideals of NCLB.

One measure that arises intuitively out of the concept of defining growth is approximation of the raw gap, defined as a district's pass rate in 2012 less its pass rate in 2003. However, this metric may not tell the full story of a district's pass rate growth.

To illustrate this, consider, for example, three suburban elementary districts in Illinois. Ford Heights School District began in 2003 with a 24.6 percent reading pass rate and increased to an 81.8 percent pass rate in 2012. Chicago Ridge School District began with a 59.3 percent reading pass rate that increased to 75 percent. Winnetka School District began with a 94.6 percent reading pass rate that increased to 99.5 percent. By solely using the raw gap to illustrate growth, Ford Heights would seem to have demonstrated the most growth over the period of NCLB, with a 57.2 percentage-point margin of pass rate growth, while Chicago Ridge and Winnetka only experienced respective 15.7 and 4.9 percentage point increases. However, though the margins of growth for Ford Heights and Chicago Ridge exceed that of Winnetka, Winnetka ended the period closest to 100-percent proficiency. Considering NCLB's overarching goal of having every district proficient by the end of the period, Winnetka should therefore have favorable progress compared to the other two in the eyes of NCLB. Furthermore, if the margin of growth is deemed the only metric of value, then Winnetka would be viewed unfavorably against these other districts since it simply had less room to grow than the other two. In terms of AYP, there just isn't much more progress to be made once a school has reached 99.5 percent passing. Due to situations like this, other metrics of growth are necessary in order to reflect progress that accounts for where district pass rates started in 2003 and ended in 2012, rather than their raw growth, which does not illustrate the entire story.

In order to account for this and to provide alternative ways to best measure growth in order to assess progress on standardized tests, this paper employs two additional measures of growth in addition to the raw gap: the percentage of the gap closed, and the percent gain from 2003. Thus, we have the following summary of measures of growth:

(1) $$\text{Raw Growth} = \text{Pass Rate}_{2012} - \text{Pass Rate}_{2003}$$

(2) $$\text{Percent Gain} = \frac{\text{Pass Rate}_{2012} - \text{Pass Rate}_{2003}}{\text{Pass Rate}_{2003}} \times 100$$

(3) $$\text{Percent Gap Closed} = \frac{\text{Pass Rate}_{2012} - \text{Pass Rate}_{2003}}{100 - \text{Pass Rate}_{2003}} \times 100$$

The above measures reflect, in their own ways, progress relative to where district pass rates started at the beginning of the period and can shed more light on improvement than just the raw gap.

In addition to raw pass rates, Table 1 displays the district averages for the above measures of growth in both reading and math for grades 3, 8, and 11. The table displays these measures for all races, and for the white, black, and Hispanic cohorts. For example, as shown in Table 1, the reading grade 3 black pass rate was 46.87 percent in 2003 and 67 percent in 2012. The pass rate grew by 19.85 percentage points from 2003 to 2012, as shown in the "Grow" column, resulting in a percentage gain of 53.61 percent ("Gain" column) and 34.82 percent of the gap closed ("Gap" column). Generally, these measures are positive for all grades, and subjects in third and eighth grade, indicating student improvement over the period of NCLB. Contrarily, with the exception of Hispanic students in grade 11 mathematics, grade 11 pass rates move in the opposite direction for all races and subjects, showing decreasing pass rates by at the least 0.14 percentage points (white grade 11 math) and at the most 8.29 percentage points (black grade 11 reading). That grade 11 behaves in an opposite fashion to grades 3 and 8 is an interesting result, and one that leaves the question of what is so different about grade 11. I am interested in exploring what factors influence this behavior.

I am also interested in what factors determine student improvement, as measured by the various empirical definitions of growth. That is, I want to see how the common factors in the literature that affect pass rates also affect measures of growth. I use a combination of community and school characteristics to explain pass rate growth, percent increase in pass rates, and the percent of the gap closed through linear regression analysis. The descriptive statistics for all of the variables used in the regression analysis are reported in Table 2, which is split by districts that report ISAT scores for grades 3 and 8 and districts that report PSAE scores for grade 11. For the most part, values are relatively similar across the two district types, which share 345 unit districts.

