Abstract Title Page

Title: The Magnitude, Destinations and Determinants of Mathematics and Science Teacher Turnover

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Abstract Body

Background/context:

Contemporary educational thought holds that one of the pivotal causes of inadequate student performance is the inability of schools to adequately staff classrooms with qualified teachers, especially in fields such as mathematics and science. At the root of these staffing problems, it is commonly believed, are shortages resulting from an inadequate supply of teachers in the face of increasing student enrollments and increasing teacher retirements.

In a series of prior analyses of comprehensive national data, we have not found the data to support this perspective (Ingersoll and Perda 2009a). The data show that there are indeed widespread school staffing problems—that is, many schools experience difficulties filling their classrooms with qualified candidates, especially in the fields of math and science. But, the data also show that these school staffing problems are not a result of an inadequate quantity of mathematics and science teachers produced. The data show that the new supply of qualified math and science teachers has more than kept pace with increases in student enrollments and, moreover, has been more than sufficient to cover teacher retirement losses. Rather, the data document that one of the most important sources of school staffing problems is preretirement teacher turnover—the departure of teachers from their teaching jobs long before retirement. The data show that as an occupation teaching has far higher annual turnover than some professions (lawyers, engineers, architects, professors, pharmacists), about the same as others (police, corrections officers), and less turnover than some lines of work (child care workers, secretaries, paralegals) (see Ingersoll & Perda, 2009b). However, the data also shows that teacher turnover depends on location and focusing on the overall national picture overlooks large variations. The largest source of variation is between different types of schools, even within districts, and these differences are tied to the characteristics and conditions of those schools. While it is true that teacher retirements are increasing, the overall volume of turnover accounted for by retirement is relatively minor when compared with that resulting from other causes, such as teacher job dissatisfaction and teachers seeking to pursue other jobs or careers. Hence, our research suggests that if schools are to ensure that all students are taught by qualified teachers, as NCLB mandates, then they must focus more on improving teacher retention.

Purpose / objective / research question / focus of study:

Description of what the research focused on and why.

The objective of this study is to use nationally representative data to examine the rates, destinations and sources of math and science teacher turnover. There are four sets of research questions we address concerning the departure of mathematics and science teachers from their schools:

1. At what rates do mathematics/science teachers move from or leave their teaching jobs? How do their turnover rates compare to those of other teachers? Have their turnover rates changed over time? What is the magnitude of both math science teacher mobility and attrition?

2. Which types of schools have higher levels of mathematics/science teacher turnover?
3. What are the destinations of mathematics/science teachers who move from or leave their teaching jobs? What proportions of those departing move to other schools, quit to raise families, go to graduate school, go into non-teaching occupations within education (e.g., school administration, higher education, etc) or go into non-educational occupations?
4. Which particular factors, aspects, and conditions of schools and of teachers' jobs are most tied to the turnover of mathematics and science teachers?

Setting:

This study utilizes nationally representative data on teachers, and therefore the setting is the whole United States.

Population / Participants / Subjects:

The data for this study come from the National Center for Education Statistics' (NCES) nationally representative Schools and Staffing Survey (SASS) and its supplement, the Teacher Followup Survey (TFS). This is the largest and most comprehensive data source available on the staffing, occupational, and organizational aspects of elementary and secondary schools.

Intervention / Program / Practice:

The practice under investigation here is teacher turnover and mobility. Assuming a body of evidence can be accumulated regarding the importance of teacher turnover, a related intervention that can be proposed are policies aimed at reducing the amount of teacher mobility. However, it is important to first correctly identify the factors involved in teacher turnover and mobility in order to develop the appropriate policy intervention.

Research Design:

In order to answer the four research questions outlined above, we utilize a number of different analytic strategies. We used descriptive statistics to establish rates of turnover, which types of schools have higher rates of turnover, and destinations of mathematics/science teachers. We conducted an analysis of the cross-location variance of the TFS data on turnover to investigate differences in rates of teacher turnover. Finally, we estimated a series of regression models to examine whether school organizational and working conditions are associated with teacher turnover, after controlling for the characteristics of schools and teachers. In our analyses we used two types of measures of school conditions: (1) school-level averages across the teachers in each school, and (2) teacher-level measures showing the extent to which individual teachers differed from others in their building. In our models, use of the former measures tells us whether particular school conditions on average are related to turnover; the latter measures tell us whether individuals who reported conditions differently than others, were also more or less likely to depart than others.

Data Collection and Analysis:

The Schools and Staffing Survey and the related Teacher Follow-up Survey are collected by NCES. Analyses include descriptive analyses, cross-location variance of the TFS data, and regression modeling.

Findings / Results:

Our analyses show, that after controlling for teacher and school characteristics, a number of factors stand out as important to math science teacher turnover. Among these are: teacher salaries; whether there are adequate classroom resources; the amount of collective faculty input into school-wide decisions, such as those concerning the curriculum, budget, hiring, evaluation, discipline and standards; and the degree of autonomy individual teachers have in their classrooms over such issues as, homework, evaluation, discipline and teaching methods. For instance, holding other factors equal, the data show that in schools where teachers have a high degree of classroom autonomy, the annual predicted probability of turnover is 10 percent. On the other hand, in schools where teachers have a low degree of classroom autonomy, the annual predicted probability of turnover is 45 percent. Likewise, in schools where teachers report that classroom resources are highly adequate, the annual predicted probability of math/science turnover is 13 percent. On the other hand, in schools where teachers report that classroom resources are not adequate, the annual predicted probability of math-science turnover is 22 percent.

