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

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This study examines the magnitude, destinations, and determinants of mathematics and science teacher turnover. The data are from the nationally representative Schools and Staffing Survey and the Teacher Follow-Up Survey. Over the past two decades, rates of mathematics and science teacher turnover have increased but, contrary to conventional wisdom, have not been consistently different than those of other teachers. Also, contrary to conventional wisdom, mathematics and science teachers were also no more likely than other teachers to take noneducation jobs, such as in technological fields or to be working for private business or industry. The data also show there are large school-to-school differences in mathematics and science turnover; high-poverty, high-minority, and urban public schools have among the highest rates. In the case of cross-school migration, the data show there is an annual asymmetric reshuffling of a significant portion of the mathematics and science teaching force from poor to not-poor schools, from high-minority to low-minority schools, and from urban to suburban schools. A number of key organizational characteristics and conditions of schools accounted for these school differences. The strongest factor for mathematics teachers was the degree of individual classroom autonomy held by teachers. Net of other factors such as salaries, schools with less classroom autonomy lose math teachers at a far higher rate than other teachers. In contrast, for science teachers salary was the strongest factor, while classroom autonomy was not strongly related to their turnover.

Keywords: *teacher career paths; teacher turnover; math and science teachers*

Introduction

Few educational issues have received more attention in the past two decades than the challenge of staffing the nation's classrooms with qualified mathematics and science teachers (see, e.g., Darling-Hammond, 1984; National Academy of Sciences, 1987; National Commission on Excellence in Education, 1983). In recent years, high-profile reports from organizations such as the John Glenn National Commission on Mathematics and Science Teaching for the 21st Century (2000), the National Research Council (2002), and the National Academy of Sciences (2007) have directly tied mathematics and science teacher staffing problems to multiple educational and societal problems—to low U.S. educational performance compared to other nations, to the minority achievement gap, and to national economic competitiveness. There are a number of competing explanations concerning the sources of, and solutions to, these mathematics and science staffing problems. One of the most prominent explanations focuses on teacher shortages. At the root of the problem, in this view, is an insufficient production and supply of mathematics and science teachers in the face of increasing student enrollments and increasing teacher retirements. Subsequent shortages, this view continues, force many school systems to lower standards to fill teaching openings, in turn inevitably leading to high levels of underqualified mathematics and science teachers and lower student performance (e.g., National Commission on Teaching and America's Future, 1996, 1997; U.S. Department of Education, 2002). Researchers and policy analysts have long held, moreover, that these shortfalls fall disproportionately on schools in disadvantaged high-minority and high-poverty communities and are a major factor in unequal educational and ultimately, occupational outcomes (e.g., Darling-Hammond, 1984; National Commission on Teaching and America's Future, 1996, 1997; Quartz et al., 2008).

The prevailing policy response to teacher shortages, both now and in the past, has been to attempt to increase the supply of teachers (Darling-Hammond, 2007; Feistritzer, 1997; Fowler, 2008; Hirsch, Koppich, & Knapp, 2001; Liu, Rosenstein, Swann, & Khalil, 2008; Lortie, 1975; Rice, Roellke, Sparks, & Kolbe, 2008; Theobald, 1990; Tyack, 1974). Over the years, a wide range of initiatives have been implemented to recruit new candidates into teaching. Among these are career-change programs, such as "troops-to-teachers," designed to entice professionals into mid-career switches to teaching, and Peace Corps–like programs, such as Teach for America, designed to lure academically talented candidates into understaffed schools. Many states have instituted alternative certification programs, whereby college graduates can postpone some or all of their formal education training and begin teaching immediately. Some school districts have resorted to recruiting teaching candidates from overseas. Scholarships, financial incentives, student loan forgiveness, housing assistance, and tuition reimbursement have all been instituted to aid recruitment. These initiatives often have been targeted in particular to mathematics and science (e.g., Fowler, 2008; Liu et al., 2008). In contrast to this historical focus on understanding the factors that attract individuals to teaching and the means to recruit new candidates into the occupation, there has been relatively less attention paid to the role of teacher turnover, migration, mobility, and attrition in these staffing problems (Hirsch et al., 2001; Ingersoll, 2001; Rice et al., 2008; Theobald, 1990).

The Importance of Employee Turnover

There is a long tradition of research in the fields of labor economics and organization theory on the consequences, positive and negative, of employee turnover for individuals, for organizations, for the larger economy, and across a range of industries and occupations (e.g., Abelson & Baysinger, 1984; Becker, 1993; Dalton, Todor, & Krackhardt, 1982; Hom & Griffeth, 1995; Jovanovic, 1979a, 1979b; Mobley, 1982; Oi, 1962; Price, 1977, 1989; Siebert & Zubanov, 2009). In general, theory and research in these traditions holds that some degree of employee turnover, job, and career change is normal, inevitable, and can be efficacious for individuals, for organizations, and for the economic system as a whole (e.g., Kimmitt, 2007). Moreover, a number of analysts have held that job transition and turnover has increased in the post–World War II economy, lifelong careers are decreasingly the norm, and there has been growth in the average number of jobs, employers, and careers held by individuals over their working lives (e.g., Sullivan, 1999).

On the other hand, theory and research on employee turnover have also long held that employee turnover can be both the cause and effect of problems in organizations. From this perspective, employee turnover is of concern not only because it may be a symptom of underlying problems in how well organizations function but also because departures can entail costs for organizations and for the larger system. In this literature, there is a general consensus that there are a variety of different types of costs and consequences associated with employee turnover, including the loss of human capital, and investments in employee development, the costs of replacement hiring and training, and disruption of production processes, and that such costs vary by industry and occupation (e.g., Price, 1989).

The Importance of Teacher Turnover

In contrast to the industrial and corporate sectors, until recently there has been little research on, or attention to, the costs and benefits, functions and dysfunctions of the turnover of teaching employees in the education sector. In recent years this gap has begun to be addressed. In a companion research study we examined national data to empirically evaluate the adequacy of the supply of qualified mathematics and science teachers and to empirically investigate the role of teacher turnover in mathematics and science shortages (Ingersoll & Perda, 2012). The data confirm that schools have more difficulty hiring mathematics and science teachers than any other field. But the data show these school staffing problems are not simply a result of an insufficient production of new mathematics and science teachers. Indeed, our data document that over the past two decades the supply of newly qualified mathematics and science teachers has more than kept pace with both increases in student enrollments and with increases in teacher retirements. However, this is not the case when we include the departures of teachers before retirement—a figure that is many times larger than retirement and a primary factor behind the need for new hires. Unlike fields such as English, there is not a large cushion of new mathematics and science teachers relative to preretirement turnover, making schools with higher turnover more likely to have problems staffing classrooms with qualified teachers. In short, the data document that one negative consequence of mathematics and science teacher turnover is its connection to the larger mathematics and science staffing problems—the so-called shortages—that confront many schools.

There have also been a growing number of efforts to identify and empirically measure the financial costs of teacher turnover (e.g., Alliance for Excellent Education, 2005; Barnes, Crowe, & Schaefer, 2007; Milanowski & Odden, 2007; Texas Center for Educational Research, 2000; Villar & Strong, 2007; also see Harris, 2009). Moreover, there have been a growing number of studies that have tried to discover whether turnover involves the loss of higher or lower caliber teachers by examining the relationship between teacher turnover and various measures of teacher quality, such as teachers' test scores, the selectivity of teachers' undergraduate institutions, teachers who have obtained National Board Certification, and student test-score gains (e.g., Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2007; Clotfelter, Ladd, & Vigdor, 2006; Committee on Evaluation of Teacher Certification by the National Board for Professional Teaching Standards, 2008; Goldhaber, Gross, & Player, 2007; Krieg, 2004). Several recent efforts have explored the impact of teacher turnover on Schoolwide performance (Keesler, 2010; Levy, Ellis, Joy, Jablonski, & Karelitz, 2010; Meier & Hicklin, 2007). Finally, there have also been some attempts to understand the impact of teacher turnover on long-term school improvement efforts (Smylie & Wenzel, 2003; for a more detailed examination of the relative levels and consequences of teacher turnover, see Ingersoll & Perda, 2012).

Along with this growing research base, in the realm of educational policy and reform there has been increasing attention to teacher turnover, and a growing consensus that teacher turnover has been a perennial problem in a substantial segment of the elementary and secondary school population, and especially in fields with staffing problems such as mathematics and science (e.g., Alliance for Excellent Education, 2005; Behrstock, 2009; Liu et al., 2008; National Commission on Teaching and America's Future, 2003). With this recognition has also come a growing demand for evidence on the sources of, and reasons behind, teacher turnover and retention, especially for fields such as mathematics and science, to provide direction on how to improve retention.

Research on Mathematics and Science Teacher Turnover

Understanding the determinants, predictors, and sources of teacher turnover has been the subject of substantial empirical research (for comprehensive reviews, see Borman & Dowling, 2008; Guarino, Santibanez, & Daley, 2006; Johnson, Berg, & Donaldson, 2005). Such research has provided increasing insight into the impact on turnover of a wide range of factors, both individual and school level, both extrinsic and intrinsic. Among the findings has been that teacher turnover is related to the teaching field. Although the data have been inconsistent at times, special education, mathematics, and science are typically found to be the fields of highest turnover (Grissmer & Kirby, 1992; Henke, Zahn, & Carroll, 2001; Ingersoll, 2006; Murnane, Singer, Willett, Kemple, & Olsen, 1991; Rumberger, 1987; Weiss & Boyd, 1990). Moreover, analysts have hypothesized that mathematics and science teachers are more likely to leave at higher rates because they are more likely than other teachers to have alternative career options in the business and technological sectors, often with higher salaries (e.g., Murnane et al., 1991; Rumberger, 1987).

However, there are important limitations to the existing empirical research—specifically for understanding and addressing mathematics and science teacher turnover. For instance, there is a dearth of information on whether mathematics and science teacher turnover is disproportionately concentrated in particular types of schools, which types of schools have higher levels of mathematics and science teacher turnover and, for those who migrate from one school to another, to what kinds of schools they move. There has been little empirical research on where mathematics and science teachers go after departing from teaching, and for what kinds of jobs and occupations mathematics and science teachers leave. Moreover, little is known about which aspects, conditions, policies, and characteristics of districts and schools, especially those more amenable to policy, are related to mathematics and science teacher turnover, especially with large-scale representative data. In particular, there has been little research examining how organizational factors, such as the quality of principal leadership, the degree of faculty input into decision making, teacher classroom autonomy, professional development opportunities, and the adequacy of school resources affect math and science teacher turnover. In addition, much of the empirical research has tended to focus on, or emphasize, some components of the overall flow of teachers from schools, while omitting others. Finally, there has been little research that examines how the above issues concerning the magnitude, destinations, and determinants of turnover may differ between math and science teachers. These limitations have meant that there is limited understanding of the magnitude, destinations, and determinants of the attrition, turnover, and the interorganizational mobility of mathematics and science teachers. Addressing these gaps is the objective of our study.

