Missed Opportunities in the Labor Market or Temporary Disruptions?

How Late Teacher Hiring Affects Student Achievement

John P. Papay[*]
Matthew A. Kraft[**]
Julia Bloom[**]
Kate Buckley[**]
David Liebowitz[**]

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Abstract

We examine the prevalence, distribution, and effects of late teacher hiring in a large urban school district. Nearly one in five new teachers in the district is hired after the start of the school year. Lower-performing schools serving low-income students struggle the most with staffing classrooms on time. Late hiring has serious consequences for student achievement. Students in classrooms with teachers hired after the start of the school year score substantially lower on standardized tests than their peers with other newly hired teachers (0.042 SD in math, 0.037 SD in reading). The effects of having a late-hired middle school math teacher persist beyond a teacher's first year, evidence of negative selection in the labor market. However, the negative effect of late hiring among elementary teachers and middle school English teachers does not persist, pointing to a temporary disruption effect. Teachers who are hired late also leave their schools and the district at much greater rates than their peers who are hired on time.

[*] Brown University
[**] Harvard Graduate School of Education

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How Late Teacher Hiring Affects Student Achievement

Education policymakers and school administrators expend considerable resources trying to staff all schools with effective teachers. Annual spending on teacher salaries and benefits alone approaches $300 billion nationwide (NCES, 2011). In recent years, national attention has focused on increasing the return from these personnel investments by developing policies and practices designed to improve teacher effectiveness and raise student achievement. Efforts to raise teacher quality have taken center stage in the federal Race to the Top competitions, and states and districts have rapidly begun to revamp human resource policies concerning teachers. These strategies make sense because we know that teachers are the most important school-level input to student learning and they vary widely in their ability to raise student test scores (Chetty Friedman, & Rockoff, 2011; McCaffrey, Koretz, Lockwood, & Hamilton, 2004; Rivkin, Hanushek, & Kain, 2005; Rockoff, 2004).

Although policymakers have focused heavily on the need to attract, retain, and reward highly effective teachers, they have paid less attention to the processes by which these teachers are hired into schools. Across the country, teacher hiring practices are often inefficient due to policy and capacity constraints that delay hiring. As a result, many school districts still begin the year without a full-time teacher in every classroom. These late hiring practices likely undercut efforts to raise teacher effectiveness and can reduce student achievement in several ways. Most obviously, districts that hire late have a reduced pool of applicants from which to choose. They face what Levin and Quinn (2003) call "missed opportunities" to hire the most qualified candidates in the labor market. This "labor market effect" would mean that the teachers hired late are, on average, less effective than their peers. Furthermore, late hiring can have a temporal

"disruption effect" on teachers and students. For example, teachers who are hired late may not have sufficient time to prepare for the start of the school year, while their students must deal with instability as classes begin and a transition to a new teacher or classroom. Finally, late hiring can have negative spillover effects on other teachers and students in a school. For example, the lack of a good job match that comes from a delayed and ineffective hiring process can raise teacher turnover, which in turn can reduce student achievement (Ronfeldt et al., 2012).

Thus, inefficient and delayed hiring practices can prevent schools from hiring, supporting, and retaining effective teachers. Importantly, the consequences of late teacher hiring are not evenly distributed across the nation's schools. Because hiring delays are most prevalent in urban districts that serve high proportions of low-income students, the effects of late hiring are concentrated on the very students who have the greatest need for effective teachers.

In this paper, we examine the prevalence, distribution, and effects of late teacher hiring in a large urban school district. We find that nearly one in five new teachers is hired after school starts in the fall, and the poorest and lowest-achieving schools struggle the most with staffing all classrooms by the start of the year. We also find that late hiring has serious consequences for student achievement. Students in classrooms with teachers hired after the start of the school year do substantially worse than their peers with other newly hired teachers (0.042 SD in math, 0.037 SD in reading). While we find some evidence of labor market effects, particularly in middle school math, we find strong evidence that late hiring has disruption effects for both teachers and students that suppress achievement. Finally, we find that teachers who are hired late leave their schools, and the district, at much greater rates than their peers who are hired on-time.

In the following section, we summarize past research on teacher hiring, focusing on the reasons for late hiring in urban districts and on how hiring practices can affect teachers and

students. We then describe our data, sample, and methods. Next, we describe the prevalence, characteristics, and distribution of late-hired teachers, and present our findings on achievement effects and retention patterns. We conclude by discussing the implications of our results for policymakers seeking to boost teacher quality in urban schools.

How Hiring Practices Affect Teachers and Students

The hiring process in schools, as in any organization, serves multiple purposes. Most importantly, it is a job matching process in which teachers choose schools and schools choose teachers. Hiring is also the first step in a teacher's induction to her school, the district, and, for novices, to the profession. Thus, an effective hiring process can help set a teacher up for success by providing them with a good school match, a clear preview of the work required, and the support necessary for a successful transition into a new school (and career). Unfortunately, in many U.S. school districts the hiring process is, as Liu and Johnson (2006) described, "late, rushed, and information-poor."

Late hiring is widespread. In her analysis of the nationally representative Schools and Staffing Survey, Engel (2012) found that 34 percent of teachers hired in 1999-2000 were hired in the second half of summer, and another 11 percent were hired after the school year had begun. The amount of late hiring varies by district, region, school demographics, and labor market conditions. For example, Jones, Maier and Grogan (2011) found that 12 percent of teachers in Michigan between 2003 and 2007 were hired after the school year had begun, while Liu and Johnson (2006) found that as many as one-third of newly hired teachers in California and Florida in 2002 were hired after the start of the school year.

Urban districts and those serving large proportions of low-income students struggle the most to fulfill their staffing needs on time. Nationally, urban and low-income districts hire

almost twice as many teachers after the beginning of the school year compared to their suburban and more affluent counterparts (Engel, 2012). Johnson et al. (2004) documented a 20-percentage point gap in the proportion of teachers hired late between low-income (28 percent) and high-income (8 percent) schools. In Michigan, late-hired teachers were more likely to work in lower-performing schools and schools that served higher proportions of non-white and low-income students (Jones, Maier and Grogan, 2011).

Why do schools hire late?

A variety of causes contribute to these persistent late hiring patterns. In a widely-referenced study from The New Teacher Project on school district hiring practices, Levin and Quinn (2003) categorized the causes of late hiring into two broad domains: (1) human resources department capacity and (2) district staff and budget policies. They explained that, in many districts, human resources departments do not have clear and strategic hiring goals, have insufficient systems to project vacancies and track applicants, and offer candidates poor customer service and communication. District policies also contribute to hiring delays, as many districts permit teachers to notify their schools late in the spring if they plan to leave or transfer schools and give transferring teachers first priority to choose a position before a search can be opened to the external candidate pool. Similarly, teachers are often allowed to announce their retirements after the end of the school year, leaving districts scrambling to find a replacement. Levin and Quinn blamed collective bargaining agreements for these challenges, although districts in states that prohibit bargaining, such as the one we describe in this study, also struggle to hire teachers on time for similar reasons. Finally, they noted that many districts face delays in hiring because school budgets are beholden to political processes at the state and local levels, which are often very slow.

While many school districts face obstacles to hiring teachers on time, these challenges are often exacerbated in urban and low-income districts. Budget approvals tend to happen later in the year for large, urban districts because they rely on greater levels of state funding and a more complex political process (Levin & Quinn, 2003). These late budget approvals delay the hiring calendar for urban districts compared to neighboring suburban schools that often compete for the same pool of teachers. Furthermore, urban schools are much more likely to have highly mobile populations and to have larger proportions of immigrant students. As a result, these districts have greater difficulties predicting enrollment and staffing needs. Schools cannot hire in the summer for positions that they are unsure will be needed in the fall.

These district-level policies and capacity constraints are not the only causes, as differential hiring practices occur across schools within the district as well. Some schools have difficulty attracting qualified applicants for certain hard-to-staff positions, such as mathematics, science, and special education (Jacob, 2007; Levin, 1985; Podgursky, Monroe, & Watson, 2004), and these positions remain unfilled as a result. Challenging working conditions that tend to exist in high-poverty urban schools exacerbate these difficulties. For example, several recent studies have shown that teachers are more likely to plan to leave schools that have poor working conditions, such as unsupportive principals or ineffective colleagues (Ladd, 2011; Boyd et al., 2011; Johnson, Kraft, & Papay, 2012).