The data indicate that over the past two decades public mathematics and science teachers have not moved from or left their schools at significantly different rates from other teachers – a finding that contradicts a number of earlier studies From the late 1980s to 2004, annual rates of total turnover for math science rose overall – 31% for math and 11 % for science – but also fluctuated from year to year during that period.

Where do they go when they move or leave? What are the destinations of mathematics/science teachers who move from or leave their teaching jobs? About half of those departures moved to other schools and about half left teaching. Of those who moved to other schools, almost half entailed cross-school transfers within the same district. Just over half of the migrants went to other districts and 90 percent of these were within the same state. About 5 percent of public school math/science movers went to private schools (this was about half of the reverse flow – those who moved from private to public). Compared to other teachers, mathematics and science teachers were less likely to move to schools in other states, but slightly more likely to move to another district in the same state, and, for science in particular, slightly more likely to move to private school teaching jobs – perhaps suggesting greater teaching job opportunities within the state.

Over half of those who left classroom teaching altogether report that they would consider returning to classroom teaching somewhere, and hence their attrition may be temporary. They also report the most important factors influencing a decision to return would be a salary increase and the ability of maintain their retirement benefits. About one third of leavers are job shifters working in the larger field of education, such as in school administration, or in higher education. While they have left the classroom, they are not a loss of human capital to the larger education

sector. Another 14 percent left to work in an occupation outside of education, just over a quarter of those leaving retired, 14 percent left to care for family members, and 4 percent left to enroll in university or college programs. Interestingly, compared to other teachers, mathematics and science teachers who left classroom teaching, were far more likely to be working in the larger field of education and were slightly more likely than other teachers to be working in a non-education occupation. Science teachers, however, were slightly less likely to be working for private business or industry than were other teachers who left teaching – which somewhat runs against the view that science teachers are more likely to have alternative career options in the private sector than other.

The data also show the flows of teachers out of schools are not equally distributed and that rates of turnover vary greatly among different locations. We conducted an analysis of the cross-location variance of the TFS data on turnover. We found that variation in turnover is significantly greater between schools within states, than between states and, moreover, that turnover is significantly greater between schools than between districts. In other words, the largest variations in teacher turnover by location are those between different schools, even within the same district. We also found that school poverty enrollments, school size, and the urbanicity of the school community were among the school characteristics most correlated with teacher turnover in public schools.

On one end of the continuum lie larger, low-poverty, suburban public schools that have, on average, 8 percent annual math science turnover. On the other end of the continuum lie smaller, rural, high-poverty public schools with double that rate. These data provide support for our theoretical perspective that fully understanding the staffing problems of schools requires examining them from the perspective of the organizations in which they occur. These data raise the questions—why do some schools have far higher turnover than others? What are the sources of teacher turnover?

We estimated a series of regression models to examine whether school organizational and working conditions are associated with teacher turnover, after controlling for the characteristics of schools and teachers. In our analyses we used two types of measures of school conditions: (1) school-level averages across the teachers in each school, and (2) teacher-level measures showing the extent to which individual teachers differed from others in their building. In our models, use of the former measures tells us whether particular school conditions on average are related to turnover; the latter measures tell us whether individuals who reported conditions differently than others, were also more or less likely to depart than others.

Although the measure for advanced salaries has a statistically significant negative relationship with turnover without controls, once other factors are held constant, the coefficient for advanced salaries (the school's highest annual salary on the teacher salary scale) is no longer statistically significant (at a 90 percent level of confidence) for math and for non math/science teachers. However, for science teachers a higher salary is significantly related to a reduced likelihood of departing. An increase in the salary by $1000 is associated with a 16 percent decrease (i.e., $\exp((-0.02)+(-0.16)) = 0.84$) in the odds of science teachers departing.

In schools with lower levels of student discipline problems, turnover rates are distinctly lower for both math/science and other teachers. A one unit increase in average reported student discipline problems between two schools (on a 4 unit scale) is associated with a 32 percent increase (i.e., exp(0.28) = 1.32) in the odds of a teacher departing. Moreover, individual teachers who reported higher levels of student discipline problems than other teachers in their building were themselves more likely to depart. But, notably the effect of school-wide conditions is stronger, about twice the size, than that of individual perceptions.

In schools which provide better principal leadership and administrative support as reported by teachers, turnover rates are distinctly lower. A one unit difference between schools in average reported support (on a 4 unit scale) is associated with a 21 percent decrease in the odds of a teacher departing. Again, as with student discipline, individual teachers who reported more positive levels of leadership support than other teachers in their building were themselves less likely to depart, although that individual effect was again only about half the size of the school-level effect.

In schools where teachers reported that necessary materials, such as textbooks and supplies were available, turnover was lower for all teachers. In this model however, the individual and school-level effects were the same size, suggesting the absence of a contextual effect of a lack of resources. In other words, teachers who had limited resources were more likely to depart, but their odds of departure was not additionally influenced by the availability of resources (or lack thereof) to other teachers in the school.

Schools with higher levels of school-wide faculty decision-making influence have lower levels of turnover. This is one of the strongest effects we found. A one unit increase in reported teacher influence between schools (on a 4 unit scale) is associated with a 23 percent decrease in the odds of a teacher departing. Moreover, whether individual teachers differed in their reports of teacher influence was not related to their turnover. Therefore, this may be entirely an organizational phenomenon reflecting differences in school-wide working conditions.