In Table 2, the BA rate, or percent of adults over 25 years of age with a bachelor's degree, serves as a representative socio-economic status variable. On average, just over 21 percent of adults in Illinois districts have bachelor's degrees, and this value ranges from 3.1 to 88.7 percent. As this measure is a five-year estimate, I assume it is constant over the entire period in question.

The ISBE reported curricular minutes of instruction only for grades 3 and 8. In both grades, English minutes of instruction decreased and math minutes of instruction increased by slight increments over the period. Finally, NCLB mandated that districts employ highly qualified teachers, or teachers who were sufficiently certified in their area of instruction. In Illinois, over 99 percent of teachers were highly qualified in 2003, and this proportion increased by about half a percent by 2012.

The growth measures, namely raw growth, percent gain, and percent of gap closed, are all measured on a 0 to 100 scale. Likewise, so are the BA rate, percent of students who are white, black, and Hispanic, the district mobility rate, or rate at which students enter or leave a school district after the start of a school year, and the percent of teachers who are highly qualified. Also reported as a percentage are the percent of districts located in center cities, suburban areas, and rural areas. The average class size is measured in the number of students. The curricular minutes of instruction is measured in minutes per day. The per pupil instructional expenditures variable is measured in thousands of dollars.

IV. Identification Strategy

Weighted least squares regression is used in this study in order to examine the effects of school district and community characteristics on the measures of growth defined in Section III. The following empirical model is estimated for all three measures of growth, in both reading and math, for grades 3, 8, and 11:

(4) $$\text{Growth Definition}_i = \beta_0 + \beta X_{1,i} + \phi X_{2,i} + \varepsilon_i$$

For districts $i = 1, 2,\ldots, n$, X_1 is a vector of community characteristics with coefficient β, X_2 is a vector of school district characteristics with coefficient ϕ, and ε_i is a district-specific error term. The community characteristics, represented by X_1, are the BA rate, which is the variable reflecting socio-economic status, and the racial makeup of the community, decomposed into the percent of students who are white (omitted), black, and Hispanic.[1] The district characteristics, represented by X_2, include class size, curricular minutes of instruction, the district mobility rate, the percent of teachers who are highly qualified, and the per-pupil instructional expenditures. In order to control for heteroskedasticity that exists when the dependent variable is an average, all regressions are weighted by the square root of district enrollment. Extreme outliers were also dropped from the analysis.[2]

Tables 3 through 5 display the regression results by grade, with results for both subjects and all definitions of growth for grade 3 in Table 3, grade 8 in Table 4, and grade 11 in Table 5. As curricular minutes of instruction were not reported by the ISBE for grade 11, this variable is omitted from the 11th grade regressions reported in Table 5. The three tables are structured

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[1] Dummy variables for whether a district is located in a rural area, suburban area, or central city are also included in the regressions, but omitted from the tables.
[2] For example, districts that experienced over 500% pass rate gain in reading were dropped. Regressions were conducted additionally dropping all outliers (i.e. districts three standard deviations from the mean), and the results did not significantly differ from those presented.

identically, with corrected standard errors reported in parentheses below the coefficient estimates.

V. Results

We begin our discussion of the results with Table 3, which displays results for third grade. We will then move our attention to the results reported in Table 4, and finally to Table 5, with overall concluding thoughts to follow.

A. Grade 3

This subsection begins with a very interesting result: the percent of adults in a school district with a bachelor's degree (BA rate), actually has a negative effect on almost every definition of growth in reading and mathematics. For example, with statistical significance, a one percentage point increase in a district's BA rate has a negative 0.08 and negative 0.23 percentage point effect on the district's growth rate and percent gain rate in reading, respectively. While this may seem counterintuitive at first glance, this effect is actually quite logical, as it is likely that students in districts with a high BA rate at the start of NCLB already performed at a high level, reflected in high 2003 pass rates. Thus, these high BA rate districts, on average, had less "room to grow" from the start. Considering the previous example, Winnetka's pass rate of 94.6 percent only left it with a maximum possible growth rate of 5.4 percentage points and a maximum gain rate of 5.7 percent (=5.6/94.6), while Ford Heights' 2003 pass rate of 24.6 percent left it with a maximum growth of 75.4 percentage points and a maximum gain rate of 306.5 percent (=75.4/24.6). The data support this; for example, while third graders overall had a 2003 average reading pass rate of 71.30 (Table 1), the 50 districts with a BA rate over 50 percent had a higher pass rate of 84.53, and the 613 with BA rates below 50 percent had a slightly lower pass rate of 70.22, leaving them relatively more room to grow. By 2012, these pass rates increased to 80.36 overall, 90.96 for the districts with BA rates over 50 percent, and 79.50 for the districts with BA rates under 50 percent. This resulted in raw pass rate growth of 9.07, 6.42, and 9.28 percentage points for each of the respective groups. In the eyes of NCLB, this result reflects relatively better on those districts with lower BA rates and more growth than those with higher BA rate since those districts improved their pass rates comparatively more over the period.