Finally, some principals are simply more effective than others at recruiting teachers and working with the district central staff to navigate the human resources hiring system expeditiously. In districts with limited human resources department capacity, principals must be entrepreneurial to recruit and obtain commitments from sought-after teachers. Principals who do not have the skills or time to do so may find themselves with open positions in the fall. Principal

turnover, which is quite high in urban districts, can exacerbate these discrepancies as new principals often do not have the networks and experience to organize an effective hiring process early in the summer.

How does late hiring affect schools and students?

Whatever the reason for late teacher hiring, such delays may hurt students and schools. We posit three broad mechanisms: negative selection in the teacher labor market ("labor market effects"), temporary disruptions for students and teachers ("disruption effects"), and spillovers resulting from increased teacher turnover in the school. The first two of these mechanisms focus on the direct effect of late hiring on students in that teacher's classroom, while the last one reflects broader, indirect effects on students in the school.

First, a late hiring timeline can produce "labor market effects" as districts may face a negatively selected labor market pool. By the fall, many teachers have already taken jobs elsewhere and schools that hire late are limited to an applicant pool that has been unable to secure employment during the summer. It is possible that the remaining job candidates are less qualified and less effective teachers. Levin and Quinn (2003) characterized this as the "missed opportunities" of late hiring and found that many highly qualified applicants withdrew from the application process in urban districts because of hiring delays. In contrast, Engel (2012) found no differences in the certification, college competitiveness, or advanced degree status of teachers hired on-time and those hired late. These observable characteristics, however, are only weakly correlated with effectiveness; thus, without direct measures of the effect of hiring on student outcomes, we cannot determine whether late hiring causes districts to hire less effective teachers.

Although the "labor market effect" story has gotten the most attention in policy circles, it is not the only possible mechanism. An alternative explanation is that districts hire equally strong

candidates after the school year has begun, but disruptions caused by late hiring temporarily reduce student achievement during that school year. Many different factors could contribute to these "disruption effects." When teachers are hired late, they have less time over the summer to learn new curricula, develop unit and lesson plans, design activities, and learn school and district operations—all of which may limit their effectiveness in their first year. Late-hired teachers must juggle all of these tasks while they are teaching. Late hiring can also disrupt student learning early in the year. When teachers are hired after the start of the school year, they take over either a class taught by an interim teacher or a newly formed class created because of inaccurate enrollment projections. This instability at the start of the year may limit students' learning during the first few weeks of school before a permanent teacher is hired. Late-hired teachers then face the additional challenge of establishing or re-establishing classroom norms and procedures, and developing relationships with students partway through the year. While we cannot disentangle the relative contributions of these different disruptive factors, all are temporary and affect students only when their permanent teacher arrives after the start of the school year.[1]

The third way in which late hiring can affect student achievement is through indirect spillovers on other students and teachers in the school. One primary spillover effect comes through increased teacher turnover, as late hiring can affect teachers' decisions to leave their schools and the profession. The rapid and "information-poor" hiring process experienced by many late-hired teachers leads to worse job matches and does not set teachers up for success in their first years (Liu & Johnson, 2006). In a series of surveys and in-depth interviews, Rutledge

[1] Importantly, although most analysts assume that late hiring results from inefficiencies and delays, some schools may use late hiring strategically to subvert district policies and staff their schools with the teachers they want. For example, a principal may come to a verbal agreement with a desired candidate, but not complete the official hiring paperwork until after the district's formal transfer process has ended. Or, a principal may hire the desired candidate on a temporary basis but need to wait until after enrollment projections have been completed in the fall before the position can become formal. In such cases, we would expect to find no effect, or a positive effect, of late hiring on student achievement.

et al. (2008) found that when principals hire teachers late, they typically are focused on filling positions before the start of the year rather than undergoing a through process to evaluate a candidate's potential. Worse matches between teachers and schools make teachers less successful and discourage them from staying in their school (Jackson, 2012). Candidates who fail to receive an adequate job preview that gives them a clear sense of what their everyday work will be like are also more likely to leave their position (Liu & Johnson, 2006). Furthermore, if late hires feel ineffective and unsupported, they may seek a better school match or another profession. Following 50 teachers in a series of longitudinal interviews, Johnson and Birkeland (2003) found that teachers who felt less successful with their students were less likely to stay in their schools and in teaching. Jones, Maier and Grogan (2011) found similar patterns among teachers in Michigan, where late hires were eight percentage points more likely to leave teaching and nine percentage points more likely to switch schools than on-time hires.

This increase in teacher turnover affects schools and students in several ways. Turnover imposes large financial costs on school districts. Estimates of these costs range widely, depending on the school district and assumptions used, but most data-driven estimates suggest that urban districts spend at least $10,000 to replace a teacher who leaves (Barnes, Crowe, & Schaefer, 2007; Birkeland & Curtis, 2006; Texas Center for Educational Research, 2000; Milanowski & Odden, 2007). These costs do not include the direct effects of turnover on student achievement. While the attrition of ineffective teachers may be valuable, teachers improve rapidly during their first several years on the job (Gordon, Kane & Staiger, 2006; Rockoff, 2004; Clotfelter, Ladd, & Vigdor, 2007; Harris & Sass, 2011; Papay & Kraft, 2011). Thus, to the extent that teachers who have accumulated experience will leave and be replaced by less effective novice teachers, student achievement may suffer. Furthermore, teacher turnover disrupts school-

wide efforts to align instruction and promote peer collaboration. Principals must redesign teacher teams to meet the skills of the new workforce, and teachers must invest time in developing productive relationships with their new colleagues. Using data from New York City, Ronfeldt and colleagues (2011) documented that this instability indeed reduces student achievement when teachers leave a school.

While there are many reasons why late hiring may affect student achievement, no empirical studies have documented this effect in practice. We present the first estimates of the direct impact of late hiring on students' academic achievement. Furthermore, we shed light on two competing explanations for the struggles of late-hire teachers advanced in the literature – labor market effects and disruption effects. Finally, we examine broader consequences of late hiring on student achievement, including spillover effects that occur from increased teacher turnover. Specifically, we ask the following three research questions:

1. *Do the observable characteristics of teachers who are hired late and the schools that hire them differ from on-time hires?*
2. *Does late hiring reduce student achievement? If so, are labor market effects or disruption effects to blame?*
3. *Are teachers who are hired late more likely to switch schools or leave the school district?*

Study Methods

Dataset and Sample

We use a comprehensive administrative dataset from a large, urban school district in the southern United States that includes student, teacher, and test records from the 1999-2000 to the 2009-2010 school years. This district has over 130,000 students and nearly 9,000 teachers. Student data include demographic information, teacher identifiers for each subject, and annual state test results in reading and mathematics. Overall, the students are broadly representative of

those in urban school districts across the country: 43% are African-American, 38% are White, and 12% are Hispanic, 10% have limited English proficiency, and 10% enroll in special educational services.

During the period we studied, the district was growing rapidly, hiring hundreds of teachers in every year. The district used a hybrid model of teacher hiring, in which potential candidates could apply directly to individual schools or to the central office. Any candidates who applied to the central office were referred to schools that appeared to be good matches. School principals had much say over hiring decisions, but all candidates had to submit an official application to the central office before a formal offer could be extended. Thus, delays could occur at several points during the hiring process.

We use two different samples of teachers, one for our descriptive analyses and one for our analyses of late hiring's effect on student achievement. For our descriptive analyses, including our estimates of the effect of late hiring on teacher retention, we examine all teachers in the district. We define teachers as those who are listed in the human resources data files as being classroom teachers and who are linked to students as the teacher of record in a class. Here, we include more than 10,000 unique teachers over the 10-year panel.

For our central analyses that examine the effects of late hiring on student achievement, we use an education production function model that requires both baseline and outcome testing data; as a result, we focus on teachers in grades four through eight in mathematics and English. We further exclude from these analyses any students in atypically small classes and any students in substantially separate special education classes.[2] Our final dataset for the student achievement analysis includes more than 300,000 student-year records, representing almost 4,000 unique

[2] Specifically, we exclude any teacher-year in which fewer than five students have baseline and outcome test scores. We exclude any class with more than 90% of students in special education. Doing so eliminates 2.3% of the sample in math and 3.3% in reading.

teachers.

