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Turnover at the Top:

Estimating the Effects of Principal Turnover on Student, Teacher, and School Outcomes

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Abstract

One in five schools loses its principal each year. Despite the prevalence of principal turnover, little empirical research has examined its effects on school outcomes. Because principal turnover may occur in response to or contemporaneous with a downturn in student achievement, the effect of a turnover is confounded with unobserved school-level factors. We employ a novel identification strategy that blocks each potential source of endogeneity to isolate plausibly causal effects of within- and between-year principal turnover. Using eight years of North Carolina administrative data from 2009-2018, we find that principal turnover is associated with significant decreases in student achievement and increases in teacher turnover. These effects are similar whether the turnover occurs over the summer or during the school year.

Introduction

About one in five principals leave their schools each year (Battle, 2010; Fuller & Young, 2009; Goldring & Taie, 2014), and researchers have begun to document adverse effects of principal turnover on student achievement, graduation rates, and teacher retention (Béteille, Kalogrides, & Loeb, 2012; Miller, 2013; Weinstein, Schwartz, Jacobowitz, Ely, & Landon, 2009). Principal turnover may affect student, teacher, and school outcomes through two primary mechanisms: disruption of ongoing organizational operations and differences in the effectiveness of the departing and replacing principals. Disruptive effects, which may occur when the turnover disrupts the ongoing operations and relationships in the school, may be short term or persist for a longer term depending on the ability of the replacement principal to restore or improve the prior conditions. This disruptive effect of principal turnover may extend to student outcomes to the extent that principals influence school climate and teacher collaborative practices, which have been shown to have associations with teacher effectiveness (Kraft & Papay, 2014) and student outcomes (Ronfeldt, Farmer, McQueen, & Grissom, 2015). In addition, the effectiveness of principals is highly variable (Branch, Hanushek, & Rivkin, 2009; Coelli & Green, 2012; Dhuey & Smith, 2018; Grissom, Kalogrides, & Loeb, 2015) and differences in effectiveness between the outgoing and incoming principals will affect the outcomes on which the principals differ. Because principal turnover is more frequent in low-performing and high-poverty schools (Battle, 2010; Fuller & Young, 2009) and these schools already struggle to recruit effective principals (Loeb, Kalogrides, & Horng, 2010), negative effects of turnover will disproportionately affect schools that are already struggling to raise student achievement.

While a large literature has explored the correlates and determinants of principal turnover (Battle, 2010; Fuller & Young, 2009; Gates et al., 2006; Papa, Jr., 2007), few have attempted to estimate the effect of that turnover on school outcomes. Identifying the causal effect of principal turnover would therefore provide insight into an underexplored component of the educator labor market. The endogeneity of the turnover event may, however, thwart efforts to estimate the average causal effect of principal turnover. The turnover is endogenous when turnover and the outcome measured after the turnover event are correlated with a third variable that is not directly controlled through the empirical strategy. Sources of endogeneity that may bias the average effect of principal turnover include school characteristics, school trends, performance dips immediately prior to the turnover event, one-time disturbances contemporaneous with the turnover event, and poor performance of the departing principal. In this study, we employ a novel identification strategy that blocks each potential source of endogeneity. We add school fixed effects and time-varying school-level covariates associated with turnover in prior research to remove school characteristics as a source of bias in the average effect estimates and fit a school-level spline to control for the potential endogeneity of school performance trends. We then add leading indicators to adjust for the effect of a short-term prior performance dip that may positively bias the post-turnover effect estimates. We add year fixed effects to control for any contemporaneous event that also affects turnover and the outcome and examine the effect of one such event for which we have data, superintendent turnover, on the estimates of the effects of principal turnover. Finally, to remove the endogenous poor performance of the departing principal on the outcomes, we refine our estimates to include only turnover events that are unlikely to be associated with poor performance, isolating these plausibly exogenous turnovers by separately estimating the effect of departing principals who are promoted or transferred to another school within the district. By excluding the departures of principals who were demoted, leave employment in the district, or leave the state education system altogether, we are likely to have purged the effect estimates of those principals whose poor performance led to their departure. While some of the principals who transferred to a principalship outside the district may not have performed poorly, the resulting average effect of principal turnover estimates have excluded any of the poor performers who managed to find positions outside the district.