The effects of race on student improvement are intriguing as well. For example, for every 1-percentage point increase in the percent of black students in the district, the raw growth in reading pass rates for all students was 0.20 percentage points. This result is statistically significant and positive at varying magnitudes for all definitions of growth in both grade levels. From Table 1, we see that the average black reading pass rate in 2003 was 46.87 – lower than the all-student average, and the averages for whites and Hispanics. Black students also experienced greater raw growth in pass rates over the period than the other subgroups, with a 19.85 percentage-point increase in reading pass rates. So, it seems like the greater black growth relative to the other subgroups that contribute to a district's overall growth has had a heightened effect on a district's overall growth. Namely, black improvement in reading has increased the magnitude of the district's overall improvement in reading. The same is true for percent gain and percent of gap closed in math and reading with the same rationale, with the exception of the math gap. In this case, the percent of the gap closed by black students is not always higher than that of the other subgroups – in fact, it is only higher than that for Hispanics (Table 1). However, its effect on the percent of the gap closed for all races is still statistically significant.

Both the local BA rate and the percent of students who are black have opposite, statistically significant effects on the percent of gap closed from the raw pass rate gain and percent of gap closed. For example, a one-percentage point increase in the percent of adults with a bachelor's degree negatively affects reading raw growth and percent gain at respective magnitudes of 0.08 and 0.23 percentage points, but positively affects the percent of gap closed at a magnitude of 0.19 percentage points. For the percent of students who are black, the effects on raw growth and percent gain in math and reading are positive, while the effects on the percent of gap closed in both subjects are negative. This trend shows evidence that there are, in fact, inherent differences between the proposed definitions of growth.

The percent of Hispanic students in the district also positively affects grade 3 percent pass rate gain, but not raw growth or percent of gap closed, at very small magnitudes. This is significantly negative for the percent of the gap closed, with a 1-percentage point increase in the percent of students who are Hispanic resulting in a widening of the gap of 0.21 percentage points in reading and 0.37 percentage points in math. This result corresponds to the relatively smaller percent of gap closed by Hispanics (21.88 percent in reading and 20.64 percent in math) than by all other subgroups (23.75 and 36.84 percent for white students and 34.82 and 25.10 percent for black students in reading and math respectively), shown in Table 1. With this exception, it seems overall like diversity has positive effects on the overall standardized test performance of third graders in both subjects.

According to Table 3, a one-student increase in average class size negatively affects every growth definition, but this effect is not statistically significant when explaining the percent of gap closed. The negative effect of class size on growth intuitively makes sense, as students are likely to respond better to more individualized attention through smaller class sizes. The effects of a one-minute increase in curricular minutes of instruction are extremely minimal in third grade, and are usually positive, with the exception of math raw growth (0.01 percentage point decrease) and percent gain (0.05 percentage point decrease).

The mobility rate, or rate at which students leave a school district and enroll in a district after the start of the school year, can be used as a reflection of district quality; it is likely that a reason students would leave or enter a district would be due to its quality (although obviously there could be other reasons people would leave a district independent of its quality). So, if a district's mobility rate is high, it might be inferred that it is of poor quality. It is likely, therefore, that the poor quality of a district negatively impacts student educational outcomes. In this particular study, that is true. Increases in the mobility rate negatively affect all three definitions of growth at varying levels of significance.

It is worth mentioning that the percent of teachers who are highly qualified are associated with the definitions of growth that are not consistently positive or negative; in third grade, these effects are negative for the percent of the gap closed, and positive for the other definitions in both subjects, but none of these estimated effects are statistically significant. This result is not surprising considering the lack of significant change in the percent of teachers who are highly qualified in Illinois over the period. Illinois non-high school districts were already hiring 99.27 percent of teachers who were highly qualified across districts in 2003, and this increased minimally to 99.87 percent in 2012 (Table 2). Since the percent of teachers who were highly qualified did not change much over the period – as there was just over half a percentage point change – it makes sense that the effect of having a highly qualified teacher is not significant in any measure of growth in pass rates over the period in either subject. This is also true for grades 8 and 11, shown in Tables 4 and 5.