Measures

Our key predictor measures whether a teacher was hired late, after the school year began. The district administrative data include the date on which each teacher began work, not the date on which they were offered the position.[3] Not surprisingly, more than 70% of all newly hired teachers start work on a single date in mid-to-late August, which is the first day of school for teachers. We categorize all teachers into three mutually exclusive groups: "standard" hires, "late" hires, and "other" hires. We define standard hires as teachers who have hire dates between June 1 and this start-of-school date, while we define late hires as teachers who are hired in the fall after school begins.[4] For teachers hired in 1999 or later, 84% fall into one of these two groups; we define all other teachers as "other" hires.[5] Thus, our main comparison is between teachers who were hired before the start of the year ($STANDARD_j$=1) and those we are confident were hired in the fall after the beginning of the school year ($LATE_j$=1). Each of these predictors is time invariant. We also code a dichotomous variable, $NEWHIRE_{jt}$, to indicate whether the teacher was newly hired in the district in that year.

[3] As a result, we cannot distinguish between the effectiveness of teachers hired early in the summer or late in the summer. Furthermore, the data do not include hire dates for teachers in 2002. For teachers hired in 2002, we use their hire date reported in the 2003 data instead. Of course, we cannot examine teachers who entered the district in 2002 and only stayed for one year.

[4] More specifically, we define late-hired teachers as those hired after the first week of the school year in order to avoid any issues of misclassification of teachers who may not complete their paperwork on the first day. Again, teachers whose formal hire date is in August may in fact have been offered the position in the spring, before June 1. We do not include teachers whose formal hire date falls between January 1 and June 1 as late hires because these teachers are more likely mid-semester replacements for teachers who leave (e.g., for maternity leave) rather than true "late hires" who fill positions that were vacant at the start of the school year. We test the sensitivity of our results to these definitions and our findings are quite consistent regardless of the definition used.

[5] The "other" category includes four sets of teachers: those hired in the first week of school, those with hire dates in the spring (from January 1 to June 1), those teachers hired before 1999, and all teachers who have missing hire dates. Defining this $OTHER_j$ predictor enables us to include these teachers – and their students – in our analyses that examine student achievement, but all of the contrasts that we present in the text are between "late" and "standard" hires defined above.

Our student-level records include student scores on the state tests in mathematics and reading, which serve as the outcomes in most of our analyses. These tests are the main assessments used in the state accountability system, so they carry high stakes for schools but not for students. We standardize these test scores by grade and year to have a mean of zero and a standard deviation of one in the district. Thus, our estimates can be interpreted as standard deviation differences in student performance. The dataset also contains student demographic information including indicators of race or ethnicity, gender, language proficiency, and special education status.

For our analyses of teacher turnover, we focus on two main outcomes. The first, $EXIT_{jt}$, indicates whether the teacher left the district after a given year. The second, $TRANSFER_{jt}$, indicates whether the teacher left their school but remained in the district after that year. We focus on the first time a teacher transfers within the district. Thus, teachers are coded as 0 in the dataset for each year in which these events did not happen, and 1 in the year after which they transferred schools or left the district.[6] Teachers are removed, or censored, from the data in years after the event occurs.

Data-Analytic Approach

Our goal is to estimate the effect of late teacher hiring on both student achievement and teacher retention. For our student achievement analysis, we focus on math and reading in grades four through eight. Our results derive from different specifications of a covariate-adjusted education production function model, in which we attempt to isolate the effect of late hiring from that of other factors that contribute to student achievement. In all cases, we model a student's test score (in math or reading) as a function of their previous-year test scores and a set of other

[6] We do not count a teacher as exiting the district if they subsequently return, although our results are not substantively different if we count any teacher as leaving the district if they do not return the following year.

predictors. We examine the effect on student achievement of late hiring, allowing the effect to differ in a teacher's first year in the district and in subsequent years (to disentangle the labor market and disruption effects). Our preferred model uses student fixed effects to exploit variation within-student over time as they move across four groups of teachers: late-hired teachers in their first year, late-hired teachers in other years, standard-hired teachers in their first year, and standard-hired teachers in future years. We specify our preferred model as follows:

$$(1) \quad \begin{aligned} Y_{it} &= \alpha_g[f(Y_{i,t-1})] + \beta_1 LATE_j + \beta_2 NEWHIRE_{jt} + \beta_3 LATExNEWHIRE_{jt} \\ &+ \gamma[f(EXPER_{jt})] + \overline{X_{jt}}'\varsigma + \overline{X_{st}}'\varphi + \delta_i + \theta_{gt} + \varepsilon_{it} \end{aligned}$$

for student *i* with teacher *j* in grade *g,* school *s*, and year *t*.[7] In all models, we include a cubic polynomial of the student's previous year's test scores in both math and reading ($f(Y_{i,t-1})$) and grade-by-year fixed effects (θ_{gt}). We allow the effects of prior-year test scores to vary by the student's grade. In our primary model, we include student fixed effects (δ_i) to account for any time-invariant differences across the groups of students who are assigned to late-hired teachers and teachers hired before the beginning of the academic year. We also include a vector of teacher-year-level means ($\overline{X}_{jt}$) and school-year-level means ($\overline{X}_{st}$) of these student demographic characteristics to account for classroom and school composition effects. In all models, we also include controls for the teacher's experience level, specified as a full set of dummy variables, to account for any differences in classroom experience between standard- and late-hired teachers.[8]

Our primary predictors of interest are the main effect of being a late hire, the main effect of being a new hire, and their interaction. Linear combinations of the parameters associated with these predictors, β_1, β_2, and β_3, allow us to uncover the effect, relative to a teacher hired in earlier

[7] In all cases we cluster our standard errors at the school-grade-year level to account for the fact that students in the same school and grade are likely to share common unmeasured influences on their achievement.
[8] We also include indicators for "other" hires to ensure that we include all possible students in the district. We omit these coefficients from our tables and discussion for simplicity.

years, of being in the classroom of a newly-hired teacher who was hired on time (β_2) or hired late ($\beta_1+\beta_2+\beta_3$). We are primarily interested in comparisons between late- and standard-hired teachers in their first year. Thus, the parameter sum ($\beta_1 + \beta_3$) represents the total effect on student achievement of being assigned to a late-hired teacher's classroom (as opposed to a standard-hired teacher's classroom) in the year the teacher was hired late. If the sum of these estimated parameters is negative and statistically significant, we can conclude that students in classrooms with teachers hired after the start of the school year do worse than their peers with other newly hired teachers who were hired on time.

Examining the individual parameters separately enables us to describe the mechanisms underlying any potential effect. Parameter β_1 represents the permanent effect of late hiring that is common to all years, including the teacher's first year in the district. In other words, this is the "labor market effect" that persists beyond the first year; to the extent that late-hired teachers continue to be less effective at raising student achievement beyond their first year, we can conclude that there has likely been negative labor market selection. Conversely, β_3 represents the effect on student achievement that *only* occurs in the year a teacher was hired late (note that late-hired teachers in their first year will be the only teachers for whom this interaction term equals one). This is the temporary "disruption effect" of late hiring that is unique to the first year.[9]

The validity of our inferences about the effect of late hiring on student achievement rests on two key assumptions. First, we must account for any differential sorting of *students* to late-hired and standard-hired teachers. If standard-hired teachers work with students who tend to score higher than expected, our results would again be biased. Teachers, both across schools and within the same school, teach vastly different students (Clotfelter, Ladd, & Vigdor, 2006). The

[9]This model assumes that these effects are linear and additively separable. In other words, there are no interactions between the labor market and disruption effects. To the extent that this hypothesis is not true, our results may mask some underlying heterogeneity in these effects.

extent to which education production function models like our Model (1) accounts for this sorting has been widely debated (Kane & Staiger, 2008; Rothstein, 2010; Chetty, Friedman, & Rockoff, 2011).