Schools with higher average levels of individual teachers' classroom autonomy have lower levels of turnover. A one unit difference in reported teacher influence between schools (on a 4 unit scale) is associated with a 37 percent difference in the odds of a teacher departing. This school-level effect is nearly three times the size of the individual effect of autonomy, suggesting a very large contextual relationship. Even more noteworthy is that the turnover of math teachers was even more strongly impacted by classroom autonomy. In fact, a one unit increase in average teacher autonomy between schools is associated with a 70 percent decrease in the odds of a math teacher departing (i.e., exp((-0.46)+(-0.75)) = 0.30). This was by far the single largest effect we found. On the other hand, the significant positive interaction effect for science teachers suggests that, unlike others, classroom autonomy had no effect on the odds of turnover (i.e., -.46 + .47 0).

We also examined the impact of whether teachers participated and found useful two types of professional development: (1) that focused on student discipline and classroom management, and (2) that focused on the content of the subjects taught. School-wide utility of the former type of PD was associated with decreases in turnover for math teachers only, but the effect was large. A one-unit increase in the school-average utility of PD focused on student discipline was

associated with a 39% reduction in the odds of turnover for math teachers. We also found significant effects of the utility of PD focused on the content taught; however, those effects existed only at the individual teacher level, not as organizational effects. Teachers who found content-focused PD more useful had a 10% lower odds of turnover. This effect was even larger for math teachers—those who found content-focused PD more useful had a 27% lower odds of turnover.

Conclusions:

All of this suggests that schools are not simply victims of inexorable demographic trends and that there is a significant role for the management of schools in both the genesis of, and solution to, school staffing problems. The data suggest that improvements in these conditions of the teaching job, such as increased teacher salaries, and enhanced faculty input into school decision making, would all contribute to lower rates of turnover, in turn, diminish school staffing problems, undermine the so-called teacher shortage and, hence, ultimately, aid the performance of schools.

Appendix A. References

References are to be in APA version 6 format.

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Abstract Title Page

Title: Teacher labor markets, segregation and salary-based policies to combat inequity across schools

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Abstract Body

Background/context:

The market for teachers differs from the typical market. In a typical market, an employer who hired more productive workers would benefit from being able to sell additional output. Competitive pressure would lead the employer to offer a better compensation package to more productive workers. Public schools, by contrast, generally expect no additional revenue from hiring more productive workers. Moreover, they are usually bound by contracts that stipulate specific salary levels for teachers with a given set of credentials. Lacking the incentive or the ability to reward higher productivity, schools become differentiated primarily by the working conditions they offer, which do vary. The most effective teachers hence cannot expect pecuniary rewards; to the extent they have any market reward at all it takes the form of superior working conditions – which generally implies a job teaching higher achieving, more affluent, or majority-race students. Although not all teachers reveal these kinds of preferences, studies dating back to Becker's 1952 study of the careers of Chicago public school teachers confirm that most do.

The sorting of more highly qualified teachers toward schools serving advantaged students reflects some combination of three mechanisms: disparities in initial placement, differences in the likelihood of exit from the profession, and differences in the propensity to move from one school to another. Our study builds on a substantial empirical literature that can be summarized by two major conclusions.

1. *Teachers, like most other people, respond to financial incentives in deciding where to work.* Teachers are attracted to positions with higher salaries; when alternatives salaries are higher, teachers are more inclined to leave their current post or to leave teaching altogether. Thus higher teacher salaries tend to reduce attrition rates, and attrition is sensitive to wage differences between teacher and non-teacher salaries.[*] Teachers with the best prospects outside of teaching are generally most likely to leave teaching. Thus higher exit rates are found for teachers with high scores on achievement tests and for math and science teachers.[†]

[*] See Murnane and Olsen (1989, 1990) and Hanushek, Kain and Rivkin (2004) (only for women having fewer than six years' experience), Podgursky, Monroe and Watson (2004), Reed, Rueben and Barbour (2006), and Krieg (2006). For the effect of non-teacher salaries, see Baugh and Stone (1982), Rickman and Parker (1990), Dolton and von der Klaauw (1995). Imazeki (2005) incorporate teacher salaries in both the current and alternative districts as well as non-teacher salaries. The former study finds significant effects in most specifications for non-teacher salaries. The latter includes both current and expected teacher salaries in a teacher's own district and neighboring ones as well as non-teaching salaries, generally finding significant wage effects for current and expected teacher salaries relative teacher salaries for women, but no effects for anyone associated with non-teaching salaries.

[†] See Murnane and Olsen (1989), Lankford, Loeb and Wyckoff (2002), and Podgursky, Monroe, and Watson (2004). Imazeki (2005) observes higher transfer rates among women teaching math and special education. In contrast, Krieg (2006) finds that high scoring female elementary teachers were less likely to quit.