Interestingly, per pupil instructional expenditures always has a negative effect on growth, which is not statistically significant except for raw pass rate growth in reading. There is more to follow analyzing this result.

B. Grade 8

The effects of many of the school and community characteristics are similar in grade 8 to grade 3. For example, BA rate, again, has negative effects on both reading and math raw growth and percent gain, and positive effects on the percent of gap closed in both subjects. All of these results are statistically significant.

In terms of race, the percent of black and Hispanic students both have generally positive and usually statistically significant effects of varying magnitudes on growth rates and the percent gain in both subjects. For example, a one-percentage point increase in the percent of black students is expected to result in raw growth in math pass rates of 0.16 percentage points. For every additional percent of students who are Hispanic, the percent gain in math pass rates is expected to increase by 0.75 percentage points. However, for the percent of students who are Hispanic in math, and the percent of students who are black and the BA rate in both subjects, the results for raw growth and percent gain are again reversed for percent of gap closed. These discrepancies in results between outcome measures give further support that the growth definitions are inherently different – particularly that percent of gap closed is different from raw growth and percent gain.

The effects of average class size and per pupil instructional expenditures on the grade 8 outcome measures are similar to those for grade 3, with varying statistical significance. In grade 8 math, a one minute increase in daily curricular minutes of instruction is expected to produce a percentage point increases of 0.18 in raw growth, 0.55 in percent gain, and 0.24 in percent of gap closed, all significant at the 1 percent level. Much smaller effects are found for reading. This result indicates that minutes of mathematics instruction have stronger effects on student improvement on standardized tests in mathematics than reading instruction does on reading tests. Perhaps this implies an argument for increasing the amount of mathematics instruction in the day, and perhaps not doing so for reading.

Similar to grade 3, the district mobility rate negatively affects all three definitions of growth in reading and math in grade 8. Furthermore, increasing per pupil instructional expenditures again has a negative effect on all three definitions of growth in both subjects, with frequent statistical significance. In grade 8 math, for example, a one thousand dollar increase in per pupil instructional expenditures results in a 2.32 percent decrease in percent pass rates.

C. Grade 11

The grade 11 results show several trends that are often opposite of those for grades 3 and 8. For every growth measure in both subjects, the local BA rate has a positive effect, while the percent of students who are black and Hispanic both have negative effects. Taking into account where grade 11 pass rates started in 2003, this result makes sense. In every racial subgroup and overall, grade 11 pass rates in 2003 were lower than those in grades 3 and 8 for both reading and math (Table 1). Therefore, grade 11 students collectively had more “room to grow” at the start of the period, so it is not surprising that influences such as the presence college-educated adults in the community would positively affect their educational progress.

In reference to the negative effects of the percent of students who are black and Hispanic on total district improvement, it makes sense considering the measures of growth displayed in Table

1. As shown in Table 1, grade 11 students overall actually had negative growth, showing declining standardized test performance over the period in question. Black students experienced the greatest decrease in pass rates, with pass rate gain in reading of negative 21.82 percent and negative 6.44 percent in math. Because of the subgroup's amplified decrease in pass rates in both subjects, it is not surprising that the percent of students who are black negatively affects every measure of growth in grade 11. The same could likely be inferred for Hispanics in grade 11, who also experienced negative pass rate growth in reading.

Increasing the average class size has the expected negative effects on raw growth and percent gain, with positive effects on the percent of gap closed. None of these results are statistically significant. The district mobility rate and per pupil instructional expenditures show results consistent with those of the other grades as well. For per pupil instructional expenditures, these effects happen to be negative and statistically significant in grade 11 math with relatively large magnitudes: namely, for every thousand dollar increase in per pupil instructional expenditures, math growth, percent gain, and percent of gap closed are expected to decrease by 0.59, 1.33, and 1.15 percentage points. So, if the effect of expenditures is significant at all, it is significantly negative. This seems to mean that increasing expenditures actually affects student improvement negatively. This result is true for all three grade levels in this study, as increasing per pupil expenditures has negative effects in every grade, subject, and growth definition. This could have important policy implications, especially with respect to NCLB.