Student fixed effects are a powerful tool to resolve many of these issues in analyses that compare teachers' effectiveness across different sub-groups. Including student fixed effects fully accounts for any non-random sorting of students to teachers on time-invariant characteristics. In essence, they enable us to compare the academic achievement of students with late-hired teachers relative to how these same students performed in other years. Furthermore, we control flexibly for prior-year test scores to account for any type of sorting on time-variant student characteristics.

Although they help resolve many possible selection biases, including student fixed effects involves several trade-offs. Most importantly, in this model our parameters of interest are only identified off of "switchers", students who move across multiple categories of teachers during their time in school. As a result, we present an alternative "baseline" specification that allows us to identify our parameters of interest using all students in our sample. That our results across these two models are strikingly similar suggests that student sorting is not driving our results; we present more evidence on this point below.

Second, we must fully account for the preferential sorting of standard-hired teachers to *schools* where they may be more successful. If teachers hired on time work in school environments where all teachers have more success, any effect of late-hiring would be conflated with the contribution of the school environment to student achievement. To account for this threat, we modify our baseline model by replacing the average school-level characteristics ($\overline{X}_{st}$) with school fixed effects. Doing so explicitly accounts for any school contributions to student

achievement and restricts our inferences to a comparison between teachers working in the same school. We also take this logic one step further, replacing these school fixed effects with school-by-grade-by-year fixed effects, restricting our comparisons to teachers who work in the same school, grade, and subject in the same year. Again, our main results are quite similar when we compare teachers within the same school or school-grade-year combination.

Our third research question asks whether teachers who are hired late are more likely to switch schools or leave the school district. We answer this question by using discrete time survival analysis (DTSA) to estimate the "risk" that a late-hired teacher transfers schools or exits the district compared to a standard-hired teacher (Singer & Willett, 2003). To conduct this descriptive analysis, we reformat our teacher-level dataset into a person-period dataset, such that each teacher contributes one row for each year of her career. Again, our time-varying outcome variables, $TRANSFER_{jt}$ and $EXIT_{jt}$, indicate whether the teacher transferred schools or left the district in each given year (1 if transferred/exited, 0 if remained in the district). Given that we only have data through 2009-10, we censor each observation at this point. Furthermore, once a teacher transfers schools for the first time or exits the district, we remove them from the relevant "risk set" in subsequent time periods.

We model the hazard (i.e. the conditional probability) of exiting the district using logistic regression, as follows:

$$(2) \qquad \text{logit } h(EXIT_{jt}) = \tau_t \sum_{k=1}^{11} I_{t=k} + \phi LATE_j + \pi_t \sum_{k=2}^{11} (I_{t=k} x LATE_j)$$

Here, we examine the probability that teacher *j* exits the district in time *t*, conditional on having not left the district in previous years; we fit analogous models for transfer by substituting our outcome $TRANSFER_{jt}$ for $EXIT_{jt}$. We model time as a complexly flexible function of indicator

variables, $\sum_{k=1}^{11} I_{t=k}$. The inclusion of the main effect of being a late-hired teacher and its interaction with the full set of time indicators allows us to estimate whether late-hired teachers have a greater probability of leaving the district after each year than their peers hired on time. If our estimate of ϕ is positive and statistically significant, we can say that late-hired teachers leave the district after their first year at a greater rate than on-time new hires. Similarly, we can compare rates of exit after the second year in the district by examining the linear combination of ϕ and π_2, and so on.

In each case, our risk set includes only teachers who have not yet left. By examining these hazard probabilities over time, we can also recover the probability that a late-hired or standard-hired teacher remains in the district until year *t*. We also present these survival probabilities in our figures. We extend these analyses by fitting additional models that include controls for teacher experience and school fixed effects. These models explicitly compare late- and standard-hired teachers with the same levels of experience and who work in the same schools, removing the possibility that any differences in the exit and transfer rates between late- and standard-hired teachers are due to differences in experience or the schools in which they work.

The Prevalence, Characteristics, and Distribution of Late Hired Teachers

We find that most teachers are hired by the beginning of the school year; however, of teachers who start in the fall, 18% are hired after the school year starts.[10] This pattern matches closely with national evidence (Engel, 2012). In Figure 1, we display the proportion of these late hires by month of hire. Many of these teachers enter schools shortly after the start of the school

[10] These figures exclude "Other" hired teachers, defined above. As such, they are conservative estimates of late hiring. Adjusting our definition of "late" and "standard" hires changes this precise figure somewhat, but in all cases a substantial proportion of teachers are hired in the fall after the school year starts.

year, in late August. However, nearly half do not begin teaching until October. These patterns suggest that many schools struggle to find full-time teachers even well after the school year has begun.

Late-hired teachers differ from their peers in the district in several ways. In Table 1, we present the characteristics of standard and late hires. We find a greater proportion of male and African-American teachers among late hires than among on-time hires. Furthermore, late-hired teachers are both older on average (by 3.6 years) and more likely to have entered the profession by alternative routes (by 11 percentage points) than teachers hired on-time. Similarly, they are less likely to have a subject-area license, a master's degree, or previous teaching experience. Interestingly, more than half of both late-hired and standard-hired teachers entered the district without prior teaching experience.

Teachers who are hired late also tend to work in different types of schools than their peers who are hired on-time. In Table 2, we present the characteristics of schools in which teachers work, by the timing of their hire. On average, the schools with more late hires are lower-performing, serve greater proportions of African-American students and have higher rates of absenteeism. For example, compared to the average on-time hire, the average late hire enters a school whose students scored 0.05 standard deviations lower in math and 0.04 standard deviations lower in reading in the previous year. However, late-hired teachers do not work in schools that serve significantly greater proportions of students living in poverty, with limited English proficiency, or who have special educational needs.

Importantly, late-hired teachers also tend to cluster in certain schools. In Figure 2, we present the proportion of each school's new hires that were hired late across the ten-year period that we study. We find that nearly 10% of all schools in the district are able to hire all of their

teachers before the beginning of the school year. By contrast, 30% of schools hire more than one of every five new hires after the school year starts. We find that 20% of the district's schools account for 53% of the total number of late hires. Late-hiring is more prevalent in middle and high schools than in elementary schools, where only 13% of teachers are hired late.

The Direct Effect of Late Hiring on Student Achievement

We find strong evidence that being assigned to a classroom with a teacher hired after school starts in the fall reduces student achievement. Students in classrooms with late-hired teachers underperform those with other new teachers hired over the summer by 0.037 standard deviations in reading (p=0.002) and 0.042 standard deviations in mathematics (p<0.001). We present these results in the first row of each panel in Table 3; the first column includes our preferred specification, where we include student fixed effects and control for classroom-level demographics and school-level average characteristics. These effects are quite large, given that a one standard deviation difference in teacher effectiveness is associated with a 0.10 to 0.15 standard deviation difference in student performance.[11] Put another way, they represent approximately 10% of the test score gap on the National Assessment of Educational Progress between low-income and higher-income students, or approximately two months of instruction for a typical middle school student (Hill et al., 2008). Thus, students in classrooms whose teachers arrive after the school year started suffer.

These results derive from an education production function model that attempts to account for the sorting of teachers to schools and students to teachers. As described above, we fit supplementary models that include controls for student characteristics instead of student fixed effects, school fixed effects, and school-by-grade-by-year fixed effects. The last two models explicitly compare late-hired and standard-hired teachers who: (1) teach in the same school; (2)

[11] This general pattern holds in our dataset and in other districts (see Hanushek & Rivkin, 2011).

teach in the same school, grade, and year. In the remaining columns of Table 3, we present the key results from each of these specifications. Our results are quite consistent across models. If anything, the student fixed effects models we present are the most conservative, at least in math. We see that students of late-hired teachers face a substantial disadvantage in the first year. In math, these effects range from 0.042 to 0.057 standard deviations. In reading, they range from 0.030 to 0.045 standard deviations.

These negative effects can arise either because the teachers who are hired late are less effective than their peers (labor market effects) or because late hiring itself is disruptive to both teachers and students (disruption effects). Our model enables us to disentangle these hypotheses, and we present these results in the second and third rows of each panel in Table 3. Interestingly, we find that the mechanism underlying these effects differs by subject. In math, the labor market effect appears to dominate, while in reading the disruption effect is most important. In math, teachers who were hired late continue to underperform their peers by 0.039 standard deviations ($p<0.001$) after their first year. This suggests that math teachers who are hired after the beginning of the school year are less effective teachers, on average, than their peers who are able to secure jobs before the start of the school year. We find no evidence of a first-year disruption effect in math. By contrast, the disruption effect appears to account for all of the effect of late hiring in reading. Late-hired English teachers perform no different than standard-hired teachers after their first year, as evidenced by our near zero and not statistically significant estimate of the labor market effect.