2. *Teachers care about certain non-wage aspects of their jobs.* Social science research going back at least 50 years suggests that teachers, by and large, prefer students who are high-achieving, affluent, and white.[‡] In studies of teacher attrition, these preferences reveal themselves directly through the estimated effect of certain school characteristics, but they also show up in comparisons of the origin and destination schools between which teachers transfer. Racial composition is the school characteristic most consistently. This aversion to nonwhite students is observed largely among white teachers.[§] There is also evidence that teachers prefer to teach high-achieving students[**]

Purpose / objective / research question / focus of study:

One important reason for concern about racial or socioeconomic segregation of public schools is that it generates an uneven distribution of teacher quality, as measured in this paper by teacher qualifications, across schools. In particular, the existing evidence clearly shows that schools with large proportions of nonwhite or low income students typically have teachers with far weaker qualifications than those in schools serving white or more affluent students. (Clotfelter, Ladd, Vigdor & Wheeler, 2007; also see summary of studies in Goldhaber, 2008). As noted above, this well- documented pattern largely reflects the operation of teacher labor markets in which the distribution of teachers across schools is affected not only by state or district policies but by also the preferences of teachers. Of particular interest for this study are the revealed preferences of teachers who are likely to be effective teachers. We use as a measure of likely effectiveness various measure of teacher qualifications. Although some observers and analysts play down teacher qualifications, our own prior research provides evidence that certain qualifications are in fact predictive of student achievement (Clotfelter, Ladd and Vigdor, 2006, 2007a, 2007b, forthcoming).

[‡] Hollingshead (1949, p. 171) reported, "Because the academic teachers believe that college preparatory students have more ability, are more interested, and do better work than those in the general course, they prefer to teach the former group." See also Becker (1952).

[§] In comparisons of origin and destination schools, Greenberg and McCall (1974, Table 3, p. 493) and Hanushek, Kain and Rivkin (2004) show that teachers moved from less to more able student bodies, as measured by average standardized test scores. Evidence of this preference also appears in two multivariate studies of attrition – Mont and Rees (1996) and, for female teachers only, Krieg (2006). Clotfelter, Ladd, Vigdor, and Diaz (2004) find that the rate of exit from low-performing schools increased with the advent of North Carolina's assessment program, one that exposed teachers in low-rated schools to fewer rewards and the prospect of punitive policies. Using data for New York City, Boyd, Grossman, Lankford, Loeb and Wyckoff (2008) find that teachers in low-performing schools were more likely to leave than those in other schools.

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In light of these preferences, the purpose of this paper is to examine the potential for salary-based policies to generate a more equitable distribution of teachers characterized by strong qualifications across schools.

Setting:

The analysis is based on rich longitudinal administrative data on teachers and schools in the state of North Carolina. North Carolina provides an excellent state for a study of this type. It is a large state with a population of over 9 million, it has a variety of regions that differ in their racial and socioeconomic characteristics, it had a short-lived state-wide policy that provided salary bonuses to teachers of certain subjects in low-performing middle and high schools, and two of its larger districts have introduced new salary supplements for some schools intended to make it easier to attract and retain high quality teachers to those schools.

Population / Participants / Subjects:

By using administrative data, we are able to include all teachers in our analysis. In fact, however, we restrict much of the analysis to teachers who began teaching spells during the period under study, that is, between 1994/95 and 2003/04. We separately analyze two sets of teachers, those who had never taught before the new spell began (novice teachers) and those who had previously taught before the spell began (veteran teachers). For each of these teachers, we have information on their teacher licensure test scores, their years of experience, their advanced degrees, and whether they are board certified. We also have basic demographic information on their gender, race and age. We are able to follow all teachers as they move from school to school within a district, to a school in a different district, or out of the population of North Carolina public school teachers.

In addition to the data on teachers, we have information on the racial and socio-economic characteristics of the students in each school, the age of the school building, student enrollment and its rate of growth. At the district level, we have information on whether the district is in the rural, coastal or mountain region; whether there is a research university or college in the county, and whether the county is a beach county.

Intervention / Program / Practice:

The policy intervention of interest for this study is differential salaries. For much of the analysis we rely on the variation across districts in teacher salaries. Although North Carolina has a statewide salary schedule, salaries differ across the state because the local districts (of which there are 115) are able to supplement teacher salaries out of local tax revenues. In addition, we are able to examine two explicit policy interventions. One is a short-lived state-wide bonus policy that paid bonuses to teachers certified in math, science or special education who were teaching in low-performing middle and high schools. The other, implemented in two of the states' school district was an "Equity plus" program that, among other things, paid higher salaries to teachers in low performing schools.

Research Design:

This study uses secondary data analysis to examine the effects of salary differentials, combined with elements of a quasi natural experiment to examine the effects of the two specific types of policy interventions. We estimate two types of models. First we estimate a series of probit models designed to predict the probability that a school fills a vacancy with a teacher with certain strong qualifications, where strong indicates that the qualification has been shown to be predictive of higher student achievement in other studies. Among the other variables of interest in these models are the schools' racial and economic mix of students. These models generate coefficients that allow us to determine the percentage difference in salary needed to offset the negative effect on the probability of filling a slot with a teacher with strong qualification of the school's racial or economic mix. In doing so we need to pay attention to the possibility of bias in our estimates that arises from our use of secondary data.

Second, we estimate two hazard models, one for the novice teachers and one for veteran teachers who start new teaching spells during the period. The goal is to predict the probability that a teacher in a given school will leave the school in time period t+1, given she is in the school in period t. We include three forms of exit from the school: switching to another school in the same district, changing districts, or leaving the profession. In addition to a large number of control variables, these hazard models include main effects for each of three teacher qualifications, the racial and economic mix of the school's students, and the teacher's salary, as well as interactions between teacher qualification and the two variables of most interest, the teacher's salary and the demographic mix of the school's students. This specification permits us to examine not only how teacher response to salaries and to the school's demographic mix, but also to determine whether teachers with strong qualifications are differentially responsive. To determine the effects of the two specific salary interventions, we are able to embed a differences in differences specification in our overall model, which represents a quasi experimental approach.