The Study

Our study uses nationally representative data to provide a comprehensive examination of the preceding questions and issues surrounding mathematics and science teacher turnover. There are three sets of specific research questions we seek to address:

1. *Magnitude:* What is the overall magnitude of mathematics and science teacher mobility and attrition? How do the turnover rates of mathematics/science teachers compare to those of other teachers? Have their turnover rates changed over time? How much do schools differ in their turnover? How much of the overall amount of turnover is concentrated in particular types of schools? Which types of schools have higher levels of mathematics/science teacher turnover?
2. *Destinations:* What are the destinations of mathematics/science teachers who move from, or leave, their teaching jobs? What proportions of those departing move to teaching jobs in other schools, quit to care for children and families, go to graduate school, retire, go into nonteaching occupations within the larger education sector (e.g., school administration, curriculum development or higher education, etc.), or go into noneducational occupations? Of those who move from one school to another, do their new schools differ from their original schools, in terms of school demographic characteristics?
3. *Determinants:* What are the reasons for mathematics and science teacher turnover? How do teacher effects compare with school effects on turnover? Which particular aspects and conditions, of schools and of teachers' jobs, especially policy-amenable factors, are most tied to the turnover of mathematics and science teachers? What is the cumulative and joint impact of changes in multiple aspects of schools on turnover?

The theoretical perspective (see Figure 1) we adopt in our research draws from the sociology of organizations, occupations, and work and the interdisciplinary field of organizational theory. Our operating premise is that in order to fully understand the causes and consequences of school turnover and staffing problems, it is necessary to examine these issues from the perspective of the schools and districts where these processes happen and within which teachers

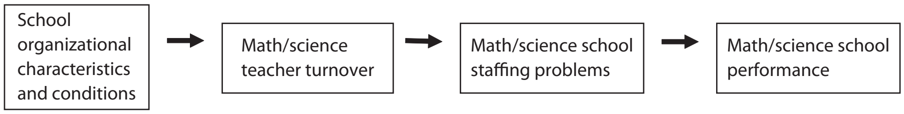

FIGURE 1. *An Organizational Perspective on the Causes and Consequences of Mathematics/Science School Staffing Problems*

work. By adopting this perspective, we seek to discover the extent to which staffing problems in schools can be usefully reframed from macrolevel issues, involving major societal demographic trends, to organizational-level issues, involving manipulable and policy-amenable aspects of particular schools and their districts. Our focus in this study is the relationships depicted on the left side of Figure 1—examining the levels, directions, and variations of mathematics and science teacher turnover and identifying the characteristics and conditions of school that are related to these departures.

Employee supply, demand, and turnover have long been central issues in organizational theory and research (e.g., Hom & Griffeth, 1995; Price, 1977, 1989). However, there have been few efforts to apply this theoretical perspective to educational research. Following, we provide a summary of two general interrelated premises underlying our analysis that we draw from this perspective.

The first is that fully understanding turnover requires examining it at the level of the organization. This premise shaped the methodology we used. Following this perspective, we compare the variation in turnover rates at the state, district, and school levels to establish the portion that lies at different levels and, in particular, between schools. We then aggregate turnover to the school level and investigate the distribution and concentration of turnover across the school population.

Our perspective also shapes which types and components of employee separations from organizations we deem relevant. Research on teacher turnover has often focused on those leaving the occupation altogether, here referred to as teacher attrition, and has often de-emphasized those who transfer or move to different teaching jobs in other schools, here referred to as teacher migration. The logic is that the latter moves are a less significant form of turnover because they do not increase or decrease the overall supply of teachers, as do retirements and career changes and, hence, do not contribute to overall shortages. From a systemic level of analysis, this may be correct. However, from an organizational-level perspective, employee migration is as relevant as employee attrition. The premise underlying our perspective is that, whether those departing are moving to a similar job in another organization or leaving the occupation altogether, their departures similarly impact and are impacted by the organization. For this reason, this distinction is rarely noted in the larger literature on employee turnover, and research on other occupations and organizations almost always includes both cross-organization movers and occupational leavers (see, e.g., Price, 1977). Here, we also include both. Furthermore, we investigate the rates and types of cross-school migrations and the degree of symmetry in cross-school migration, by comparing the characteristics of movers' original and destination schools.

The same holds for temporary attrition—those who leave teaching for a year or more and then return. The latter, of course, do not represent a permanent loss of human capital from the teacher supply and, hence, do not permanently contribute to overall shortages. Indeed, we have shown elsewhere (Ingersoll & Perda, 2010) that the re-entrance of former teachers is a major source of new supply. However, temporary attrition, like migration, can contribute to school staffing problems. Again, from an organizational perspective, temporary attrition results in a decrease in staff that usually must be replaced, regardless of whether those leaving later return to that same school or another.

A second premise underlying our theoretical perspective is that fully understanding turnover requires examining the character and conditions of the organizations within which employees work and that there can be a significant role for the management of particular schools in both the genesis of, and solution to, school staffing problems. A long tradition of research has shown that, in addition to the perceptions and characteristics of individual employees, the overall conditions of workplaces and job sites significantly affect the attachment of employees to the organization (e.g., Cotton & Tuttle, 1986; Griffeth, Hom, & Gaertner, 2000; Halaby & Weakliem, 1989; Hom & Griffeth, 1995; Kalleberg & Mastekaasa, 1998; Mobley, 1982; Mueller & Price, 1990; Price, 1977). This premise also shaped the methodology we used. Following this perspective, we empirically compare the relationship to turnover of both overall schoolwide conditions and each individual's own perceptions of school conditions. Moreover, recognizing that the various conditions in schools are interrelated, we examine the cumulative and joint impact of changes in multiple aspects of schools on turnover.

In the next section, we describe our data source, define our measures, and describe our methods. In the following sections of this article, we present our results sequentially for each of our three research questions. We then conclude by summarizing our findings and then discussing their implications for understanding and addressing mathematics and science school staffing problems.

Data and Methods

Data

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 Follow-Up Survey (TFS). This is the largest and most comprehensive data source available on the staffing, occupational, and organizational aspects of elementary and secondary schools. The U.S. Census Bureau collects the SASS data for NCES from a random sample of schools stratified by state, public/private sector, and school level (for information on SASS, see NCES, 2005). There are six SASS cycles to date: 1987–1988, 1990–1991, 1993–1994, 1999–2000, 2003–2004, and 2007–2008. Each cycle of SASS includes separate, but linked, questionnaires for school and district administrators and for a random sample of teachers in each school. In addition, after 12 months, the same schools are again contacted and all those in the original teacher sample who had moved from or left their teaching jobs are given a second questionnaire to obtain information on their departures. This latter group, along with a representative sample of those who stayed in their teaching jobs, comprise the TFS. Unlike most previous data sources on teacher turnover, the TFS is large, comprehensive, nationally representative; includes the reasons teachers themselves give for their departures; and includes a wide range of information on the characteristics and conditions of the schools that employ teachers. It also is unusual in that it does not solely focus on a particular subset of separations, but includes all types of departures (for information on the TFS, see Chandler, Luekens, Lyter, & Fox, 2004).

Our analysis uses data primarily from the 2003–2004 SASS and the 2004–2005 TFS. The 2004–2005 TFS has the advantage of having a larger sample size than the more recent 2008–2009 cycle of TFS. We focus on public sector schools (including charter schools). The 2003–2004 SASS sample is comprised of 43,244 teachers (of which 5,189 teachers are math or science) from 8,747 public schools. The 2004–2005 TFS sample is comprised of 5,323 teachers (of which 279 teachers are math and 383 are science) from 3,763 public schools. Our analyses use the final NCES supplied weights in order to obtain unbiased estimates of the national population of schools and teachers in the year of the survey.

Measures and Methods

Our analyses compare qualified mathematics teachers, with qualified science teachers, with all other teachers (those not qualified in either mathematics or science or both). There is a great deal of debate concerning how to define teachers as "qualified" in any given field. Here, we adopt a postsecondary major-based definition—roughly equivalent to that used in the No Child Left Behind Act (NCLB). We define a teacher as qualified in a field if he or she holds an undergraduate degree, or a graduate degree, in that or a related field. We count as qualified both noneducation and subject-area education degrees. For mathematics, we define as qualified those who indicated they had completed an undergraduate or graduate major in mathematics or mathematics education. We define qualified science teachers as those who indicated they had completed an undergraduate or graduate major in science education, biology, physics, chemistry, earth science, another natural science, or engineering. Eighty-five percent of these qualified mathematics and science teachers were employed in departmentalized settings at the middle or secondary school levels. The remainder was employed in primary schools, usually as math instructors in mathematics enrichment courses, rarely as regular multiple-subject elementary school teachers. Like NCLB, we do not count as qualified those with only a teaching certificate in a field, absent a degree or major in that field. Unlike NCLB, we do not use teachers' test scores (such as Praxis) as a means of assessing qualifications in a field because our data do not have such information. Moreover, we do not base our definition of qualified teachers on a respondent's teaching assignments, where, for example, a teacher assigned to teach mathematics is assumed to be qualified in mathematics. Identifying teachers according to their fields of assignment can be inaccurate because of the widespread practice of out-of-field teaching, in which teachers are assigned to teach subjects for which they have few formal qualifications (Ingersoll, 1999). We chose a major-based method of identification because it represents those teachers with a credential signifying human capital in the field—the subject of major policy concern. But, note, we do not focus on, nor distinguish, the quality, character, match, fit, effectiveness, or performance of teachers. All of the latter are, of course, crucial from both a theoretical and policy perspective. But parallel to most analyses of labor supply and demand, we focus on qualified employees.

Our analysis is divided into two stages. In the first stage, we present mostly descriptive statistics to address our three research questions. In the second stage, we follow up with a detailed multiple logistic regression analysis of the predictors of turnover to further address the third research question. Next, we describe these stages of our analysis.