In addition to subject-area differences, we might expect to find differences by grade level. In fact, the differing results by subject area described above are unlikely to exist for the elementary school teachers because they typically teach both math and English. To examine this

in more detail, we split our sample and estimate results separately for elementary and middle school students. In Table 4, we present the results from our baseline model; we move away from the student fixed effects model here because our results are imprecise, particularly in elementary school where we only have two years of data. Although this approach is less precise than our full model across grades, it reveals a more nuanced pattern, and we find differing results across grade levels in math. In elementary school English, elementary school math, and middle school English, the results are quite consistent, showing large disruption effects in the first year and little evidence of negative labor market selection. In middle school math, however, the labor market effect is quite large, suggesting that late-hired teachers who teach middle school math may indeed be less successful math teachers than their peers who are hired on time.

This pattern makes sense, as middle school teachers are hired specifically for different subject areas. Given that the market for potential math teachers is generally much tighter than that for English teachers, it is not surprising that districts hiring late face negative selection in the labor market (Levin, 1985; Podgursky, Monroe, & Watson, 2004). These patterns suggest that districts and schools that hire middle school math teachers earlier during spring and summer leave fewer effective math instructors available for districts that hire late. It is less clear why we find no disruption effect in middle school math. In part, the larger labor market effects suggest that these teachers may both start behind their peers and not have the skills to recover from a difficult first year. It is possible that their lower set of skills prevents them from recovering from this rocky start and permanently affects their growth trajectory.

In differentiating between disruption and labor market effects, we must consider two additional threats to validity. Our ability to distinguish between these two hypotheses is based on differences in student achievement patterns over the course of a teacher's career. In reading and

elementary math, we find that students assigned to teachers who had been hired late perform no worse than students assigned to other teachers after the first year. First, these patterns could simply reflect differential effectiveness and attrition of late-hired teachers. To understand this threat, imagine that the late-hired teachers who leave the district after their first year are the very worst performers among all late-hired teachers, while standard-hired teachers who leave are simply of average effectiveness. In the second year, we would see that late-hired teachers appeared relatively more effective, and we might attribute this trend to a disruption effect in the first year rather than simply a difference in the types of teachers who remained in the district.

Thus, we need to examine whether late-hired teachers who leave are relatively less effective (compared to late-hired teachers who stay) than other standard-hired teachers who leave (compared to other standard-hired teachers who stay). In Table 5, we present results from a test of this hypothesis. First, we predict each teacher's contribution to student achievement from a basic value-added model.[12] In the first column of Table 5, we show the relative difference in teacher effectiveness for standard-hired teachers who leave compared to those who stay. In the second column, we present the same difference for late hires. The third column presents the key result, the difference in these differences. We find that the average difference in effectiveness between late-hired teachers who leave and those who stay is nearly identical to the average difference for standard-hired teachers. This holds overall and when we compare teachers with the same level of teaching experience. Thus, we find no evidence of the type of differential attrition that would bias our results.

Second, these patterns could reflect differential sorting of students to teachers over time. Given that we control flexibly for teacher experience in our models, we would need to see a

[12] We use a model similar to our baseline model, but we remove the predictors that focus on the timing of hiring and we include a teacher fixed effect. We predict these fixed effects for each teacher. We fit two versions of this model, one that includes indicators for teacher experience and one that does not.

pattern in which late-hired teachers were assigned different types of students over the course of their careers than their peers hired on-time. In particular, we might worry that late-hired teachers are disproportionately likely to have low-performing students in their first year, which could produce the apparent disruption effects that we see. To examine this threat, we fit a modified version of model (1) in which we remove lagged student achievement from the right-hand-side of our model and use it as an outcome. In other words, we examine whether late-hired teachers are assigned lower-performing students in their first year or throughout the rest of their careers, relative to teachers hired on-time. Again, because our model includes student fixed effects, this type of sorting would have to be on time-varying student characteristics. We present these results in Table 6 for mathematics teachers in the top panel and reading teachers in the bottom. We examine two outcomes: prior-year achievement in mathematics and reading. Overall, we find no evidence to suggest that our results are driven by the type of student sorting on time-varying characteristics that might explain away our results. The only statistically significant result suggests that late-hired reading teachers teach disproportionately higher-scoring students than we would expect in their first year, a pattern that would work against the results we find.

Spillover Effects: Teacher Retention

Teacher turnover has important consequences for organizational capacity and, ultimately, student achievement. High levels of turnover can produce organizational instability and lead to classrooms staffed by larger proportions of novice teachers, both of which reduce student achievement (Ronfeldt et al., 2011). Notably, the district has quite high turnover rates overall. Furthermore, we find that late-hired teachers are much less likely to stay in the district than standard-hired teachers, and those who remain are more likely to transfer schools. We present our results on teacher retention from our discrete-time survival analysis models in Table 7. We

show our results from teacher exits in the top panel and teacher transfers in the bottom panel. Column 1 contains the estimated hazard probability of exiting the district for standard-hired teachers each year through their 5th year in the classroom. The next three columns illustrate the difference in retention rates for late-hired teachers, overall, controlling for teacher experience, and comparing teachers in the same school using school fixed effects. For example, the second row (labeled "After 2nd Year") suggests that, among all teachers who stayed in the district for a second year, 19.8% of on-time hires did not return for a third year, compared to 23% of late hires (a 3.2 % point difference). In the bottom panel, we present analogous findings from our analysis of teacher transfers.

We illustrate these differences in Figure 3. In the top panel, we present the estimated hazard probabilities of exiting the district from our baseline model; in the bottom panel we present the implied survival probabilities that teachers in each group have stayed in the district through each year, from 1 to 11. We see much higher rates of exit for late-hired teachers in their first two years. For example, 80% of standard-hired teachers remain in the district for a second year, compared to just 71% of late hires. As seen in the bottom panel, this retention gap between late-hired and standard-hired teachers does not narrow appreciably over time. By the fourth year, half of all standard hires remain in the district, compared to just 39% of late hires. Similarly, we see higher rates of transfer among late-hired teachers, at least in their first year in the district. Five percent of standard-hired teachers change schools after their first year, compared to 7% of late-hired teachers.

It is possible that these patterns are the result of specific teachers sorting patterns. For example, we would see similar patterns if late-hired teachers tended to teach in schools with less supportive working conditions because teachers frequently leave these schools for more

supportive work environments (Ladd, 2011; Johnson, Kraft, & Papay, 2012). Thus, it may not be the late-hiring itself, but the working conditions in schools where late-hired teachers work, that drive the increased turnover we observe in our data. It is also possible that differences in experience among late and standard hires are driving these turnover patterns. However, as seen in columns 3 and 4 of Table 5, we find quite similar patterns when we compare teachers with the same level of teaching experience or who work in the same schools.

It is also important to note that our data do not allow us to distinguish between voluntary and involuntary turnover. It could be that some of these differences in exit and transfer rates are due to late hired teachers being more likely to be terminated or counseled out of the district. Whatever the reasons, these patterns are further evidence of both the struggles of late-hired teachers in their first year and the relatively poor match quality between late-hired teachers and their positions. Hiring teachers after the beginning of the school years contributes to increased staffing instability in schools.

Conclusion and Implications

Teacher hiring is a critical, but often overlooked, element of the larger human capital pipeline in education. In many large urban districts, teachers have come to expect the hiring process to be an end-of-summer scramble that continues well past the beginning of the academic year. In the district we study, nearly 20% of teachers are hired in the fall after the school year begins. Ultimately, students pay the price for these delays. When students are assigned to teachers who have been hired after the school year starts, their achievement suffers compared to their peers assigned to other newly hired teachers. Furthermore, teachers who are hired late leave their schools and the district at much greater rates than their peers hired on time. These turnover patterns contribute to late-hiring's effects on student achievement. When teachers leave the

district, they are replaced by new hires, many of whom are novice teachers. On average, these teachers are less effective at raising student achievement than teachers who remain in the district. And, the instability caused by turnover disrupts the school organization and reduces student achievement (Ronfeldt et al, 2011).