Data Collection and Analysis:

Most of the data come from the North Carolina Education Research Data Center which obtains the data from the North Carolina Department of Public Instruction. By the time we as researcher s gain access to the data, the data center has removed all original identifiers to preserve confidentiality. As is the case with all administrative data, this data set required substantial cleaning to make it usable for our purposes and we needed to supplement it with information from other sources.

Given the importance of teacher salaries to this study, we have paid particular attention to the salaries available to teachers in other jobs. To that end, we have constructed alternative salaries for each teacher for each year for teaching and non teaching positions in nearby districts, defined as those within 30 miles of her current district. The inclusion of these alternative salaries means that we are measuring a teacher's own salary relative to the alternative salaries available to her.

For details of the data analysis strategy, see the previous section.

Findings / Results:

Our analysis first confirms the findings in the extent literature that teachers are reluctant to remain in schools with high proportions of nonwhite students, even after we control for the proportion of students eligible for free lunch. Second, we find that in making their decisions to leave a school, teachers are quite responsive to salary differentials. Taken together, these results suggest that salary differentials are potentially useful as a tool for retaining teachers in the schools serving disadvantaged students. Importantly, however, we find that teachers with the stronger qualifications are both more responsive to the racial characteristics of the students and less responsive to salary differentials than are their counterparts with weaker qualifications. As a result the salary differentials required to retain the teachers with strong qualifications are far larger than those for weaker teachers.

With respect to the specific policy interventions, we find some support for the conclusion that the Equity Plus program reduced teacher departure rates but only in one of the two districts, Charlotte-Mecklenburg, and not in the other. With respect to the statewide bonus program, our analysis supports some of our earlier research by showing that the bonuses reduce somewhat the departure rates of experienced teachers from low performing middle and high schools (Clotfelter, Gleenie, Ladd, and Vigdor 2008a and b.).

Conclusions:

Teachers are indeed responsive to salary differences but the salary differences would need to be quite large to have much impact on the willingness of the teachers with strong qualifications to teach in schools with large proportions of minority or low-income children. The bottom line is that from a societal point of view, it may well be less costly, at least from a financial perspective, to promote a more equitable distribution of high quality teachers across schools by balancing the mix of students across schools than by using salary differentials.

Appendices

Not included in page count.

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Abstract Title Page

Title: Estimating Cause: Teacher Turnover and School Effectiveness in Michigan

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Abstract Body

Background/context:

Teacher supply is a pressing educational policy issue for states. States must regularly address questions such as, "Do we have enough teachers to meet our needs? Do we have certain subjects that lack teachers?" Perhaps most importantly, however, states must address the extent to which their teacher supply issues relate to student achievement and school effectiveness.

While teacher supply can be considered from a labor market perspective, it is also important to consider the organizational nature of teacher labor force composition within each school. Ingersoll (2001) has argued that teacher turnover is an organizational feature of a school, and as thus, contributes to the culture of the school itself. Schools have distinct organizational conditions, which relate to teacher turnover and staffing problems, all of which affect performance (Ingersoll & Perda, 2009). A body of evidence suggests that the community of the school has important implications for school performance and effectiveness (Coleman & Hoffer, 1987; Rosenholtz, 1989; Bryk, Lee, & Smith, 1990). Following this research tradition, it becomes important to understand how teacher supply and demand is specific to each school, and how a school-specific supply and demand of teachers relates to other characteristics of that school.

In the teacher supply and demand literature, the bulk of the research actually focuses more heavily on calculating teacher supply than on estimating demand. The general formula for estimating supply, as outlined by NCES, is calculated as the sum of continuing teachers, teachers moving from school to school, new (first-time) teachers and re-entrants into the profession (Boe & Gilford, 1992). These supply calculations are focused on identifying all of the potential streams of teachers into the teaching force. However, since a substantial amount of the "supply" of teachers is derived from those who are retained from the previous year, an adequate estimation of supply demands strongly on the ability to model retention and attrition (Boe & Gilford, 1992). It is not surprising, then, that much of the teacher supply research focuses on teacher turnover, attrition and retention.

A key aspect of undersupply is teacher turnover, defined here as the rotation of teachers into and out of a school. This is slightly different than teacher attrition, which is more concerned with teachers leaving the profession entirely. Turnover or "churn" can be more localized to a specific school, and I argue that it is an organizational characteristic of the school itself that interacts with other key school characteristics. The local nature of teacher turnover can lead to localized teacher shortages, whereby schools that may already struggle with staffing are further challenged by a high turnover of teachers from year to year.

From an organizational perspective, however, attrition and turnover have similar effects on the schools in that both represent a decrease of staff that must be replaced (Ingersoll & Perda, 2009). Teacher turnover and attrition are important issues for states, districts and schools. Teacher attrition is costly to districts and schools; studies place the cost of hiring a new teacher at approximately $10,000 (Barnes, Crowe, & Schaefer, 2007; Milanowski & Odden, 2007; Reichardt, 2006). Teacher attrition disrupts school community and hinders school improvement efforts (Ingersoll, 2001). Finally, some evidence suggests that when qualified teachers leave, they are replaced by less qualified teachers (Reichardt, 2008). More than half of teacher turnover is migration from one school to another (Ingersoll, 2001).