In the first stage, we analyze data primarily from the TFS to summarize the rates, levels, magnitude, and concentration of turnover for mathematics, science, and nonmathematics/-science teachers. We examine the types of schools mathematics and science teacher migrants move from and to, and the types of jobs and occupations leavers go to. We then examine the reasons teachers themselves give for their migration and attrition drawn from sets of items in the 2004–2005 TFS questionnaire that asked teacher-respondents to indicate the importance of various factors for their departures. Self-report data such as these are useful because those departing are, of course, often in the best position to know the reasons for their departures. But such data are based on the subjective attributions by those who had earlier departed, introducing possible attribution bias. Moreover, the items are often general (e.g., "dissatisfied with teaching") and do not indicate which specific aspects of teaching, or of schools, are related to turnover. To address these limits, we follow up in our second stage with a regression analysis that examines the association with turnover of a more specific set of school organizational characteristics/conditions, based on data from the full set of respondents in the SASS (including both those who stayed and those who later departed).

In the regression models, the dependent variable—teacher turnover—is based on whether each teacher remained with the school, moved to another school, or left teaching within 1 year after the 2003–2004 SASS administration. The 2004–2005 TFS, which includes only about 12% of teachers from the original SASS sample, only has 279 mathematics and 383 science teachers. To increase the sample size specifically for our regression analyses, we combined the TFS measure of turnover with a preliminary measure of turnover collected from school principals for the entire SASS teacher sample (from the 2004–2005 TFS Teacher Status Survey).[1] This increased our sample size to 43,244 teachers, including 5,189 in math or science.

We progressively examine three groups of predictors of turnover: teacher characteristics, school characteristics, and organizational conditions. Table 1 provides definitions for these variables. Table 2 provides mean teacher characteristics, school characteristics, and organizational conditions associated with the teachers in the combined SASS/TFS sample.

Following previous research on teacher turnover, in the regression models we include control variables for several key individual teacher characteristics: race/ethnicity, gender, and age. Because of its U-shaped relationship, we transform age into a three-category set of dummy variables—younger (less than 30), middle-aged (31–50), and older (greater than 50).

Following previous research on schools (e.g., Bryk et al., 1990; Chubb & Moe, 1990; Coleman & Hoffer, 1987), in the regression models, we include, as independent variables, school characteristics typically found to be important in this literature: school level, school size, the type of school locale (i.e., urban, rural, suburban), and the proportion of the student population in poverty (i.e., eligible for free or reduced lunch).[2]

Finally, after controlling for the preceding teacher and school factors, we focus on the relationship to turnover of eight key aspects of the organizational character and conditions in schools: teacher salary, student discipline problems, leadership and support, school resources, faculty schoolwide decision-making influence, teacher classroom autonomy, professional development (PD) activities focused on student discipline and classroom management, and PD activities focused on the teacher's subject-area content. This study does not attempt to provide a comprehensive analysis of all the many aspects of schools that may possibly impact the turnover of mathematics and science teachers. We focus on this set of eight particular characteristics of schools because they have long been considered among the important aspects of effective school organization (see, e.g., Goodlad, 1984; Coleman & Hoffer, 1987; Grant, 1988; Chubb and Moe, 1990; Bryk et al., 1990; Guarino, Santibanez & Daley 2006; Smylie & Wenzel 2003), are important indicators of the professional status of an occupation (Darling-Hammond 2007; Rosenholtz 1989; Sizer 1992; Talbert & McLaughlin 1993; Ingersoll 2003; Ingersoll & Merrill, 2012), are ostensibly policy amenable, have not been investigated for math and science teacher turnover, and are available from our data source.

Unlike most empirical analyses that use either individual teacher's salaries or the school's mean teacher salary, we use the normal yearly base salary for teachers at the highest step on the district salary schedule because it better assesses differences in the organizational-level compensation structure.[3] For the measure of student discipline problems within the organization, we use an index of eight items on student misbehavior, crime, abuse, conflict, disrespect, and theft within schools, as reported by teachers. For the measure of school leadership and support, we utilize an index of five items on the degree of assistance, the expectations, recognition, and leadership communicated or provided to the faculty by the school principal, as reported by teachers. For the measure of school resources, we use one item on the degree to which necessary materials and resources are provided, as reported by teachers. For the measure of Schoolwide faculty decision-making influence, we use an index of seven items on the degree of collective faculty input into decisions concerned with school policies over budgets, the curriculum, hiring, standards, student discipline, PD, and teacher evaluation, as reported by teachers. For the measure of teacher classroom autonomy, we use an index of six items on the degree of individual teacher control in their classrooms over course content, textbook choice, homework, student discipline, student evaluation, and techniques, as reported by teachers. For the measures of PD activities, we utilize two items on the usefulness of activities focused on student discipline and classroom management and also on subject-area content, as reported by teachers.

This second stage of the analysis examines whether the likelihood of individual teachers moving from or leaving their teaching jobs is related to the above measures of school organizational characteristics and conditions, while controlling for individual-level characteristics of teachers and school demographic characteristics. To discern if, and to what extent, mathematics and science teachers' likelihood of departure are more or less likely to be related to our range of school characteristics and organizational conditions, in our models we include interaction terms between each of these predictors and our measures for both mathematics and science teachers. Because different school organizational conditions are often interrelated, and their relations to turnover possibly confounded, along with a full model, we also estimate the

TABLE 1

Definitions of Measures Utilized in the Regression Analysis

Teacher Turnover: a dichotomous variable where 1 = *not teaching in same school as last year* and 0 = *stayer/currently teaching in same school*.

Teacher Characteristics

Young: a dichotomous variable where 1 = *teacher less than 30 years of age* and 0 = *other teachers*.

Old: a dichotomous variable where 1 = *teacher older than 50 years of age* and 0 = *other teachers*.

Male: a dichotomous variable where 1 = *male teacher* and 0 = *female teacher*.

Minority: a dichotomous variable where 1 = *non-White teacher* and 0 = *other teachers*.

Teacher Field

Math: a dichotomous variable where 1 = *degree in math or math education* and 0 = *all other teachers*.

Science: a dichotomous variable where 1 = *degree in one of the sciences or science education* and 0 = *all other teachers*.

School Characteristics

Rural: a dichotomous variable where 1 = *rural* and 0 = *suburban or urban*.

Suburban: a dichotomous variable where 1 = *suburban* and 0 = *rural or urban*.

Secondary level: a dichotomous variable where 1 = *junior or senior secondary* and 0 = *elementary or middle or combined* (K-12).

Size: student enrollment of school.

Poverty enrollment: percentage of students eligible for the federal free or reduced-price lunch program for students from families below poverty level.

Organizational Characteristics/Conditions

Highest salary: for districts with a salary schedule for teachers, normal yearly base salary highest step, or if no district salary schedule, the highest teacher yearly base salary, as reported by school administrators.

Student discipline problems: on a scale of 1 = *never happens* to 5 = *happens daily*, the school mean of teachers' reports for eight kinds of student discipline problems: disruptive behavior; absenteeism; physical conflicts among students; robbery; vandalism; weapon possession; physical abuse of teachers; verbal abuse of teachers.

School leadership support: on a scale of 1 = *strongly disagree* to 4 = *strongly agree*, the school mean of teachers' reports for four items: principal communicates expectations; administration is supportive; principal enforces rules for student discipline; principal communicates objectives; staff are recognized for job well done.

School resources: on a scale of 1 = *strongly disagree* to 4 = *strongly agree*, the school mean of teachers' reports for one item: necessary materials such as textbooks, supplies, and copy machines are available as needed by the staff.

Schoolwide faculty influence: on a scale of 1 = *none* to 4 = *a great deal*, the school mean of collective faculty influence over seven areas: student performance standards; curriculum; content of in-service programs; evaluating teachers; hiring teachers; school discipline policy; deciding spending of budget.

Classroom teacher autonomy: on a scale of 1 = *none* to 4 = *a great deal*, the school mean of individual teachers' control over six areas: selecting textbooks and other instructional materials; selecting content, topics and skills to be taught; selecting teaching techniques; evaluating and grading students; determining the amount of homework to be assigned; disciplining students.

Student-discipline-focused professional development: on a scale of 1 = *not receive or not useful* to 4 = *very useful*, the school mean of teachers' reports of the usefulness of any professional development activities that focused on student discipline and management in the classroom.

Subject-content-focused professional development: on a scale of 1 = *not receive or not useful* to 4 = *very useful*, the school mean of teachers' reports of the usefulness of any professional development activities that focused on the content of the subjects they taught.

We used factor analysis (with varimax rotation method) to evaluate our indices of student discipline problems, school leadership, faculty influence, and teacher autonomy. We considered item loadings of at least .4 necessary for inclusion in a factor. No items loaded on more than one factor. Each factor had high internal consistency ($\alpha > .7$). The measures of student discipline problems, leadership, resources, faculty influence, teacher autonomy, and professional development are all school means of the reports of the total SASS teacher sample for each school and not limited to the reports of those in the smaller TFS sample.

TABLE 2
Descriptive Statistics for Independent Variables Utilized in Regression Analysis

	Proportion		
Categorical Predictor Variables	All Teachers	Mathematics	Science
Teacher characteristics			
Young	.17	.17	.14
Old	.30	.29	.30
Male	.25	.39	.47
Minority	.17	.15	.18
Teacher field			
Mathematics	.05	1.0	0.0
Science	.07	0.0	1.0
School characteristics			
Rural	.19	.21	.18
Suburban	.52	.55	.50
Secondary	.30	.66	.59

	M (*SD*)		
Continuous Predictor Variables	All Teachers	Mathematics	Science
School characteristics			
School size (in 100s)	8.04	10.97	10.74
	(6.07)	(7.62)	(7.45)
Poverty enrollment (in 10s)	4.12	3.28	3.77
	(2.93)	(2.50)	(2.85)
Organizational characteristics/conditions			
Highest salary (in $10,000s)	6.08	6.01	6.15
	(1.30)	(1.29)	(1.32)
Student discipline problems (scale 1–5)	2.29	2.43	2.52
	(0.71)	(0.69)	(0.72)
School leadership support (scale 1–4)	3.32	3.24	3.21
	(0.65)	(0.66)	(0.66)
School resources (scale 1–4)	3.14	3.25	3.06
	(0.89)	(0.84)	(0.93)
Faculty influence (scale 1–4)	2.21	2.18	2.13
	(0.61)	(0.59)	(0.60)
Teacher autonomy (scale 1–4)	3.38	3.39	3.37
	(0.52)	(0.46)	(0.52)
Discipline-focused prof. dev. (scale 1–4)	1.77	1.57	1.62
	(1.04)	(0.92)	(0.95)
Content-focused prof. dev. (scale 1–4)	2.64	2.45	2.46
	(1.03)	(1.05)	(1.09)

Note. Means and deviations are at the teacher level and associated with teachers in the sample.

coefficients for each measure of school organizational conditions in a separate model in order to avoid the problem of multicollinearity.