Interestingly, we find consistent evidence of labor market effects only in middle school mathematics, not for middle school English teachers or elementary school teachers. In middle school math, it appears that schools do indeed struggle to find effective candidates after the school year begins. That there is a labor market effect in middle school math makes sense. The market for math teachers in general is more constrained because there are fewer qualified candidates available and more job opportunities outside of the education sector. Although we have no data on the effects of late hiring on high school students, these findings suggest that late-hired high school math and science teachers might also be less effective teachers on average due to this negative labor market selection process and the tighter market for highly qualified teachers in these areas.

However, in elementary school math, elementary school reading, and middle school reading, the effect of late hiring appears to be almost entirely a transitory disruption, negatively affecting students only in a teacher's first year. This suggests that late hiring affects students and teachers in ways that go beyond the simple "missed opportunities" story of labor market selection. After the first year, these late-hired teachers appear to be just as effective as their peers hired on-time. The disruption effect we find among elementary school and middle school teachers is likely caused by a combination of factors. Lack of planning and preparation time over the summer, insufficient induction to the school and district, the challenges of building a classroom culture after the school year has started, and the fact that students have been in class

for weeks or months with an interim teacher or in a very large class may all play a role. Although we cannot evaluate the relative importance of each of these factors, the key lesson is that late hiring produces a disruption that has serious effects on student achievement.

Importantly, the negative consequences of late hiring are concentrated in high-poverty, urban schools, which hire many more teachers after the school year starts than suburban schools. In urban districts, delayed school budgets, restrictive teacher transfer policies, administrative inefficiencies, and uncertain enrollment projections all contribute to the challenge of hiring teachers on time. Importantly, although teachers unions and collective bargaining agreements often get blamed for late hiring, we find that hiring delays are common in a state that prohibits bargaining. Thus, while district policies may contribute to these challenges, teachers unions cannot be held solely responsible. Any solution must be broader and address the organizational failures of urban districts to operationalize an efficient and effective hiring process.

Furthermore, late hiring is not only a district-level problem. Instead, as we show, hiring delays are often concentrated among a minority of schools in a district. Some schools appear to navigate the hiring process more successfully than others. Late hiring is most prevalent in the district's worst-performing schools; as a result, the students who most need the support and consistency of effective full-time teachers often begin the year without them. Although we cannot disentangle the many potential causes for these school-level differences in hiring, past research suggest that principals and working conditions each play a key role. Principals play a central role in the hiring process, particularly in districts such as the one we study where hiring takes place, in part, at the school level (Liu & Johnson, 2006). Schools with poor working conditions struggle to attract and retain teachers, producing high rates of turnover that exacerbate the challenges of hiring teachers (Ladd, 2011; Boyd et al., 2011; Johnson, Kraft, & Papay, 2012).

What is clear is that late hiring is an all too common practice among schools and districts. We build on past research that documents the prevalence of late hiring, and we present clear evidence on its effects. Although hiring in districts has slowed in recent years, this trend is not likely to continue. Nationwide, nearly 50 percent of new teachers leave the profession within five years, the school-aged population is growing, and the retirement of a large cohort of baby-boomer teachers is rapidly approaching (Ingersoll, 2003). These trends suggest that, despite budget shortfalls and the current climate of teacher layoffs, schools will soon need to hire large numbers of new teachers. As others have described in detail, schools and districts need to find ways to move up hiring timelines. Our results should provide policymakers and district officials with additional urgency in ameliorating these challenges. Delayed hiring has substantial deleterious effects on student achievement.

Importantly, our study only examines the direct effect of late-hiring on the achievement of students these teachers teach. However, late hiring likely has spillovers in many different areas; in other words, its effect extends beyond the students in these classrooms to affect a teacher's peers and other students in a school. For example, teachers who are hired late likely need additional support that is not easily provided by the school or district in formal pre-service induction. Any such spillover effects would depress the achievement of other students; our estimates not only do not capture these spillovers, but their existence would lead our results to be understated. As schools begin to become more integrated organizations where teachers collaborate and plan together, these spillovers will likely become even more important pieces of the overall effect of late hiring.

Policymakers tend to conceptualize the human capital pipeline as just that – a sequential and ordered process in which we prepare, recruit, hire, induct, develop, and retain teachers.

However, these processes are much more interrelated than they are distinct. Improving the teacher hiring process has the potential to improve student achievement directly, but also to contribute to resolving other pressing issues on which policymakers have spent a great deal of energy: attracting and selecting highly qualified teachers, supporting their improvement throughout their careers, and retaining them. Moving up the hiring timeline and improving the process could contribute to all of these areas.

Uprooting the causes of late hiring will take time. Policies will need to be renegotiated and rewritten, central offices will need to invest in organizational capacity, systems will need to be developed to complete budgets and enrollment projects earlier in the year, and principals will need to be supported to navigate human resource systems effectively. These steps are not impossible, and several districts have worked to move up hiring timelines by securing budgetary approval earlier in the year and reworking internal teacher transfer processes. But, in the near future, many schools will continue to fill open staff positions after the beginning of the school year. Our findings suggest that simply attempting to recruit stronger candidates after the school year has begun will not eliminate the negative consequences of late hiring. Instead, schools and districts must also work to limit the disruption caused by late hiring. Targeting extra support to late-hired teachers cannot solve all of the challenges posed by late hiring, but it can help districts limit the negative effects of this practice, at least in the near term.

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Figure 1. Percent of late-hired teachers by month of hire.

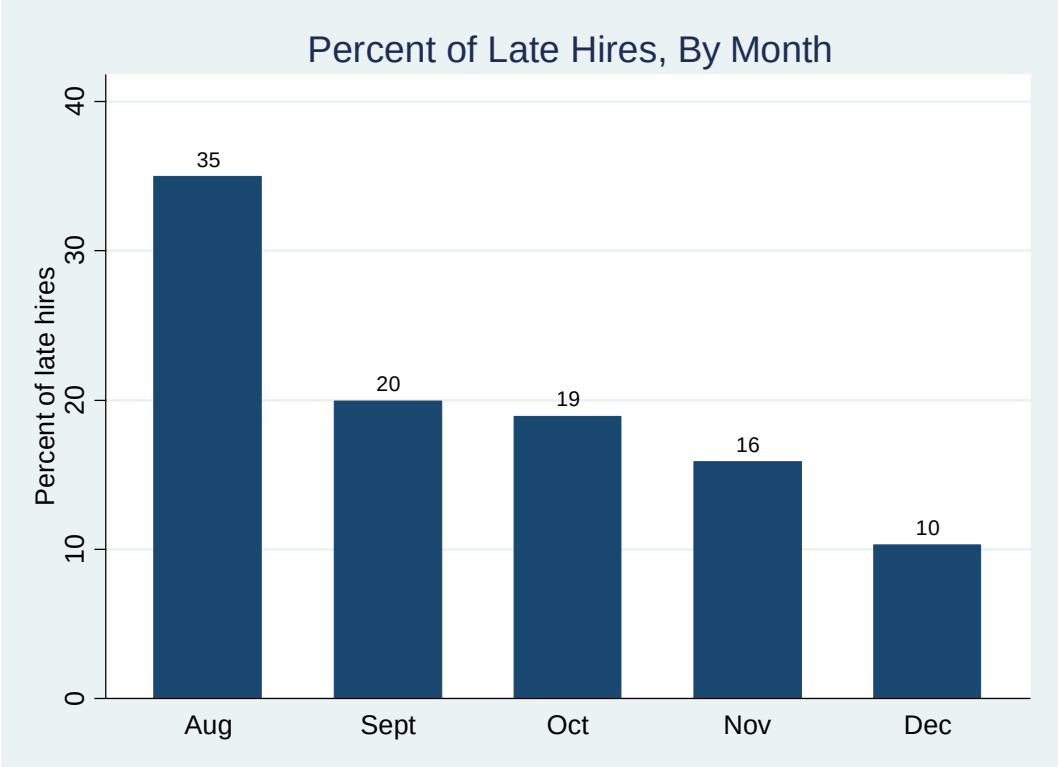


Figure 2. Distribution of the percentage of new hires in a school who were hired late, across schools in the district.