One perspective in teacher supply research suggests that the teaching profession is plagued by abnormally high rates of turnover within schools, as well as high rates of attrition

from the profession entirely (Ingersoll, 2001). However, others have found that when comparing teachers to comparable fields, such as nurses, social workers and accountants, teacher turnover is not significantly higher (Harris & Adams, 2007). Stinebrickner (2002) found that exit rates are not lower in other professions, and that non-teachers change professions more but non-teachers also return to the workforce more quickly after an exit than teachers do. The crux of this argument appears to revolve primarily around pre-retirement attrition. Harris & Adams (2007) suggest that teacher attrition is lower, but that there are larger numbers of early retirements than in other professions. There is also some evidence to suggest that the distribution of teacher attrition is U-shaped, with high attrition among older and very young teachers (Grissmer & Kirby, 1997; Harris & Adams, 2007).

In general, teachers appear to leave the teaching force for a number of reasons: salary (Dolton & van der Klaauw, 1999; Shen, 1997; Loeb, Darling-Hammond, & Luczak, 2005); a feeling of a lack of empowerment or influence (Shen, 1997); and family factors, such as childbearing, especially for female teachers (Stinebrickner, 1998; 2002). There is debate about whether salary or organizational factors are more important: Stinebrickner (1998) finds that salary considerations are more important than organizational characteristics, while Hanushek, Kain, & Rivkin (2004) find that teacher attrition is related more to being in schools with lower-achieving and minority students than to salary considerations.

From the perspective of school organizational characteristics, the type of schools that tend to have high turnover are: those with high rates of student poverty (Shen, 1997; Smith & Ingersoll, 2004; Hanushek et al., 2004); small schools (Stockard & Lehman, 2004; Ingersoll, 2001); schools with high numbers of minority students (Carroll, Reichardt, & Guarino, 2000; Hanushek et al, 2004); charter schools (Smith & Ingersoll, 2004); those with a high proportion of inexperienced teachers (Shen, 1997); private schools (Smith & Ingersoll, 2004; Ingersoll, 2001; Whitener et al., 1997; Arnold, Choy & Bobbitt, 1993) and urban schools (Lankford et al, 2002). These characteristics can all be considered part of the "working conditions" that play a role in supply and demand in labor market theory (Guarino, Santibanez, & Daley, 2006). Several analyses found that working conditions, particularly large class size, facilities problems, multi-track schools, and a lack of textbooks, are more important than salary when determining teacher attrition (Loeb, Darling-Hammond, & Luczak, 2005; Futernick, 2007; Hanushek, Kain & Rivkin, 2004).

Purpose / objective / research question / focus of study:

The purpose of this paper is investigate issues related to within-school teacher supply and school-specific teacher turnover within the state of Michigan using state administrative data on Michigan's teaching force. This paper 1) investigates the key predictors of teacher turnover and mobility, 2) develops a profile of schools that are likely to experience higher rates of teacher turnover, and most importantly, 3) investigates the effect of high teacher turnover as measured by student achievement and school AYP status. Using propensity scores, this analysis seeks to isolate the potential treatment effect of lowering teacher turnover in schools that are plagued by high teacher turnover levels.

Teacher supply is defined here as specifically the within-school number of FTEs in each subject area in a given year. Teacher turnover, or "churn," is the rate at which teachers leave each school, but does not reference whether or not teachers leave the profession. Teacher attrition and retention refers to teachers leaving the teaching profession, or "stopping out" and returning at a later point.

There are two important limitations that it is important to acknowledge. The first is that these analyses do not address issues related to teacher quality, although there is a growing body of evidence that suggests that the quality of a teacher is significantly related to student performance and growth (Rivkin, Hanushek, & Kain, 2000; Sanders & Rivers, 1996, Clofelter, Ladd, & Vigden, 2007). One reason is that there are not adequate measures of teacher "quality" in the dataset, even if such a set of agreed-upon measures existed. While there is information regarding teacher licensure, this is not a good proxy for quality. Thirty-seven percent of teachers (46, 162 teachers) have professional licenses, 20% (24,385) have provisional licenses, and 25% have 18/30 hour continuing licenses (30,164). Clearly, these are not meaningful distinctions with regards to quality, as there are sure to be variations in quality among the tens of thousands of teachers who hold the same license. Secondly, this supply calculation does not explicitly include compensation levels, as suggested by some teacher supply and demand models. In Michigan, data on teacher compensation are not available at the present time (Pantal, Podgursky, Ehlert, Hull, & Schneider, 2008).

Setting:
This research is conducted using the Registry of Educational Personnel (REP) database, an administrative longitudinal database collected and maintained by the state of Michigan.

Population / Participants / Subjects:
The entire teaching force in the state of Michigan is included in this analysis. One key benefit of this dataset is that it contains the whole universe of teachers, which reduces the uncertainty inherent when conducting inferential statistics on a sample of the population.

Intervention / Program / Practice:
It is not feasible or ethical to undertake a randomized control trial with the whole population of Michigan schools, whereby some schools were assigned to have high rates of turnover and others were assigned to have low rates of turnover. However, it is possible to use a quasi-experimental design, such as a propensity score match, to estimate the effect of the treatment, decreasing teacher turnover.