D. General patterns in Growth Measurements

Overall, the results show that average class size, the mobility rate, and per pupil instructional expenditures negatively affect the raw growth in pass rates, the percent pass rate gain, and the percent of gap closed in reading and math. While those results are consistent for all three grades, some effects are actually reversed between grades 3 and 8 and grade 11. Namely, the effects of the community characteristics, local BA rate, percent of students who are black, and percent of students who are Hispanic, are reversed from the grades 3 and 8 regressions to the grade 11 regressions. This likely speaks to differences in the educational experience between those grades, and perhaps differences in student motivation to excel on standardized tests from grades 3 and 8 to grade 11. Overall, it seems like students are generally less motivated to excel on standardized tests in grade 11, which could account for their average decline in pass rates over the period. Based on the results shown, it can be inferred that there are inherent differences between grades 3 and 8 and grade 11. Moreover, this trend gives even further reason for having various empirical definitions of growth. As a large reason for the reversed effects of these variables on grade 11 student improvement is due to where the student pass rates began in 2003, this reinforces the importance of accounting for where students started through a definition like percent pass rate gain, and not just using their raw growth as the only representation of progress.

In all three grades and both subjects, R^2 increases in value in the following order: percent of gap closed, raw growth, percent gain. Therefore, this model explains the least amount of variation in the percent of gap closed, while this model best explains that in the percent gain. The different explanatory power of the various definitions of growth, along with the observed differences in the magnitudes and signs of coefficients between regressions, suggests that the definitions of growth are actually inherently different. This may have implications for which growth measures most effectively capture student improvement as well.

VI. Conclusion and Future Research

Several trends that have emerged from the above analyses have serious policy implications. First of all, the results show that empirical measures used to define student growth should take into account where students started at the beginning of the period in question. In terms of the definitions of growth used in this paper, one may consider using percent pass rate gain instead of raw pass rate growth, as it actually accounts for the original pass rate, and is therefore more informative. Measuring how students have improved relative to where they started would be better for NCLB as well. Perhaps instead of using AYP, which is just a raw amount of growth from year to year, policy-makers should employ a more revealing measure such as percent gain in order to more accurately and holistically measure student progress. Based on the regression results, it is clear that policy-makers could employ a more appropriate measure of pass rate growth. Because federal funding is at stake for districts that do not meet the requirements of AYP, it is imperative to use the most appropriate measure of growth in order for the Department of Education to impose sanctions to the districts that actually merit them. That percent gain better captures improvements in student outcomes than raw growth shows evidence that the current system of evaluating student progress is problematic.

Furthermore, threatening a reduction federal funding for districts that do not meet AYP may not be the most effective policy, based on the above results. In all three grades, the effects of increases in per pupil instructional expenditures on all three measures of growth are negative, suggesting that throwing money at the problem of a lack of improvement does not necessarily solve the problem. This along with the significant evidence that community factors, which school districts cannot control, do affect student improvement suggests that perhaps the federal solution for districts that are not improving enough should encompass more than just a loomed withholding of funds, as this is clearly not the only thing that affects student outcomes.

The above analyses have produced results that suggest that a combination of school district and community characteristics do affect student educational outcomes, a conclusion that is consistent with the literature. However, the results still leave questions about how to most effectively capture student improvement, since certain inputs in the education production function produce very different effects on different definitions of student improvement. Perhaps that is why there are so many education production function estimates – there does not seem to be one widely accepted "best" way to capture student educational performance and its determinants. Due to this, there is much more that I would like to explore in regard to the education production function.

First of all, I would like to examine differences in pass rates between racial subgroups over the period of NCLB in order to assess whether the Act's goal of closing the achievement gap, or increasing the performance of low-achieving subgroups relative to higher-achieving subgroups, was achieved. I would also like to explore whether reductions in the achievement gap can be explained using the education production function.

While this study explored the effects of the racial makeup on the entire district performance, it would be interesting to estimate the effects of the races represented on their own performance, or the own-race effects. For example, I would like to see how an increase in the percent of students who are black affects the pass rate growth of black students. I would like to do the same for the white and Hispanic subgroups as well.