As mentioned earlier, our measures of organizational conditions, other than salaries, are based on teachers' self-reports. Teachers' responses within any individual school, of course, may vary because teachers within the same building may differ as to how positive or negative they perceive various conditions to be. In background analyses we partitioned the variance of each measure of organizational conditions into within-school and between-school components. The intraclass correlation, or the portion of the variation that lies between schools, ranged from 13% for subject-area PD to 43% for student discipline, indicating that part of each measure is unique to each teacher respondent and that part is common to all teachers within a school.

Following our theoretical perspective, we try to capture and compare both components in our analyses, by using two types of measures of organizational conditions: averages across the teachers in each school and the extent to which individual teachers differed from others in their building. In our models, use of the school-average measures tells us whether particular organizational conditions on average are related to turnover; the teacher-deviation measures tell us whether individuals who perceived conditions differently than other faculty in their school were also more or less likely to depart than were others. This allows our analysis to compare the direction and magnitude of the relationship of turnover with schoolwide conditions and with individuals' own perceptions. This also allows us to partly address the issue of attribution bias, mentioned earlier. For instance, a highly satisfied or highly disgruntled individual might be more or less likely to depart, while also over- or underestimating organizational conditions, making it appear there is a relationship between the two. Using separate measures for school averages and individual deviations allows us to partly address this individual bias.

It is important to recognize the distinction in interpretation of our school-level and individual-level organizational conditions variables. While both variables are based on teachers' perceptions of conditions in a school, the response of any individual teacher is likely a function of the actual state of organizational conditions in the school, along with that teacher's personal opinion (which may not match those of other teachers in the same school) and that teacher's ability and willingness (or not) to provide frank and accurate ratings of school conditions. Therefore, while the school-level aggregation of these organizational conditions is based on the reports of all responding teachers in the school and is likely to be a useful indicator of actual conditions in that school, the individual teacher measures may or may not reflect actual differences in conditions for any one teacher. Instead, these individual-level variables may reflect differences in personal attitudes, perceptions, or characteristics that are unrelated to actual conditions. These parameters may likely be influenced substantially by individual differences between teachers that are not a function of schoolwide conditions but that influence teachers' responses to the SASS survey items. Our underlying assumption is that it is useful to estimate and control for the direction and magnitude of the relationship between turnover and these individual-level measures of teacher's perceptions of conditions.

This strategy of separating school characteristics into school-level and teacher-level indicators has a strong foundation in multilevel or hierarchical modeling (Raudenbush & Bryk, 2002) and contextual effects analysis (Iversen, 1991). These include multilevel analyses in which variables representing group means and contextual characteristics are included as predictors in the model and individual variables are expressed as deviations from the group means (Kreft, De Leeuw, & Aiken, 1995; Raudenbush & Bryk, 2002, p. 33). Here, we examine and compare organizational conditions as contextual effects versus individual effects.[4]

Our analysis used PROC GENMOD in SAS (Version 9.2) because it adjusts for the nonrandom clustering of teachers within schools resulting from the multilevel structure of the sample and uses within- and between-school predictor variables to estimate separate effects across multiple levels. This procedure also supports logistic regression and allows for the inclusion of sampling design weights. Use of weights is necessary because the SASS and TFS samples over- or undersample certain segments of the teaching population. While the TFS data are longitudinal in the sense that the turnover outcomes transpired a year after the collection of the SASS measures of school characteristics and organizational conditions, it is important to note that any relationships found between these variables and turnover represent statistical associations between measures and do not imply causality.

Results

The Magnitude of Mathematics and Science Teacher Turnover

Elementary and secondary teaching is one of the largest occupations in the United States—it represents 4% of the entire nationwide civilian workforce. There are, for example, over twice as many K–12 teachers as registered nurses and

TABLE 3

Percentage Annual Public School Teacher Migration, Attrition, and Total Turnover, by Field and by Year

	Nonmath/Science				Math				Science			
Year	Move	Leave	Total	*N*	Move	Leave	Total	*N*	Move	Leave	Total	*N*
1988–1989	8.1	5.7	13.8	4022	7.0	5.0	12.0	365	6.2	5.0	11.2	503
1991–1992	7.3	5.3	12.6	3975	7.1	3.6	10.7	365	7.3	4.9	12.2	502
1994–1995	7.1	6.6	13.7	3953	8.0	7.3	15.3	279	7.7	5.2	12.9	330
2000–2001	7.7	7.4	15.1	4394	7.7	6.5	14.2	323	7.4	9.0	16.4	428
2004–2005	8.3	8.4	16.7	4614	9.0	7.1	16.1	279	5.1	7.2	12.3	383

five times as many teachers as either lawyers or professors (U.S. Bureau of the Census, 2008). Numerically, there are also large flows of teachers into, between, and out of schools each year. For instance, the SASS data show that at the beginning of the 2003–2004 school year, about 49,600 mathematics and science teachers were hired into public schools in which they had not taught the prior year. By the following school year, the TFS data show that about 51,400 mathematics and science teachers—equivalent to 103% of those who entered public schools at the beginning of the year—departed their public schools. Hence, before, during, and after the 2003–2004 school year there were over 100,000 job transitions into, between, or out of schools by mathematics and science teachers—representing over one quarter of the entire mathematics/science public school teaching force of 368,575.

The TFS data also show that from the late 1980s to 2005, annual rates of total turnover for public school mathematics and science teachers, while fluctuating from year to year, overall rose—by 34% for mathematics and by 10% for science (see Table 3). But the data also show, surprisingly, that during this period mathematics and science teachers did not move from or leave their public schools at consistently different rates from other teachers, such as in English and social studies.

The data also show the flows of teachers out of schools have not been equally distributed, vary greatly by location, are highly concentrated in a relatively small portion of the school population, and are tied to the demographic characteristics of schools.

To discern the sites or sources of variation, we conducted an analysis of the cross-location variance of the combined SASS/TFS data on turnover. The data showed that variation in turnover is far greater between schools within states than between states and, moreover, that turnover is far greater between schools than between districts. In other words, the largest variations in rates of teacher turnover by location are those between different schools, even within the same district.[5] This provides support for our organizational-level theoretical perspective.

To examine the distribution of turnover across schools and to discern the degree to which turnover is concentrated, we aggregated the combined SASS/TFS data on turnover to the school level and then subdivided the population of schools into quartiles based on school-level turnover rates.[6] The data showed that the bottom quartile of schools had an average annual turnover rate of 8%. These schools accounted for just 14% of all teacher turnover in 2004–2005. In contrast, the top 25% of public schools had an average annual turnover rate of 32% and accounted for 45% of all turnover in that year. We were not able to conduct either the above cross-location analysis of variance or the above school aggregation analysis on mathematics/science teachers alone because of their smaller sample size. However, we suspect that the results for mathematics and science would differ little, because our other analyses show similar cross-school differences in turnover for mathematics and science teachers. Similar to other teachers, we found school demographic characteristics—poverty enrollments, minority enrollments, and the urbanicity of the school's community—were among the school characteristics most correlated with mathematics and science teacher turnover. That is, poor, minority, and urban public schools have among

TABLE 4

Percentage Public School Teacher Migration and Attrition, by New Schools of Movers and by New Occupation or Status of Leavers and by Field (2004–2005)

	Nonmath/Science	Math	Science
Mover's new schools			
Another public school within same district	25	27	17
Another public school in different district	23	29	22
Private school	1	.2	3
Total movers	*49*	*56*	*42*
Leaver's new occupation or status			
Retired	15	13	17
Job in education, but not K–12 teaching	14	17	22
Caring for family members	7	1	2
Noneducation job	6	8	9
Unemployed	2	.1	4
Student at university/college	2	2	4
Disabled	.5	0	.2
Other	4	3	1
Total leavers	*51*	*44*	*58*

the highest mathematics and science turnover levels, both for those moving to other schools and those leaving teaching altogether.

The Destinations of Mathematics and Science Teacher Turnover

What are the destinations of mathematics/science teachers who moved from or left their teaching jobs? The TFS data show that in 2004–2005 about 25,000 of those departing their schools moved to other schools and about 26,400 left classroom teaching altogether. Of those who left classroom teaching altogether, just under a third retired (Table 4). Interestingly, another third of leavers were job shifters who left classroom teaching but did not leave education; they took other jobs in the larger education sector, such as in school administration, curriculum development, or educational publishing.[7] Science teachers, in particular, were a bit more likely to go into nonclassroom education jobs than were nonmath/science teachers. It is unclear why this is so.

In contrast, far fewer teachers left classroom teaching to take noneducation jobs, and surprisingly, mathematics and science teachers were not more likely than other teachers, at a statistically significant level, to leave classroom teaching to take noneducation jobs, such as in technological fields. Moreover, in further analyses of these data, we found that, of those who left for noneducation jobs, mathematics and science teachers were no more likely than others to be working for private business or industry. Likewise, relatively few left to care for family members (predominantly for pregnancy and raising children) or to enroll full-time in university or college programs.

Of those who moved to other schools, a large portion were cross-school transfers within the same school district (see Table 4). Just over half of the migrants went to teaching jobs in other districts, most within the same state. About 5% of all public school mathematics/science movers went to private schools; about double this number moved in the reverse direction—from private to public. Compared to science and other teachers, mathematics teachers appear in Table 4 to have had higher cross-school and cross-district teaching job mobility—but these differences are not at a statistically significant level.