Research Design:
Using a method to estimate teacher supply and demand developed to help the state of Michigan identify areas of teacher undersupply, teacher supply is generated by summing the number of FTEs within each subject within each school (Keesler, Wyse & Jones, 2008). This calculation provides an accurate depiction of the actual quantity of FTEs who are assigned to a particular school in a given year. However, these current supply calculations do not account for potential teacher attrition; by summing the FTEs taught in a given year and then comparing them with estimated demand, supply may be overestiamted by assuming that it will stay relatively constant. If a school has a particularly high attrition rate, then the number of FTEs will most likely not stay constant, which suggests that each subject-area supply calculation may need to be weighted by school- and subject-specific attrition rates. Therefore, school-specific attrition rates or "churn" are estimated using the longitudinal nature of the available administrative data, which takes into account the fact that turnover is a more localized factor, not necessarily an aggregate one. This is a departure from how other researchers tend to look at attrition (Ingersoll, 2001; Murnane, Singer, & Willett, 1998). Ingersoll and Perda (2009) disaggregate the data and looks

at shortages in specific fields. It is important to underscore that this proposed dissertation work looks at this for specific schools and specific fields, and within science, for specific endorsement-level supply/demand matches (i.e. physics endorsements for physics courses).

To examine the predictors of teacher turnover, a multilevel model is estimated, with teachers nested within schools. The outcome is the predicted probability of an individual leaving a given school. Individual level predictors include demographics, subject assignment and license type. School-level predictors include school demographics, and more importantly, the school-specific turnover rate, in order to investigate whether or not the school's level of turnover is related to individual teacher decisions to leave. Regression analyses are conducted on key predictors of school-level turnover rates, in order to isolate the factors that are most correlated with teacher turnover in a given school. The end result is a profile of both the types of schools that are likely to have high turnover rates, as well as the type of teacher that is likely to leave a given school and how school-level organizational characteristics may interact with that decision.

If teacher turnover is an integral part of the organizational culture and is related to student achievement as hypothesized, then decreasing teacher turnover should increase student achievement. To evaluate this empirically, a propensity score matching approach will be used again. First, the predicted probability of having low turnover will be estimated (with the cut-off for "low turnover" estimated based on the distribution of turnover rates for all schools). Then, schools will be matched on their propensity for low turnover. Finally, using a multinomial logit predicting membership in each of the quadrants above, the effect of low turnover will be estimated by comparing quadrant membership among schools that have equal probabilities of having high turnover but different actual turnover rates. In other words, for schools who look similar on all characteristics but who have low rates of turnover or high rates of turnover, what would the potential effect be of lowering the turnover rate in a given school in terms of both undersupply and AYP status?

Data Collection and Analysis:

The data in the REP are collected annually, in order to comply with federal regulations. Therefore, there is no new data collection necessary.

Findings / Results:

In related work the topic of teacher supply, undersupply was calculated using a demand formula generated for the state of Michigan by myself and a research team. The formula is:

$$D_i = (ax_i/y)/z \quad (1)$$

where

D_i = number of teachers needed to meet graduation requirements in a subject area
a = proportion of years that the student body is required to take in a given subject
x_i = student enrollment
y = class size
z = number of periods taught per FTE per day[††]

There appears to be an association between schools that are undersupplied and failing AYP. While many schools that are undersupplied are able to meet their AYP requirements, there

[††] See Keesler, Wyse & Jones, 2008, on the IES website (http://ies.ed.gov/ncee/edlabs/regions/midwest/pdf/techbrief/tr_00508.pdf). As this formula and the resulting undersupply calculations are not the key focus of this paper, I will limit my discussion of it here.

appears to be a pattern with respect to schools that are undersupplied and failing AYP. Schools that are undersupplied in all or any one of the four key areas and failing AYP are more likely to be high poverty, high minority, Title I, and/or located in urban areas. Failing to meet AYP targets could be more a function of the demographic profile of the schools than whether a school is undersupplied or not. Although the number of schools that are undersupplied is relatively small, the number of students affected by undersupply is not insignificant. For example, 72,798 students attend the 61 schools that are undersupplied in mathematics and ELA. Moreover, looking at the characteristics of undersupplied schools can help to target resources or potential interventions more effectively. Twenty-five percent (223) of schools are undersupplied in math, seven percent (64) are undersupplied in English/language arts, five percent (41) are undersupplied in science, and four percent (39) are undersupplied in social studies (see Table 1). Fifty-two schools are undersupplied in both math and ELA, which represents 6% of the total. A smaller number (9) are undersupplied in all core areas.

Figures 1 and 2 in Appendix B show the relationship between being undersupplied in FTEs in mathematics and ELA and the percent of the students meeting AYP targets for urban, high minority, and high poverty schools. These figures show that most of these schools are not making AYP targets and that if schools are undersupplied in FTEs it is very unlikely that the schools with these characteristics will meet AYP. For ELA, there are only five schools that are undersupplied in FTEs that are also able to meet AYP. There is only one school that is undersupplied in FTEs meeting the AYP targets for mathematics that are urban, high poverty, and high minority. Schools with these characteristics that are scoring just above the cut score are likely to have difficulty meeting AYP requirements in the future when the cut scores are raised. What is unclear, however, is the extent to which the undersupply conditions outlined above are related to teacher turnover and mobility—are schools undersupplied because of a constant "revolving door" of teachers? The additional analyses outlined here will investigate that relationship further.

Results from a separate report completed and under review by the state of Michigan find that schools with high proportions of inexperienced teachers (those with provisional licenses) are less likely to pass AYP. All of this suggests that a critical element in the relationship between undersupply and school effectiveness lies in teacher turnover, or the "churn rate" of schools. The analyses outlined here will expand on the preliminary results and provide a more complete picture of the relationship between undersupply, "churn," and school effectiveness.