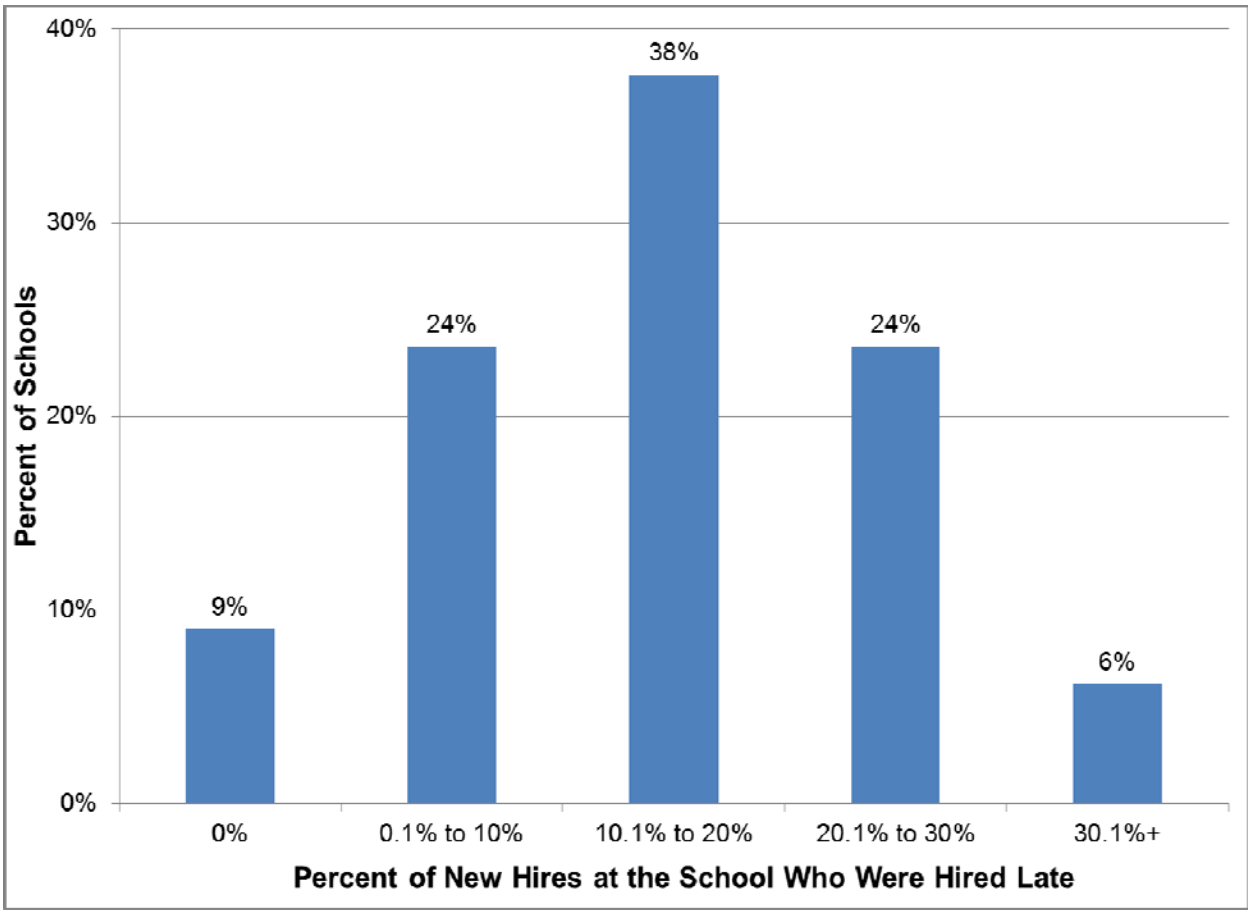
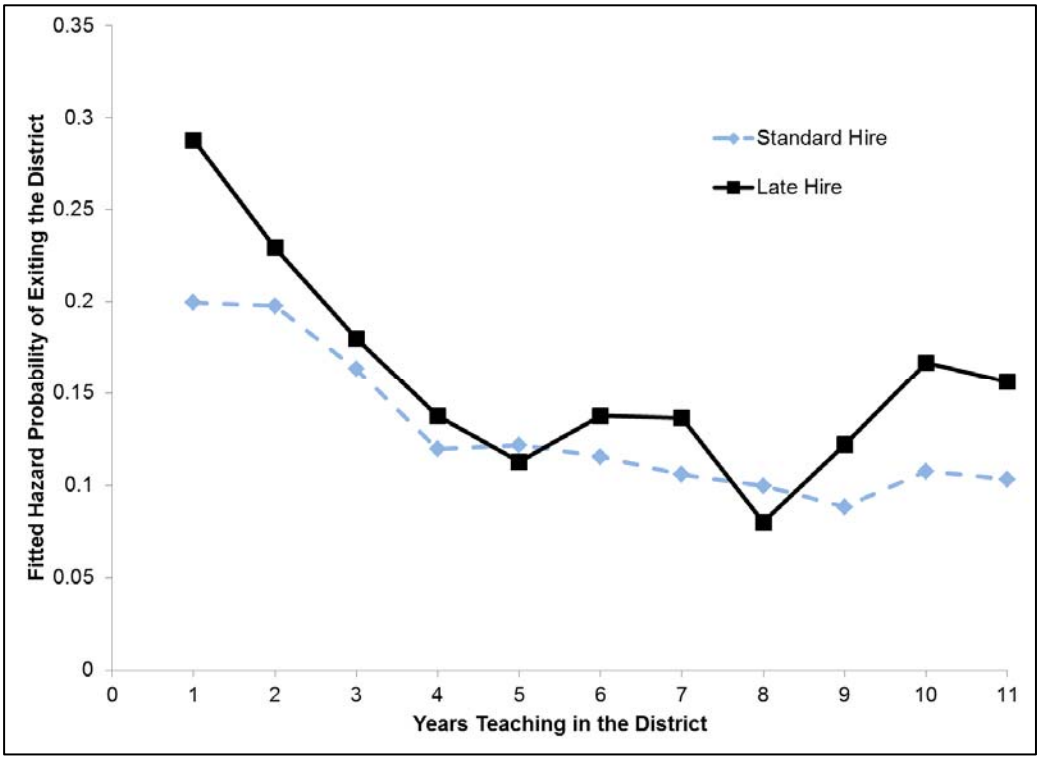


Figure 3. Estimated hazard probability of leaving the district (top panel) and estimated survival probability of remaining in the district (bottom panel), by year for standard and late-hired teachers.



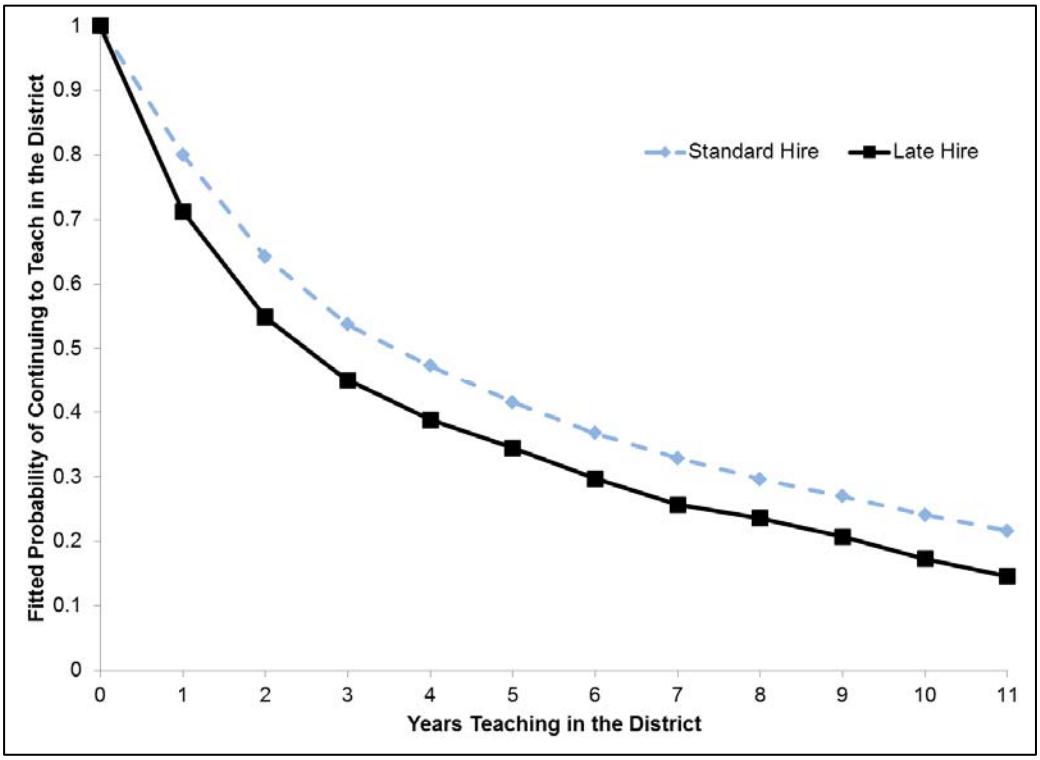


Table 1. Average characteristics of late-hired and standard-hired teachers in the district.