In addition, we used the TFS data to more closely examine the characteristics of the destination schools of cross-school migrants in order to discern the degree of symmetry in math/science teachers' moves to and from different types of schools (small sample sizes necessitated combining math with science teachers in this part of the analysis). The data

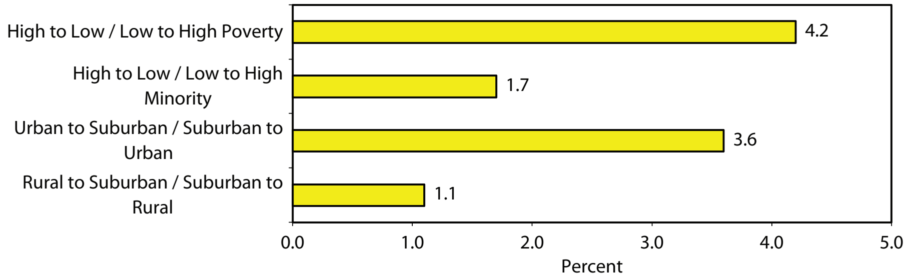

FIGURE 2. *Ratio of Math/Science Teachers Moving in Opposite Directions To and From Particular Types of Public Schools (2004–2005)*

show that, interestingly, math and science teachers who moved between schools were most likely to go to schools that were similar demographically. For instance, in 2004–2005, a majority of those math/science teachers who moved from high-poverty or high-minority schools migrated to schools with similar poverty and minority enrollments. Moreover, of all of those who moved from high-poverty schools, the percentage that went to low-poverty schools was similar to the percentage in the reverse direction (i.e., of all those moving from low-poverty schools, the percentage that went to high-poverty schools). However, because math/science teachers in poor, minority, and urban public schools had far higher rates of out-migration, there ended up being a net gain and loss for schools, according to school demographic differences. For instance, as shown in Figure 2, of math/science teachers who migrated between the 2004 and 2005 school years, over four times as many went from high-poverty schools to low-poverty schools as in reverse.[8] Likewise, of math/science teachers who moved, over 3 times as many went from urban to suburban schools, as in reverse. The net result is a large annual asymmetric reshuffling within the school system of a significant portion (about 25,000 math/science migrants in 2004–2005) of the math/science teaching force, with a net loss on the part of poor, minority, and urban schools and a net gain to nonpoor, nonminority, and suburban schools. These patterns are similar for the nonmath/science portion of the teaching force and provide further 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.

The Determinants of Mathematics and Science Teacher Turnover

These data also raise the following important question: What are the reasons for and sources of these levels and patterns of mathematics and science teacher turnover? One method of answering this question is to ask those who have moved or left why they did so. Tables 5 and 6 present data on the percentage of teachers in the TFS who reported that particular reasons were "very" or "extremely" important in their decisions to move or leave, on a 5-point scale from "not important" to "extremely important." We grouped the individual reasons into categories as shown. Note that the percentages in the tables add up to more than 100%, because respondents could indicate more than one reason for their departures. (Also note that these self-reported reasons overlap content-wise with the self-reported data on current occupational status, presented earlier in Table 4.)

As expected, retirement is a leading reason for those who left teaching, although less so for science teachers (Table 6). Smaller portions of both movers and leavers indicated that their moves or leaves were a result of school staffing actions—such as their school being closed, being individually laid off, transferred, reassigned, or fired. Mathematics teachers were less likely to be transferred to other schools; on the

TABLE 5

Of Public School Teachers Who Moved *to Other Schools, Percentage Reporting Various Categories of Reasons Were Very or Extremely Important to Decision, by Field (2004–2005)*

	Nonmath/Science	Math	Science
School staffing action	19.4	1.3	17.5
Family or personal	26.1	30.9	27.0
To pursue other job or dissatisfaction	68.5	74.2	82.7

Note. In Table 5, we grouped 11 reasons for moving in the questionnaire into three categories, as follows: (1) school staffing action: layoff/involuntary transfer; (2) family or personal: new school closer to home; (3) to pursue other job/dissatisfaction: for better salary or benefits; felt job security higher at another school; opportunity for better teaching assignment at new school (subject or grade level); dissatisfied with workplace conditions; dissatisfied with support from administration; dissatisfied with job responsibilities; lack of autonomy; dissatisfied with opportunities for professional development; dissatisfied with old school for other reasons.

TABLE 6

Of Public School Teachers Who Left *Teaching, Percentage Reporting Various Categories of Reasons Were Very or Extremely Important to Decision, by Field (2004–2005)*

	Nonmath/Science	Math	Science
Retirement	32.1	29.1	22.5
School staffing action	14.6	10.1	19.7
Family or personal	44.7	49.1	18.1
To pursue other job or dissatisfaction	46.1	48.4	61.8

Note. In Table 6, we grouped 12 reasons for leaving in the questionnaire into four categories, as follows: (1) retirement; (2) school staffing action: reduction-in-force/layoff/school closing/reassignment; (3) family or personal: change in residence; pregnancy/child rearing; health; other family or personal reasons; and (4) to pursue other job/dissatisfaction: for better salary or benefits; to pursue position other than that of K–12 teacher; to take courses to improve career opportunities within education sector; to take courses to improve career opportunities outside of education sector; dissatisfied with teaching as career; dissatisfied with previous school or teaching assignment.

other hand, science teachers were more likely to be laid off—accounting for almost 20% of their attrition and almost double that of mathematics teachers. However, the reasons for either of these findings are unclear from these data.

A significant portion of teacher outflows, both moving and leaving, were highly influenced by personal and family factors—a spouse's job requires a move, health issues, closer proximity to a school, a desire to raise a family. These types of job transitions are, no doubt, normal occurrences in any workplace, occupation, or industry. However, science teachers were far less likely to leave for this set of reasons. Again, it is unclear why from these data; perhaps it may be due to gender differences and childrearing as a reason; the data show science has fewer female teachers than most fields, including mathematics (see Table 2).

The most prominent set of factors, behind both moving and leaving, according to teachers, was a desire to obtain a better job or career, or dissatisfaction with some aspect of their teaching job. This was even more true for science teachers. While 22% of science teachers who left teaching indicated retirement was a major reason, 62% reported a major reason was dissatisfaction or desire for a better job. Unlike the first three categories in Tables 5 and 6 (retirement, school staffing actions, and family/personal), the last category (pursuing a different career or dissatisfaction) could more often be a voluntary choice and more often tied to the character of the schools as organizations and teaching as a job—potentially policy-amenable factors. But as we discussed in the Data/Methods section, there are limitations to these self-reported data on reasons for turnover. It is, for instance, unclear what factors in particular are behind the large portions of mathematics and science moving and leaving for better jobs or because of dissatisfaction.

We follow up next with our multivariate analysis that examined a more specific set of school organizational characteristics and conditions, based on data from the full set of respondents in the combined SASS/TFS, while controlling for background factors.

Individual, School, and Organizational Predictors of Turnover

We estimated a series of regression models using the combined SASS/TFS data (see Note 1) to examine whether our collection of measures of school organizational characteristics and conditions were associated with teacher turnover. The predictor variables and associated regression estimates from each model are shown in Table 7. We separately entered each of the organizational condition variables into a basic model that included only controls for basic teacher and school characteristics. To evaluate whether relationships between the predictors and turnover differed by field—between mathematics teachers and science teachers, and nonmathematics/science teachers—each analysis included measures of interactions between the predictors and the two mathematics and science teacher field variables. We tested all possible interactions in each model but displayed only those which showed significance at least at the .10 level.[9]

Our analyses show that a number of the individual characteristics of teachers, both mathematics/science and others, were related to their likelihood of staying or departing at a statistically significant level, after controlling for other factors. Among the teacher background variables, the age of teachers was the most salient predictor of the likelihood of their turnover. Both younger (less than 30) and older (greater than 50) teachers were more likely to depart than are middle-aged teachers. For instance, the relative odds of young teachers departing were just over 2 times higher than for middle-aged teachers. Male teachers were slightly more likely to depart than were female teachers, and minority teachers were not more or less likely to depart than were White teachers.

After controlling for other characteristics, having a degree in mathematics and/or science was also slightly related to turnover. The odds of a mathematics teacher departing were up to 42% higher than nonmathematics/science teachers—but the coefficient was only marginally statistically significant in two of the eight models. This finding is in stark contrast with the result that across all eight models, science teachers had odds of departing that was 16% to 19% lower than nonmathematics/science teachers. Consistent with the bivariate data in Table 3, even after controlling for other factors, in 2004–2005, science teachers had slightly lower turnover than did others.

Some of the school characteristics were also related to turnover. School poverty stood out as a key variable. In general, teachers had statistically significantly higher rates of turnover in higher poverty schools than in lower poverty schools. A 10 percentage point increase in the proportion of students eligible for free or reduced lunch was associated with a 2% to 5% increase in the odds of teachers departing. This poverty effect was no different for mathematics or science teachers than for others; the results across the eight models show the interaction between poverty and field was not significant.

After controlling for other factors, teachers in rural schools were up to 20% less likely to depart than were those in urban schools. Although suburban schools had statistically lower turnover in the bivariate analysis, once other factors, such as school poverty, were controlled there was little difference in turnover between suburban and urban schools. Also, the likelihood of turnover from secondary schools was little different than turnover from elementary and K–12 combined schools. In model 2, teachers in smaller schools departed at slightly higher rates; an enrollment difference of 100 students was associated with a 1% difference in the odds of teachers departing. For these school characteristics, there were no significant interactions with math and science, with the exception of school size. Its relationship was more pronounced for mathematics teachers, as evidenced by the consistently significant interaction between the mathematics indicator and school size. For mathematics teachers, an enrollment decrease of 100 students was associated with a 3% to 4% increase in the odds of teachers departing.

The question of particular interest here is, After controlling for the characteristics of teachers and schools, were the organizational conditions of schools associated with turnover? In each of the models shown, the introduction of the organizational variable improved the model likelihood statistic by a statistically significant amount; moreover, after controlling for the characteristics of teachers and schools, a number of conditions remained significantly associated with turnover.

Although the measure for top salaries (the highest annual salary on the school district's teacher salary scale) had a statistically significant negative bivariate relationship with turnover without controls, once other background factors were held constant as shown in Model 1, the coefficient for highest salaries was no longer statistically significant (at a 90% level of confidence) for mathematics and for nonmathematics/science teachers. However, for science teachers, salaries seemed to matter more. A \$10,000 difference across two schools in their highest teacher salary offered was associated with a 17% difference in the odds of science teachers departing. The SASS data indicate that, in 2003–2004, the average starting salary in public schools for a teacher with a bachelor's degree and no experience was about \$32,000, and the average maximum salary (the measure used here) was about \$61,000.