Conclusions:

Preliminary results clearly suggest that the composition of a school's workforce is related to the school's AYP performance. The evidence also strongly suggests that a key element in this is teacher mobility, which is a malleable factor that a state or district could potentially target resources toward remedying. Given these two elements, the proposed analysis is positioned to provide important policy-relevant information that is actionable for policymakers and that can potentially be utilized to improve school effectiveness.

Appendix A. References

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Appendix B. Tables and Figures

Table 1: Percentage of Schools with an Undersupply of FTEs by MMC Subject Areas
(N=886 schools)

	Percent of Schools with No Undersupply of FTEs	Percent of Schools with Undersupply of FTEs	Percent of the Total High School Population Affected by the Undersupply[1,2]
Core Subjects			
Math	75% (663)	25% (223)	50% (268,031)
English Language Arts	93% (822)	7% (64)	15% (80,794)
Science	95% (845)	5% (41)	10% (51,378)
Social Studies	96% (847)	4% (39)	8% (45,049)
Undersupply of FTEs in Subjects			
Math and ELA	94% (834)	6% (52)	13% (70,619)
All core subjects	99% (877)	1% (9)	2% (12,182)

[1] Total number of students (n= 531,443) is taken from the sum of enrollments of the 886 schools in our analysis
[2] Percentages refer to the percent of students in schools that are undersupplied in the various areas

Figure 1: Undersupply of FTEs in Mathematics versus Percent above Cut Score for MEAP Mathematics Test for urban, high poverty, and high minority schools

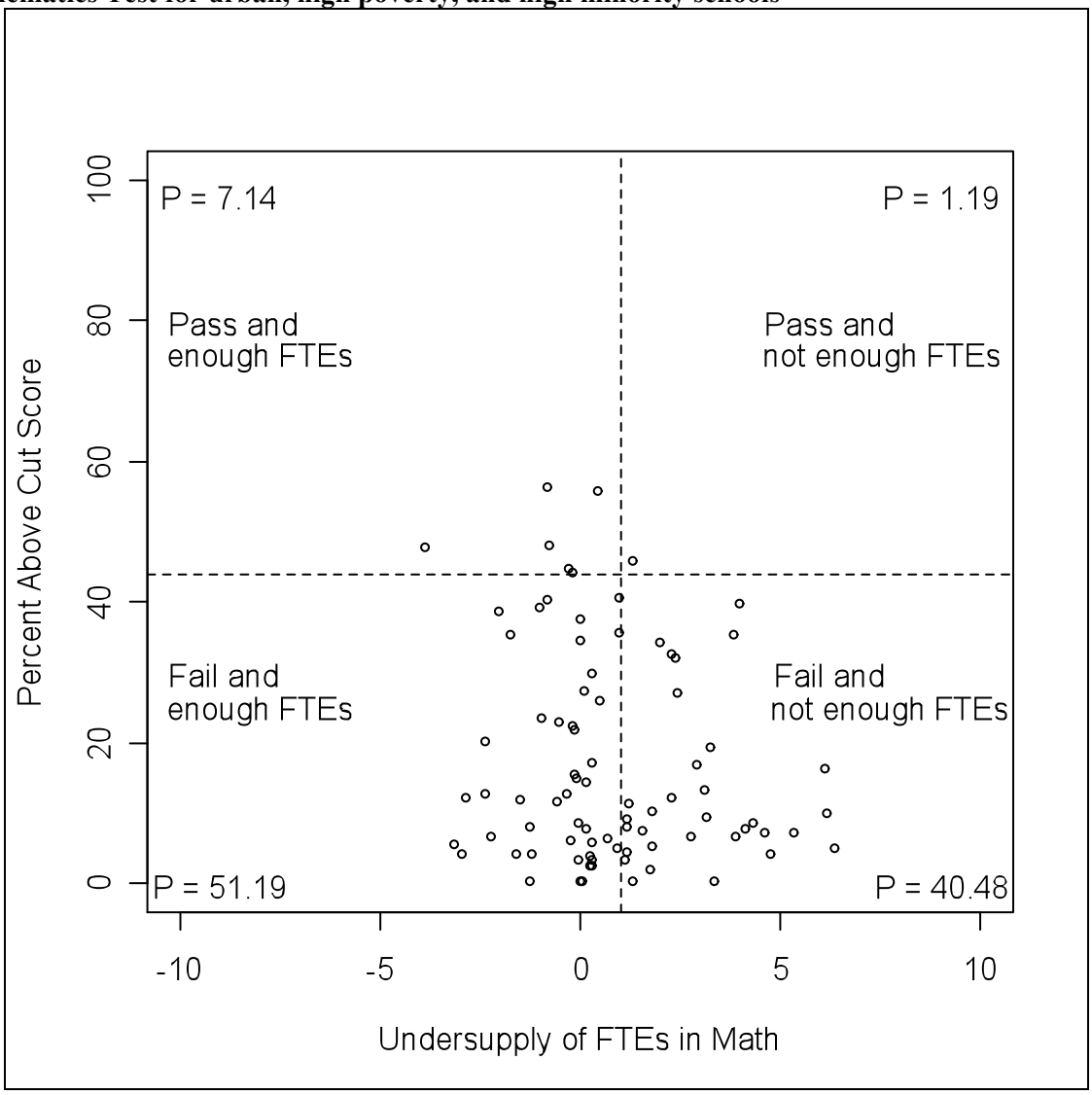

Figure 2: Undersupply of FTEs in ELA versus Percent above Cut Score for MEAP Reading Test for urban, high poverty, and high minority schools