Teacher Characteristic	Standard Hires	Late Hires	Difference
Male	21.5%	26.8%	5.3% ***
African-American	20.0%	28.3%	8.3% ***
Asian	1.4%	1.4%	0.0%
Hispanic	3.3%	3.8%	0.5%
Alternative Pathway	25.8%	36.5%	10.7% ***
Math License	10.2%	7.9%	-2.3% **
English Language Arts License	15.1%	11.9%	-3.2% ***
Masters Degree	23.0%	18.7%	-4.3% ***
Novice (1st salary step)	50.1%	54.8%	4.7% ***
Age	31.6	35.2	3.6 ***

Note: *p<0.05, **p<0.01, ***p<0.001. N=10,616.

Table 2. Average characteristics of the schools in which standard-hired and late-hired teachers teach.

School Characteristic	Standard Hires	Late Hires	Difference
Average math score (previous year)	-0.07	-0.12	-0.05 ***
Average reading score (previous year)	-0.10	-0.14	-0.04 ***
School met AYP	34.8%	28.8%	-6.0% ***
Average days absent	9.08	10.09	1.01 ***
% Poverty	49.3%	50.8%	1.5% ~
% LEP Students	9.8%	9.5%	-0.3%
% SPED Students	10.1%	10.1%	0.0%
% Asian Students	4.3%	4.4%	0.1%
% Hispanic Students	10.8%	10.0%	-0.8% **
% African-American Students	46.0%	48.4%	2.4% ***

Note: *p<0.05, **p<0.01, ***p<0.001.

Table 3. Effect of late teacher hiring on student achievement, in math (top panel) and reading (bottom panel), from different specifications of model (1).

	Late-Hired vs. Standard-Hired Teachers			
	Preferred Model	Baseline Model	School Fixed Effects	School-Grade-Year Fixed Effects
Mathematics				
1st Year	-0.042 ***	-0.057 ***	-0.051 ***	-0.044 ***
	(0.012)	(0.013)	(0.013)	(0.012)
"Labor Market Effect"	-0.039 ***	-0.045 ***	-0.033 ***	-0.026 ***
	(0.008)	(0.008)	(0.008)	(0.007)
"Disruption Effect"	-0.003	-0.012	-0.019	-0.018
	(0.014)	(0.016)	(0.015)	(0.014)
Observations	367,221	367,139	367,264	367,264
Reading				
1st Year	-0.037 **	-0.045 ***	-0.036 **	-0.030 **
	(0.012)	(0.012)	(0.010)	(0.011)
"Labor Market Effect"	-0.002	0.006	0.009	0.004
	(0.006)	(0.006)	(0.006)	(0.006)
"Disruption Effect"	-0.035 **	-0.051 ***	-0.045 ***	-0.034 **
	(0.013)	(0.013)	(0.012)	(0.013)
Observations	311,144	311,070	311,159	311,159
Student fixed effects	X			
School-level averages	X	X		
Grade-by-year fixed effects	X	X	X	
Teacher experience controls	X	X	X	X

Notes: *p<0.05, **p<0.01, ***p<0.001. Standard errors clustered by school-by-grade-by-year reported in parentheses.

Table 4. Effect of late teacher hiring on student achievement by grade level, in math and reading, from our baseline specification.

	Late-Hired vs. Standard-Hired Teachers			
	Mathematics Achievement		*Reading Achievement*	
	Elementary	Middle	Elementary	Middle
1st Year	-0.089 ***	-0.044 *	-0.052 **	-0.041 *
	(0.019)	(0.018)	(0.016)	(0.016)
"Labor Market Effect"	-0.014	-0.051 ***	-0.008	0.012
	(0.012)	(0.011)	(0.009)	(0.007)
"Disruption Effect"	-0.076 **	0.007	-0.044 *	-0.053 **
	(0.022)	(0.021)	(0.018)	(0.018)
Observations	153,616	213,523	150,164	160,906

Notes: *p<0.05, **p<0.01, ***p<0.001. Standard errors clustered by school-by-grade-by-year reported in parentheses.

Table 5. Relative effectiveness of teachers who leave the district compared to teachers who stay, for standard-hired and late-hired teachers in math (top panel) and reading (bottom panel).

	Effectiveness of Teachers who Leave vs. Teachers who Stay		
	Standard Hires	Late Hires	Relative Difference
Mathematics			
Overall	-0.002	-0.004	-0.002
	(0.006)	(0.020)	(0.021)
	[p=0.686]	[p=0.827]	[p=0.923]
Conditional on Experience	-0.010 ~	-0.009	0.001
	(0.006)	(0.020)	(0.021)
	[p=0.092]	[p=0.661]	[p=0.957]
Reading			
Overall	0.005	0.001	-0.004
	(0.005)	(0.016)	(0.017)
	[p=0.311]	[p=0.953]	[p=0.815]
Conditional on Experience	0.007	0.006	-0.001
	(0.005)	(0.016)	(0.017)
	[p=0.141]	[p=0.700]	[p=0.959]

Notes: ~ p<0.10, *p<0.05, **p<0.01, ***p<0.001. Standard errors clustered by school-by-grade-by-year reported in parentheses. Estimated p-values in brackets.

Table 6. Estimated "effect" of late hiring on prior-year student test scores in reading and mathematics, for mathematics teachers (top panel) and English teachers (bottom panel).

	Outcome	
	Student reading scores (lagged)	Student math scores (lagged)
Mathematics		
1st Year	-0.005	0.009
	(0.009)	(0.011)
"Labor Market Effect"	-0.001	0.001
	(0.005)	(0.006)
"Disruption Effect"	-0.004	0.008
	(0.011)	(0.013)
Observations	367,139	367,139
Reading		
1st Year	0.027 *	0.001
	(0.011)	(0.013)
"Labor Market Effect"	-0.011	-0.009
	(0.006)	(0.007)
"Disruption Effect"	0.038 *	0.011
	(0.013)	(0.015)
Observations	311,070	311,070

Notes: *p<0.05, **p<0.01, ***p<0.001. All models include student fixed effects. Standard errors clustered by school-by-grade-by-year reported in parentheses.

Table 7. Fitted hazard probabilities of exiting the district (top panel) or transferring schools within the district (bottom panel) for standard-hired and late-hired teachers, by year in the district.

Years in District	Average for Standard Hires	Difference for Late Hired Teachers		
		Overall	Controlling for Experience	Controlling for School Fixed Effects
Exit the District				
After 1st Year	0.200	0.088 ***	0.087 ***	0.077 ***
After 2nd Year	0.198	0.032 *	0.033 **	0.027 *
After 3rd Year	0.163	0.017	0.016	0.031
After 4th Year	0.120	0.018	0.017	0.001
Transfer Schools within the District				
After 1st Year	0.051	0.019 **	0.016 ***	0.022 ***
After 2nd Year	0.083	0.002	0.003 *	0.003 *
After 3rd Year	0.075	-0.012	-0.006	-0.010
After 4th Year	0.085	-0.011	-0.006	-0.004

Notes: ~ p<0.10, *p<0.05, **p<0.01, ***p<0.001.