As mentioned earlier (except for salary), in our analyses we used two types of measures of organizational 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

TABLE 7

Odds Ratios From Logistic Regression Analysis of the Likelihood of Mathematics and Science Teacher Turnover

	Model 1	Model 2	Model 3	Model 4
School *N*	6,627	7,795	7,795	7,795
Teacher *N*	34,375	40,195	40,195	40,195
Intercept	0.11***	0.13***	0.12***	0.12***
Teacher characteristics				
Young	2.12***	1.97***	1.99***	1.99***
Old	1.36***	1.30***	1.31***	1.31***
Male	1.22**	1.19**	1.20**	1.21***
Minority	0.96	1.06	1.04	1.03
Teacher field				
Mathematics	1.42~	1.28	1.28	1.32
Science	0.84~	0.81*	0.82*	0.83*
School characteristics				
Rural	0.80*	0.85*	0.81**	0.83*
Suburban	0.97	0.99	0.97	0.96
Secondary	1.01	0.95	1.01	1.01
School size (in 100s)	1.00	0.99*	0.99	0.99
School Size (in 100s) × Mathematics	0.96**	0.97*	0.97*	0.97*
Poverty enrollment (in 10s)	1.05***	1.02~	1.04***	1.04**
Organizational characteristics/conditions				
Highest salary (in 10,000s)	0.98			
Science × Highest Salary	0.85*			
Student discipline problems				
School level		1.32***		
Teacher level		1.15*		
School leadership support				
School level			0.79***	
Teacher level			0.86**	
School resources				
School level				0.90~
Teacher level				0.90**

(continued)

TABLE 7. (CONTINUED)

	Model 5	Model 6	Model 7	Model 8
School *N*	7,795	7,795	7,795	7,795
Teacher *N*	40,195	40,195	40,195	40,195
Intercept	0.12***	0.12***	0.12***	0.12***
Teacher characteristics				
Young	1.99***	1.97***	1.99***	1.95***
Old	1.28***	1.30***	1.30***	1.30***
Male	1.21**	1.21***	1.20**	1.16**
Minority	1.04	1.03	1.04	1.05
Teacher field				
Mathematics	1.30	1.42~	1.26	1.25
Science	0.83*	0.82*	0.83*	0.83*
School characteristics				
Rural	0.82*	0.90	0.81	0.80**
Suburban	0.96	0.99	0.96	0.96
Secondary	1.02	1.11	1.03	1.01
School size (in 100s)	0.99	0.99	0.99	0.99
School Size (in 100s) × Mathematics	0.97**	0.96**	0.96**	0.97*
Poverty enrollment (in 10s)	1.04**	1.03**	1.04***	1.04***
Organizational characteristics/conditions				
Faculty influence				
School level	0.77***			
Teacher level	0.99			
Teacher autonomy				
School level		0.63***		
School Level × Mathematics		0.47*		
School Level × Science		1.60~		
Teacher level		0.85**		
Discipline-focused prof. dev.				
School level			1.03	
School Level × Mathematics			0.61*	
Teacher level			0.97	
Content-focused prof. dev.				
School level				0.91
Teacher level				0.90***
Teacher Level × Mathematics				0.82*

~$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

in their building. In our models, use of the former measures tells us whether particular school conditions on average were related to turnover; the latter measures tell us whether individuals who reported conditions differently than others in their schools were also more or less likely to depart than others.

As shown in Model 2, in schools with lower levels of student discipline problems, turnover rates were distinctly lower for both mathematics/science and other teachers. This is one of the stronger relationships we found. A 1-unit increase in average reported student discipline problems between two schools (on a 5-unit scale) was associated with a 32% increase 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 have departed. But notably the association of schoolwide conditions was stronger, about twice the size, than that of individual perceptions.

As shown in Model 3, in schools that provide better principal leadership and administrative support as reported by teachers, turnover rates were distinctly lower. A 1-unit difference between schools in average reported support (on a 4-unit scale) was associated with a 21% 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 coefficient was again smaller than the school-level coefficient.

In schools where teachers reported that necessary materials, such as textbooks and supplies were available, turnover was lower for all teachers. In Model 4, the individual- and school-level associations were the same size. In other words, teachers who themselves had limited resources were more likely to depart, as were teachers in schools in which necessary resources were not generally available across the building.

As shown in Model 5, schools with higher levels of schoolwide faculty decision-making influence had lower levels of turnover. This is also one of the stronger relationships we found. A 1-unit increase in reported faculty influence between schools (on a 4-unit scale) was associated with a 23% decrease in the odds of a teacher departing. Moreover, whether individual teachers differed in their reports of faculty influence was not related to their turnover. Therefore, this may be entirely an organizational phenomenon reflecting differences in schoolwide organizational conditions.

As shown in Model 6, schools with higher average levels of individual teachers' classroom autonomy had lower levels of turnover. A one-unit difference in reported teacher autonomy between schools (on a four-unit scale) was associated with a 37% difference in the odds of a teacher departing. This school-level association was much larger than the individual association of autonomy, suggesting a very large contextual relationship. Thus, the overall classroom autonomy held by teachers in the building had a larger relationship than an individual's own perceptions of their classroom autonomy. Even more noteworthy is that the turnover of mathematics teachers was even more strongly related to classroom autonomy. In fact, a one-unit increase in average teacher autonomy between schools was associated with a 70% decrease in the odds of a mathematics teacher departing. This was by far the single largest relationship we found. On the other hand, the significant positive interaction coefficient for science teachers suggests that, unlike others, classroom autonomy had little relationship to the odds of turnover.

We also examined the relationship with turnover of whether teachers participated in and found useful two types of PD: (1) that focused on student discipline and classroom management and (2) that focused on the content of the subjects taught. Schoolwide utility of the former type of PD was associated with decreases in turnover for mathematics teachers only, but the relationship 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 mathematics teachers. We also found significant associations for the utility of PD focused on the content taught; however, those relations existed only at the individual teacher level, not at the organizational level. Teachers who found content-focused PD more useful had 10% lower odds of turnover. This relationship was even larger for mathematics teachers—those who found content-focused PD more useful had 27% lower odds of turnover.

We also estimated our same set of models for movers and leavers separately to explore differences in the predictors of each component of turnover. In most cases the direction and magnitude of the coefficient was similar to that found in the models analyzing the full sample in Table 7. For none of our eight measures of organizational characteristics were there statistically significant differences in their degree of association with leaving versus moving. In other words, organizational conditions associated with higher rates of teacher migration were similarly associated with higher rates of teacher attrition.

The separate models in Table 7 estimate the independent relationships to turnover of each organizational condition. However, as discussed in the Data/Methods section, the preceding organizational conditions do not exist in isolation; schools with higher levels of one were also likely to have higher levels of others. This is born out in Table 8, which estimates the relationships of all of the organizational conditions concurrently in a full model. The attenuation of the size of some of the coefficients when all of the variables are modeled simultaneously, making some statistically insignificant, confirms this confounding between related variables. However, the fact that the associations of some of the organizational conditions were not strong enough to be individually statistically significant in the full model in Table 8 does not mean they have no value as components in a collective set of school organizational conditions. To get a sense of the joint association with turnover of multiple organizational conditions, we estimated predicted turnover rates by entering a range of values for the set of all organizational variables. Holding the control variables constant at the sample mean, we set the eight organizational condition variables to values corresponding to the 10th percentile, the 25th percentile, the mean, the 75th percentile, and the 90th percentile for the sample. This allowed us to predict the turnover rates of mathematics and science teachers for a range of hypothetical schools, beginning with those that have the worst organizational conditions (i.e., at the 10th percentile on each of the eight organizational measures) and concluding with those that have the best organizational conditions (i.e., at the 90th percentile on each of the organizational measures). Results from this analysis are depicted in Figure 3 and reveal a clear collective relationship between organizational conditions and turnover. This relationship is remarkably strong for mathematics teachers, whose predicted annual turnover rates are only 2.8% in the schools with the best organizational conditions versus nearly 42% in schools with the worst organizational conditions. In science the relationship is not as strong but is still quite large, ranging from 6.9% in the best schools to 17.2% in the worst schools.

It is also worth noting that once all of the organizational conditions are included (in the full model), the coefficients for school poverty

TABLE 8

Odds Ratios From Logistic Regression Analysis of the Likelihood of Mathematics and Science Teacher Turnover

	Full Model
School N	6,627
Teacher N	34,375
Intercept	0.12***
Teacher characteristics	
Young	2.03***
Old	1.38***
Male	1.19**
Minority	0.99
Teacher field	
Mathematics	1.43~
Science	0.80~
School characteristics	
Rural	0.90
Suburban	0.96
Secondary	0.98
School size (in 100s)	0.99
School Size (in 100s) × Mathematics	0.95**
Poverty enrollment (in 10s)	1.02
Organizational characteristics/ conditions	
Highest salary (in 10,000s)	0.97
Science × Highest Salary	0.86~
Student discipline problems	
School level	1.25*
Teacher level	1.07
School leadership support	
School level	0.90
Teacher level	0.89~
School resources	
School level	0.99
Teacher level	0.93~
Faculty influence	
School level	0.93
Teacher level	0.86*
Teacher autonomy	
School level	0.70**
School Level × Mathematics	0.42*
School Level × Science	1.67~
Teacher level	0.87*
Discipline-focused prof. dev.	
School level	1.08
School Level × Mathematics	0.57**
Teacher level	1.01
Content-focused prof. dev.	
School level	0.97
Teacher level	0.78*
Teacher Level × Mathematics	0.90***

~$p < .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

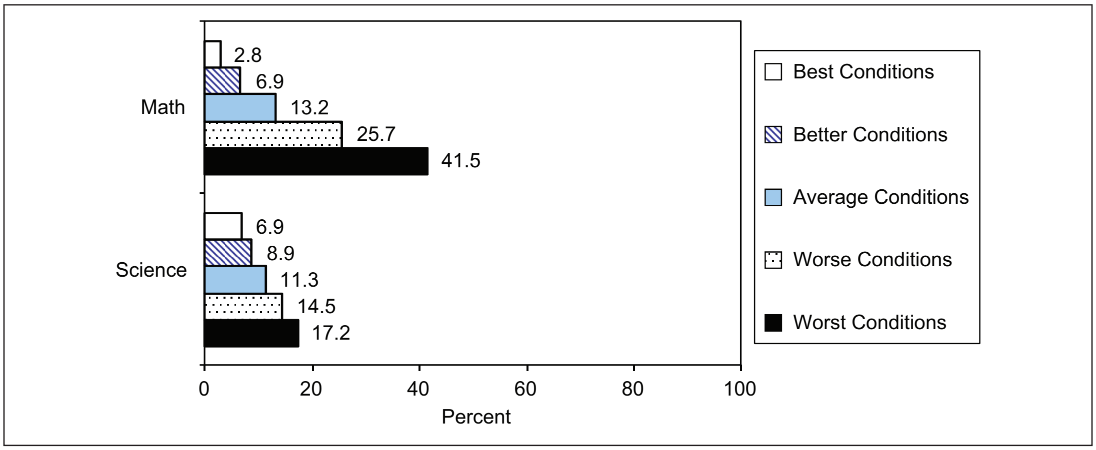

FIGURE 3. *Predicted Public School Teacher Turnover Rates, by School Organizational Condition Percentiles, by Field (2004–2005)*

and rural schools decrease and become statistically insignificant—suggesting that worse organizational conditions account for a large part of the higher turnover in poor and urban schools.