Another aspect of the education production function that deserves more exploration is the question of the correct outcome variable. As shown in the results of this study, the three outcome measures represented are distinct from each other, with community and school characteristics sometimes having very different effects on them. Since these effects are sometimes different, it is difficult to decide which measure of student improvement is actually the best. This opens the possibility that there could be other measures of growth that are just as effective as the ones this paper presented. In particular, I would like to explore using the high school graduation rate as an outcome variable for regressions on grade 11 data. Wenger (2000) hypothesizes that schools actually face a trade-off between test scores and graduation rates in that schools may have to sacrifice the former in order to use resources to increase the latter; this is evidenced by trends of decreasing test scores coupled with increasing graduation rates observed since 1960. To compensate for this, there is a portion of the literature that sees high school graduation rates as the best educational output measure, rather than a measure based solely on test scores (Boggess, 1998; Goldin, 1998; Chen, 2013; Heckman and LaFonatine, 2012; Iatarola and Reubenstein, 2007; Murnane, 2013). Thus, it would be interesting to see how the district and community characteristics affect growth in the high school graduation rate, which does not involve standardized test pass rates, compared to the standardized test-based outcome measures.

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Appendix

Table 1
Pass Rates

	Reading						Math					
	N	2003 Pass Rate	2012 Pass Rate	Grow[a,i] (pp)	Gain[ii] (%)	Gap[iii] (%)	N	2003 Pass Rate	2012 Pass Rate	Grow[a,i] (pp)	Gain[ii] (%)	Gap[iii] (%)
All Races												
Grade 3	663	71.30	80.36	9.07	15.72	22.41	663	84.67	91.37	6.70	9.40	33.38
Grade 8	653	67.31	87.02	19.71	32.78	59.39	653	59.48	86.34	26.86	55.03	66.04
Grade 11	427	57.06	52.97	-4.08	-6.30	-12.07	427	53.30	51.53	-1.76	-1.98	-5.59
White												
Grade 3	630	74.78	83.17	8.33	12.90	23.75	630	87.36	93.39	5.93	7.68	36.84
Grade 8	628	69.94	88.60	18.55	29.33	60.98	628	63.02	88.40	25.16	45.84	68.05
Grade 11	424	59.44	56.74	-2.71	-3.41	-9.16	424	55.46	55.34	-0.14	-1.40	-1.79
Black												
Grade 3	137	46.87	67.00	19.85	53.61	34.82	137	64.89	77.93	13.19	25.34	25.10
Grade 8	140	47.72	76.94	27.36	68.96	50.39	140	27.86	71.34	41.98	189.93	58.13
Grade 11	86	33.91	27.12	-8.29	-21.82	-15.97	86	25.00	23.06	-3.85	-6.44	-7.42
Hispanic												
Grade 3	155	57.02	71.36	12.73	29.51	21.88	156	77.18	85.94	8.16	13.58	20.64
Grade 8	142	49.79	84.40	33.90	83.41	64.54	142	40.72	82.97	41.20	131.39	68.70
Grade 11	94	39.42	38.92	-1.05	-3.15	-4.48	94	36.41	49.09	3.80	20.69	3.51

[a] This is the only growth variable being statistically tested. Pass rate growth is statistically significant at the 1% level for all grades, subgroups, and subjects except for grade 11 white math and grade 11 Hispanic reading.
[i] Corresponds to equation (1) in section III
[ii] Corresponds to equation (2) in section III
[iii] Corresponds to equation (3) in section III

Table 2
Descriptive Statistics

	2003				2012			
	Mean	SD	Min	Max	Mean	SD	Min	Max
Districts with Grade 3 and 8 ISAT Scores[a]								
Local BA Rate	23.78	14.91	3.1	88.7	23.78	14.91	3.1	88.7
Percent Students White	83.03	23.84	0	100	75.47	27.14	0	99.6
Percent Students Black	8.43	18.93	0	100	8.7	18.98	0	100
Percent Students Hispanic	6.15	11.35	0	94.2	10.07	15.34	0	94
Grade 3 Average Class Size	20.68	3.80	5	36	20.6	3.97	5	35
Grade 8 Average Class Size	21.51	4.71	8.9	40	20.3	4.75	7.3	39.4
Grade 3 Daily Minutes of Eng. Inst.	142.19	27.76	40	220	138.63	27.15	43	230
Grade 3 Daily Minutes of Math Inst.	58.14	9.82	30	100	61.77	11.1	30	120
Grade 8 Daily Minutes of Eng Inst.	86.83	20.67	15	282	86.08	18.14	37	151
Grade 8 Daily Minutes of Math Inst.	46.47	11.92	23	235	49.21	11.26	38	105
District Mobility Rate	14.18	7.39	0.6	40.9	12.88	7.66	0.7	55
Percent of Teachers who are Highly Qualified	99.27	3.35	31.6	100	99.87	0.83	88.6	100
Per Pupil Instructional Expenditures	4.30	0.90	2.33	10.45	5.94	1.45	3.41	15.09
Center City Districts	3.32	17.92	0	100	3.32	17.92	0	100
Suburban Districts	80.54	39.62	0	100	80.54	39.62	0	100
Rural Districts	16.14	36.81	0	100	16.14	36.81	0	100
Districts with Grade 11 PSAE Scores[b]								
Local BA Rate	21.52	12.41	3.1	79.4	21.52	12.41	3.1	79.4
Percent Students White	88.51	17.98	0.2	100	82.47	21.44	0.5	99.5
Percent Students Black	5.59	13.35	0	98.7	5.88	13.54	0	98.4
Percent Students Hispanic	4.43	9.20	0	76.8	7.44	12.51	0	87.7
Grade 11 Average Class Size	17.89	3.83	7.9	31	16.51	4.18	7.1	31
District Mobility Rate	12.82	5.97	1.9	40.1	12.47	6.33	0.9	55
Percent of Teachers who are Highly Qualified	99.29	2.47	73.1	100	99.86	0.89	88.6	100
Per Pupil Instructional Expenditures	4.52	1.06	2.86	9.42	6.09	1.53	3.72	12.67
Center City Districts	2.58	15.86	0	100	2.58	15.86	0	100
Suburban Districts	74.71	43.52	0	100	74.71	43.52	0	100
Rural Districts	22.72	41.95	0	100	22.72	41.95	0	100

[a] After dropping extreme outliers, there are 663 elementary and unit districts in the grade 3 analysis and 653 districts in the grade 8 analysis.
[b] There are 427 high school and unit districts in the grade 11 analysis.

Table 3
Grade 3 Growth in Pass Rates by Subject

	Reading			Math		
	Grow	Gain	Gap	Grow	Gain	Gap
Local BA Rate	-0.08***	-0.23***	0.19	-0.14***	-0.21***	-0.23
	(0.03)	(0.05)	(0.12)	(0.02)	(0.03)	(0.15)
Percent Students Black	0.20***	0.54***	0.30***	0.20***	0.35***	0.38***
	(0.02)	(0.04)	(0.09)	(0.02)	(0.03)	(0.11)
Percent Students Hispanic	-0.02	0.03	-0.21***	-0.01	0.02	-0.37***
	(0.02)	(0.03)	(0.08)	(0.01)	(0.02)	(0.09)
Grade 3 Average Class Size	-0.27**	-0.57**	-0.42	-0.20**	-0.33**	-0.69
	(0.12)	(0.23)	(0.53)	(0.10)	(0.15)	(0.67)
Grade 3 Curricular Minutes of Instruction	0.02	0.02	0.10	-0.01	-0.05	0.18
	(0.01)	(0.03)	(0.06)	(0.03)	(0.04)	(0.17)
District Mobility Rate	-0.31***	-0.55***	-0.98***	-0.29***	-0.38***	-1.72***
	(0.05)	(0.10)	(0.23)	(0.04)	(0.07)	(0.29)
Percent of Teachers who are Highly Qualified	0.12	0.30	0.31	0.24	0.53	-0.52
	(0.34)	(0.61)	(1.42)	(0.27)	(0.41)	(1.78)
Per Pupil Instructional Expenditures	-0.47**	-0.59	-1.09	-0.25	-0.29	-2.26
	(0.32)	(0.60)	(1.39)	(0.26)	(0.40)	(1.74)
Constant	10.11	7.98	13.96	-3.87	-25.54	141.94
	(33.67)	(61.76)	(142.92)	(27.12)	(41.74)	(179.37)
R^2	0.1731	0.3013	0.0925	0.2641	0.3180	0.0902