When other factors are controlled, the strongest organizational predictors for mathematics teachers were the degree of individual classroom autonomy held by teachers, the provision of useful content-focused PD, useful PD concerning student discipline and classroom management, and the degree of student discipline problems, for science teachers, the strongest factors were the maximum salary offered by school districts, the degree of student discipline problems in schools, and useful content- focused PD.

Conclusions and Implications

Some turnover of mathematics and science teachers is, of course, normal, inevitable, and beneficial. For individuals, departures leading to better jobs, either in teaching or not, can be a source of upward mobility. For schools, departures of low-performing employees can enhance organizational outcomes. For the educational system, teacher outflows, such as cross-school migration, temporary attrition, or those leaving classroom teaching for other education-related jobs, do not represent a net or a permanent loss of human capital to the education system as a whole and can be beneficial to the system.

However, from an organizational level of analysis and from the viewpoint of those managing schools, none of these types of departures are cost free, whether permanent, to other schools or to other education jobs. All have the same effect; they typically result in a decrease in classroom mathematics and science instructional staff in that particular organization who usually must be replaced. As mentioned earlier, in a companion study of math and science teacher supply and demand (Ingersoll & Perda, 2010), we have documented that mathematics and science teacher turnover is a major factor behind the mathematics and science teacher shortage. The data show that over the past two decades the new supply of qualified mathematics and science teachers has more than kept pace both with increases in student enrollments and with increases in teacher retirements. Indeed, while the number of students has increased by 19% and teachers by 48% over the past two decades, the number of qualified math and science teachers employed has increased by 74% and 86%, respectively. Nevertheless, a persistent minority of the school population has continued to report serious problems filling their math and science teaching openings. An important source of these problems is revealed when we factor in preretirement losses of teachers—a figure that is many times larger than losses due to retirement—and a primary factor behind the need for new hires.

In this present study, we have followed up by more closely examining the magnitude, destinations, and determinants of mathematics and science teacher turnover from public schools. It is useful to summarize our main findings, next, by examining and comparing the actual numbers involved.

Qualified math and science teachers represent about 12% of the entire K–12 teaching force. Between the 2003–2004 and 2004–2005 school years, about 51,400 qualified mathematics and science teachers, or about 14% of the mathematics and science public school teaching force, departed from their schools. This rate represented an overall increase since the late 1980s. But contrary to a number of studies, (e.g., Grissmer & Kirby, 1992; Henke et al., 2001; Ingersoll, 2006; Murnane et al., 1991; Rumberger, 1987; Weiss & Boyd, 1990), the data show that mathematics and science teachers do not have higher rates of turnover than other teachers. The turnover of mathematics and science teachers has fluctuated up and down but, overall, has not been consistently different than that of nonmathematics/science teachers. Indeed, in 2004–2005 science teachers had slightly lower turnover than others.

Either way, these outflows are large; just before, during, and just after the 2003–2004 school year, over one quarter of the entire mathematics/science public school teaching force was in job transition—into, between, or out of schools. Focusing on overall rates of turnover, however, masks an important part of the story—math and science teacher turnover is not equally distributed across locations.

One possible source of turnover differences could be regional differences in nonteaching labor market opportunities, such as technical jobs, available for teachers with math and science human capital. Our data did not allow us to control for labor market characteristics, but our analysis of variance revealed that the largest variations in overall teacher turnover by location are not between regions, states, or districts but those between different schools, even within the same district. In other words, within the same state and locale, the same teacher labor market and the same licensure and pension system, the extent of turnover varies greatly among schools. Teacher turnover is highly concentrated in a small portion of the school population. The data show that 45% of all public school teacher turnover, between the 2004 and 2005 school years, took place in just one quarter of the population of public schools.

Mathematics and science teachers departed for a wide variety of destinations. Of those 51,400 who departed, about 4,500 math and science teachers left teaching to work in jobs outside of education. A commonly held view in both the research and education policy realms (e.g., Murnane et al., 1991; National Academy of Sciences, 2007; National Research Council, 2002; Rumberger, 1987) is that teachers with a mathematics and science background are more likely to have alternative career options in the private sector than others. But contrary to this widely held view, our data show that qualified mathematics and science teachers were no more likely than other teachers to leave to take noneducation jobs, such as in technological fields, or to be working for private business or industry.

In contrast, far more teachers, in general, left for nonteaching jobs within the education sector, such as school administration or curriculum—likely for reasons of career or salary advancement. While 4,500 math and science teachers left teaching to work in noneducation jobs, a far larger number—10,200 math and science teaches—left for nonclassroom teaching jobs within the education sector. Science teachers, in particular, were a bit more likely to go into nonclassroom education jobs than were nonmath/science teachers—although it is unclear if this is an ongoing trend.

One possible hypothesis for our finding that mathematics and science teachers did not frequently leave for jobs in technology and industry is that there may not be large numbers of other career options for those math and science teachers with only a bachelor's degree in the field. Another possible hypothesis is that math and science majors who decided to go into teaching may have a prior personal commitment to education that increases their retention. A third possible hypothesis is that math and science majors who decided to go into teaching may have lower academic ability than their fellow majors who pursued careers in industry and hence do not feel they realistically have similar career options. These hypotheses are worthy of further investigation.

It is widely believed that teacher retirement is a major factor behind teacher staffing problems (e.g., National Commission on Teaching and America's Future, 1996, 1997; U.S. Department of Education, 2002). However, in 2004–2005, only about 7,000 math and science teachers reported retirement was a very important reason for their decision to leave teaching. In contrast, about 34,400 math and science teachers indicated the main motive behind their moves or leaves was dissatisfaction with teaching, dissatisfaction with their schools, to move to a better fitting or better paying teaching job, to seek other career opportunities in education, or to pursue a career out of the education sector entirely.

To further investigate the determinants of these departures, our analyses focused on the role of a number of organizational characteristics and conditions long considered important to effective schools and important to professionalized workplaces. As expected, we found that schools greatly varied in their organizational conditions. We also found that all were statistically related to teacher turnover. But there were some interesting differences for math and for science.

For math teachers, by far the strongest predictor was the degree of individual classroom autonomy held by teachers in schools in regard to content, texts, materials, techniques, and grading in their courses. Salary, in contrast, was not as strong a factor. Moreover, the paramount importance of classroom autonomy for math teachers appears to be a relatively new development; in our background analyses of similar data from the early and mid-1990s, classroom autonomy was not as strong a factor for math teachers. Other factors for math teachers were the degree of student discipline problems in the school and the usefulness of both types of PD—in content and in classroom management.

In contrast, for science teachers, the strongest factor was the maximum teacher salary offered by school districts and the degree of teacher classroom autonomy in their school was not a strong factor. Along with salaries, there were also other factors strongly related to the turnover of science teachers, such as the degree of student discipline problems in the school and the extent to which individuals received useful content-focused PD (for a detailed analysis examining the impact of the preservice education and preparation on the turnover of math and science teachers, see Ingersoll, Merrill, & May, 2012a).

At this point, we can only speculate as to why math and science teachers were differentially affected by classroom autonomy. One possible hypothesis to explain the growing salience of individual classroom autonomy for math teachers could be that the increase in nationwide testing in math has lead to a decrease in the degree of classroom autonomy delegated to math teachers and subsequent tension and dissatisfaction surrounding math teachers' capacity to meet the standards. Because science, as of 2004, was a far less tested subject, a lack of autonomy in the classroom could have been less of a concern. The impact of the accountability and testing movement on math and science retention is worthy of further investigation—a project we have subsequently been undertaking (see Ingersoll, Merrill, & May, 2012b).

Most of the relations between turnover and conditions in schools appear to be partly or entirely the result of organizational-level phenomena. That is, regardless of an individual's own views of conditions in schools, positive schoolwide conditions were related to an individual's likelihood of turnover, especially for student discipline, leadership, autonomy, influence, and discipline PD. Moreover, the relationship to teacher turnover of these organizational conditions increased cumulatively. These conditions do not exist in isolation from one another. Schools tend to have positive or negative levels of more than one condition simultaneously. Schools with positive levels of progressively more of these conditions had progressively lower turnover of math and science teachers. As a result, collectively, these conditions had a very large net relationship with turnover. These findings provide support for our theoretical perspective that school organization, management, and leadership matter. Schools exhibiting more characteristics associated with effective organization, and more of the indicators associated with professionalized workplaces, had significantly better retention of math and science teachers.

While our analysis focused on identifying the organizational characteristics and conditions of schools that predict math and science teacher turnover (depicted on the left side of Figure 1), we did not address a related and important question—what state, district, and school factors predict these positive organizational characteristics and conditions of schools? In short, how do school system leaders, especially in disadvantaged settings, create these conditions? This is an important policy concern warranting further research.

Our findings have implications for several streams of reform and policy. For instance, differential pay and incentive programs for math and science teachers are a major source of debate and reform. While our analyses did not evaluate the impact of differential teacher compensation on turnover, our finding on the relatively lesser importance of salaries for math teachers' retention has implications for such policy. Increasing monetary rewards may result in enhanced recruitment of math teachers, but the data show that regardless of how high the salaries, if there is a lack of classroom autonomy, schools will lose math teachers and at a far higher rate than most other teachers. In contrast, while for science teachers salaries were a strong factor, other factors were also strongly related to turnover. This is important because, given the large size of the teaching force, salary increases are expensive. For instance, raising the annual salary of all qualified science teachers by only $2,000 each would cost almost $0.5 billion per year.