N = 663 elementary and unit districts
*** denotes statistical significance at the 1% level
** denotes statistical significance at the 5% level
* denotes statistical significance at the 10% level

Table 4
Grade 8 Growth in Pass Rates by Subject

	Reading			Math		
	Grow	Gain	Gap	Grow	Gain	Gap
Local BA Rate	-0.20***	-0.44***	0.16***	-0.26***	-0.97***	0.11**
	(0.02)	(0.05)	(0.05)	(0.03)	(0.09)	(0.05)
Percent Students Black	0.02	0.13***	-0.19***	0.16***	1.08***	-0.11***
	(0.02)	(0.04)	(0.04)	(0.02)	(0.07)	(0.04)
Percent Students Hispanic	0.17***	0.53***	0.06*	0.16***	0.75***	-0.01
	(0.01)	(0.03)	(0.03)	(0.02)	(0.06)	(0.03)
Grade 8 Average Class Size	-0.21***	-0.59***	-0.04	-0.18**	-0.46*	0.17
	(0.06)	(0.14)	(0.14)	(0.08)	(0.26)	(0.13)
Grade 8 Curricular Minutes of Instruction	0.01	-0.004	0.06	0.18***	0.55***	0.24***
	(0.02)	(0.04)	(0.04)	(0.03)	(0.10)	(0.05)
District Mobility Rate	-0.02	0.10	-0.33***	-0.21***	-0.60***	-0.47***
	(0.04)	(0.10)	(0.10)	(0.06)	(0.19)	(0.09)
Percent of Teachers who are Highly Qualified	-0.01	0.33	0.77	-0.03	-0.36	0.84
	(0.29)	(0.65)	(0.67)	(0.37)	(1.21)	(0.59)
Per Pupil Instructional Expenditures	-0.60**	-1.17**	-0.10	-1.21***	-2.32**	-1.07**
	(0.25)	(0.55)	(0.57)	(0.32)	(1.04)	(0.51)
Constant	33.52	33.24	-16.44	42.61	108.73	-21.78
	(29.74)	(64.59)	(66.76)	(36.71)	(121.58)	(58.90)
R^2	0.4625	0.5864	0.1765	0.4903	0.6224	0.1811

N = 653 elementary and unit districts
*** denotes statistical significance at the 1% level
** denotes statistical significance at the 5% level
* denotes statistical significance at the 10% level

Table 5
Grade 11 Growth in Pass Rates by Subject

	Reading			Math		
	Grow	Gain	Gap	Grow	Gain	Gap
Local BA Rate	0.08**	0.19***	0.06	0.10***	0.22***	0.18**
	(0.03)	(0.06)	(0.09)	(0.04)	(0.07)	(0.09)
Percent Students Black	-0.11***	-0.35***	-0.15**	-0.09***	-0.32***	-0.12*
	(0.02)	(0.04)	(0.07)	(0.03)	(0.06)	(0.07)
Percent Students Hispanic	-0.06**	-0.14***	-0.10	-0.02	-0.04	-0.06
	(0.02)	(0.04)	(0.06)	(0.03)	(0.05)	(0.07)
Grade 11 Average Class Size	-0.01	-0.03	0.32	-0.004	-0.15	0.34
	(0.12)	(0.22)	(0.33)	(0.14)	(0.29)	(0.34)
District Mobility Rate	-0.07	-0.08	-0.14	-0.11*	-0.19	-0.20
	(0.06)	(0.10)	(0.16)	(0.07)	(0.14)	(0.17)
Percent of Teachers who are Highly Qualified	-0.40	0.23	-1.66*	-1.14***	-2.36***	-2.39**
	(0.37)	(0.67)	(1.02)	(0.43)	(0.88)	(1.06)
Per Pupil Instructional Expenditures	-0.28	-0.60	-0.57	-0.59**	-1.33**	-1.15*
	(0.23)	(0.41)	(0.63)	(0.26)	(0.55)	(0.65)
Constant	35.46	-28.21	147.47	112.94	238.50	228.17
	(37.34)	(66.82)	(101.88)	(42.67)	(88.21)	(105.57)
R^2	0.1989	0.3487	0.0758	0.1594	0.2155	0.1059

N = 427 high school and unit districts
*** denotes statistical significance at the 1% level
** denotes statistical significance at the 5% level
* denotes statistical significance at the 10% level