There are also important implications of these results for reform geared toward shortages. As noted in the beginning of this article, increased teacher production and recruitment have long been the dominant strategies to address mathematics and science teacher staffing problems. Nothing in this research suggests that bringing new qualified mathematics and science candidates into teaching is not a worthwhile step. But the data indicate that new teacher production and recruitment strategies alone do not directly address a major root source of mathematics and science teacher staffing problems—turnover. To illustrate, President Bush pledged in his 2006 State of the Union speech to recruit 30,000 new mathematics and science teachers across the nation. Subsequently, President Obama in his 2010 State of the Union speech called for the recruitment of 10,000 math and science teachers each year for a decade. Comparison with our above figures is revealing: after the end of the prior school year (2004–2005), about 26,400 mathematics and science public school teachers left teaching. Of these, 7,000 left to retire, another 14,000 indicated they left to pursue another job or career, or because of job dissatisfaction. Improving the retention of those mathematics and science teachers brought into teaching by these recruitment initiatives could prevent the loss of this investment and also help to lessen the ongoing need for creating new recruitment initiatives. All this suggests the efficacy of developing teacher recruitment and retention initiatives together.

Our two studies collectively also have large implications for research on the math and science achievement gap. Researchers have long held that teacher shortages fall disproportionately on schools in disadvantaged high-minority and high-poverty communities and are a major factor in unequal educational, and ultimately, occupational outcomes (e.g., Darling-Hammond, 1984; Liu et al., 2008; National Commission on Teaching and America's Future, 1996, 1997; Quartz et al., 2008). As mentioned previously, despite large gains in the number of math and science teachers, nevertheless each year a persistent minority of schools report difficulty filling their math and science positions. The data show these are also schools likely to have higher teacher turnover. In turn, higher turnover schools are more likely to be high poverty, high minority, and urban. While numerous studies have documented the latter finding, there has been little research on why this is so (for comprehensive reviews, see, e.g., Borman & Dowling, 2008; Guarino et al., 2006). Our data analyses found that organizational conditions statistically accounted for the relationship between school poverty, school urbanicity, and teacher turnover. In other words, the high rates of math and science teacher turnover in high-poverty, urban, public schools do not appear to be a matter of student and school demographic characteristics per se—teachers are not fleeing from poor and minority children—in contrast, teachers are fleeing from the poor organizational conditions disproportionately found in such schools. Elsewhere we have undertaken a detailed analysis of a related topic—the magnitude, destinations, and determinants of minority compared to white teacher turnover—with interestingly similar results (Ingersoll & May, 2011).

Moreover, a similar portrait holds for cross-school migration. Prior studies using data from Texas (Hanushek, Kain, & Rivkin, 2004) and from New York state (Lankford, Loeb, & Wyckoff, 2002) to examine teacher cross-school and cross-district migration concluded that the movement of teachers from high-need urban schools to lower need suburban schools resembles an asymmetric "brain drain" and exacerbates an unequal distribution of qualified teachers across demographically different settings. However, our analyses of national data show that the majority of teachers who moved between schools tended to *not* move to demographically different school settings. Indeed, movers were most likely to migrate to demographically similar types of schools. But because of the far higher overall migration rates of math and science teachers from high-poverty, high-minority, and urban public schools, the end result was an annual asymmetric reshuffling of significant numbers of math and science teachers from poor to not-poor schools, from high-minority to low-minority schools, and from urban to suburban schools.

Moreover, while our findings provide support for the view that school organization and management matter, it is important to recognize that investigating the role of school leadership in the problems of the educational system, especially for disadvantaged communities, is a highly contentious subject. For example, some hold that incompetent or corrupt school managers are a major factor in the plight of low-income, inner-city public schools. Others forcefully respond that this viewpoint unfairly places responsibility for the problems of low-performing schools on the victims of these same problems and unfairly shifts responsibility away from systemic inequities in funding and resources (for an earlier discussion of this debate, see, e.g., Kozol, 1991).

This study's organizational perspective shifts attention away from this polarized debate, does not blame either managers or demography, but focuses on discovering which policy-amenable aspects of schools as organizations—their practices, policies, characteristics, and conditions—are related to their ability to retain qualified math and science teachers. The data suggest that poor urban schools with improved organizational conditions will be far more able to do so. To be sure, the data do not suggest that altering any of the organizational conditions we examined would be easy—there can be numerous financial, political, organizational, and legal barriers. However, unlike reforms such as teacher salary increases and class-size reduction, changing some of the above organizational conditions, such as the degree to which teachers have input into Schoolwide decisions, and the amount of autonomy teachers hold in their classrooms, would appear to be less costly financially—an important consideration, especially in low-income settings.

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Notes

1. This TFS Teacher Status Questionnaire is administered to school principals a year after the original SASS Teacher Survey questionnaires to collect data on one measure—the current occupational status of all those teachers in the original SASS sample. It asks principals to indicate whether the previously sampled teachers are still teaching in that same school, in another school, have left teaching altogether, and so forth. Subsequently, a subsample of stayers and almost all of those teachers reported to have moved or left are administered the TFS questionnaire.

We were able to discern some error by principals in the Teacher Status questionnaire measure in distinguishing between migration (movers) and attrition (leavers). Essentially, school principals tend to overreport the number of leavers because teachers who quit their jobs often do not inform their previous schools that they have moved to another school. However, this measure is quite accurate in accurately identifying who is and is not still working at the original school. By comparing individual teacher's values for the Teacher Status measure from SASS (i.e., the principal's report) with confirmed final turnover from the TFS (i.e., the teacher's report), we found the Teacher Status measure was about 93% accurate in distinguishing teachers who had departed from those who had not.

More specifically, the Teacher Status measure from SASS accurately identified 90% of confirmed leavers (i.e., 2,385 out of 2,650) as having left the teaching occupation. However, the Teacher Status measure classified 29% of confirmed movers (i.e., 559 out of 1,911) as having left the teaching occupation, and an additional 1% of confirmed movers (i.e., 18 out of 1,911) as stayers. When no distinction is made between movers and leavers, the Teacher Status measure was 92% sensitive (i.e., 4,471 out of 4,886 teachers identified as departing did, in fact, move from or leave their teaching jobs), and the Teacher Status measure was 96% specific (i.e., 2,442 out of 2,532 teachers identified as not turning over did, in fact, stay in their teaching jobs). This translates to an overall accuracy rate of 93% (i.e., 6,913 out of 7,418).

In our merger of the SASS and TFS measures, we corrected the Teacher Status measure using TFS data by replacing the Teacher Status indicator with the confirmed TFS status indicator for those teachers included in the TFS sample. This results in a final teacher status measure that is approximately 96% accurate (i.e., assuming that the rate of inaccuracies in the Teacher Status data identified by the TFS cross-validation represents the expected rate of inaccuracies for the rest of the SASS sample not included in the TFS). This is calculated by applying the sensitivity and specificity rates above to the uncorrected Teacher Status data (i.e., 40,563 stayers and 3,064 movers/leavers), and assuming 100% accuracy for those teachers included in the TFS data (i.e., 2,864 stayers and 4,565 movers/leavers), we end up with an overall accuracy rate of 96% (i.e., $[(40{,}563 \times .96) + (3{,}064 \times .92) + (2{,}864 \times 1.00) + (4{,}565 \times 1.00)] / 51{,}056 = 0.96$).

2. The proportion of a school's student population that is minority is also related to teacher turnover. However, minority enrollment is highly intercorrelated and confounded with poverty enrollment and, since the latter had a stronger relationship to turnover, we did not include the former in our regression analyses. For an analysis of teacher turnover that differentiates these effects, see Ingersoll and May (2011).

3. Especially with an aging teaching workforce, it can be unclear if differences in average school-level salary levels are due to real differences in the compensation offered to comparable teachers at different schools or are due to differences in the experience and education levels of the teachers employed. That is, a school with more educated or more experienced teachers may appear to offer better salaries, when, in fact, they do not. A more accurate method of comparison across schools is to compare the normal salaries paid by schools to teachers at common points in their careers. Public school teacher salary levels are often standardized by school districts according to a uniform salary schedule, based on the education levels and years of experience of the teachers. In our background analyses, we tested a number of alternative salary measures:

(1) teacher's actual individual-level salaries;
(2) starting—the district's normal yearly base salary for a teacher with no teaching experience and a bachelor's degree;
(3) advanced—the districts' normal yearly base salary for a teacher with 10 years of experience and a master's degree; and
(4) highest—the district's normal yearly base salary for a teacher at the highest possible step on salary schedule.

The last measure had a relatively strong association with turnover compared to the others, and it also had relatively fewer missing data; hence, it is used in this study. This measure represents the organizational financial rewards teachers can look forward to at an advanced point in their careers if they stay in their particular schools and, hence, we expect could affect their decisions to depart or stay.

This measure also may have limitations. Some might argue that school salary schedules do not accurately capture the relationship of salary with rates of teacher turnover because candidates can obtain this information in deciding whether to accept a particular teaching job. From this viewpoint, since public school teachers are compensated according to published salary schedules that change only infrequently, new entrants can predict with almost complete certainty how much they will be paid in each year in the future. Hence, if a teacher did accept a job, it could be that they are satisfied with their school's salary levels and, hence, most likely low salaries would not be a factor in future turnover.

On the other hand, sometimes teachers may, of course, accept jobs with salaries below what they would prefer and then move in a few years when a better paying job opens up. Goodlad (1984) and others have argued that, while money is not a major factor in teachers' choice of a job, it is a major factor in their decision to move or leave teaching. In this view, beginning teachers are primarily motivated by nonpecuniary and intrinsic values, but if these kinds of expectations are frustrated, salaries can become a source of considerable dissatisfaction. Hence, from this viewpoint, salary schedules would be related to turnover precisely because they allow teachers to predict how much they will be paid in the future. This analysis does not presume the validity of either view but simply tests whether differences in highest possible salaries among schools are related to turnover.

4. For an insightful alternative strategy to deal with this issue, see Boyd et al. (2011).

5. Using a four-level logistic HLM model, estimated via MLwiN 2.20, we partitioned the variance in teacher turnover in the 03-04 SASS. Of the total variance in annual turnover, 77% was among schools, 16% was among districts, and 7% was among states.

6. For further detail concerning our methods of aggregation, see Ingersoll and May (2010).

7. For an insightful analysis of the flows of job shifting within education, see Quartz et al. (2008).

8. To create high, middle, and low poverty and minority categories, we divided the TFS sample of teacher movers into third-tiles. Low-poverty schools are those with 29% or less low-income students, and high poverty are those with 57% or more. Low-minority schools are those with 22% or less minority students, and high minority are those with 69% or more.

9. We exponentiated the coefficients from logistic regression models to produce odds ratios reflecting the relative change in odds associated with a one-unit increase in the predictor variable. For interactions, we calculated odds ratios by adding coefficients from the main effect and the interaction term for a variable and then exponentiating.

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