In addition to the empirical challenges stemming from the potential endogeneity of the turnover event, measurement limitations may have also affected estimated effects of principal turnover in prior research. All studies of the effects of principal turnover to date have used administrative data from a state or a large district or districts, which provide annual snapshots of the staff employed at each school. Relying on annual measures of principal turnover forces researchers to treat principal transitions as a once-per-year event, when in reality principals frequently transition during the school year. If within-year principal departures disrupt ongoing school operations more than between year departures or if a more limited pool of replacements are available mid-year, estimates using annual turnover measures would be weighted averages of within- and between-year turnover. Recent research on teacher turnover suggests within-year teacher turnover has adverse effects on student achievement, while between-year turnovers have null or, in some cases, positive effects (Henry & Redding, 2018). Examining the heterogeneous effects of the timing of principal turnover may contribute to the understanding of its consequences for student outcomes.

In sum, this study contributes to the study of principal labor markets in four ways: first, we isolate the causal effect of the turnover event from sources of endogeneity that may bias existing estimates. Our causal effect estimates combine the average disruptive and compositional effects of principal turnover. Second, we leverage unique monthly pay records to measure principal turnover separately within- and between-year. In doing so, we investigate the potentially heterogeneous effects that within- or between-year turnover may present. Third, we hone in on a subset of plausibly exogenous turnover events by separately estimating the effect of principals that transfer to other schools within the district or are promoted. Finally, we estimate the effect of principal turnover on student, teacher, and school outcomes that a principal transition may be expected to affect. Specifically, we ask:

1. To what extent do within- and between-year principal turnover affect school-level outcomes, including test scores, school proficiency rate, test score gains, graduation rate, and teacher mobility?
2. To what extent are the estimated effects of principal turnover heterogeneous with respect to timing, that is, are within- and between-year effects of principal turnover on student achievement different?

Literature Review

A limited research base to date has aimed to estimate the effect of principal turnover on student outcomes. Drawing from school-level administrative data from North Carolina elementary and middle schools for 12 years from 1994-95 through 2005-06, Miller (2013) found that test scores were 0.021 to 0.041 standard deviations lower in the first year of a new principal. Using school and year fixed effects and estimating separate effects for years prior to and following the principal transition, the study also documented pre- and post-transition dips in student achievement gains lasting two years. The study also estimated the effect of principal turnover on teacher retention, finding that 1.5 to 2.8 percent fewer teachers returned to the school in the first year of a new principal. The negative effect on teacher retention began in the last year of the departing principal and continued for an additional year following the transition. While this method improves upon estimates that do not account for the pre-transition dip or multiyear negative effect of principal turnover, the estimates may still be confounded by the underlying school trend and the endogeneity of the turnover event.

A study of principal turnover in 80 newly opened New York City high schools found that multiple principal turnovers were associated with a 3.06 percent decline in high school graduation rates between 1993-94 and 2001-02 but that a single principal transition in the 10-year time period did not significantly affect school-level outcomes (Weinstein et al., 2009). The authors did not find evidence that principal turnover was associated with lower rates of passing Regents exams. These estimates came from ordinary least squares regressions with school-level covariates, year fixed effects, and school-level covariates, but not for stable but unobserved school characteristics, the pre- or post-turnover trend in the outcomes, or the endogenous poor performance of the departing principal..

A study across all grade levels in Miami-Dade County Public Schools from 2003-04 to 2008-09 found evidence that principal turnover was associated with increased odds of teacher turnover and decreased student achievement (Béteille et al., 2012). The authors found that the odds of teacher turnover were 10 percent higher and math achievement was 0.007 standard deviations lower in the year of a principal transition. The authors accounted for potential school-level shocks by controlling for school-level student out-migration the year prior to the transition and including a leading indicator of principals' departure. The authors did not find the pre-turnover dip in math achievement reported by Miller (2013).

An early school-level analysis in 149 San Francisco-area schools with one to two principal transitions from 1975-76 through 1980-81 found a lagged effect of principal turnover, with sixth-grade test scores declining in the second year of a new principal (Rowan & Denk, 1984). Using a linear partial adjustment model assuming an equilibrium achievement level based on school-level welfare receipt and limited English proficiency, the authors found a 1.5 to 2 point decrease in the percentage of test items answered correctly in the year following the principal transition, but no significant effect the year of the transition. The estimation strategy accounted for the stable unobserved school characteristics by including a school fixed effect and the sample-level changes over time with a time trend. However, it did not include a pre-transition dip, school-level shocks, school-level trends, or a continued effect more than one year following the transition.

Methods

In this section, we begin by outlining our empirical strategy and how it addresses the sources of endogeneity that may be biasing the estimates in previous studies described above. We then describe the data and sample, and finally the measures, including the outcomes on which we estimate the effects of principal turnover, variables we use to construct pathways out, and covariates.

Empirical Strategy

We proceed by introducing our primary modeling approach, which aims to estimate the average disruptive and compositional effects of the turnover event by addressing the school-level confounders that are likely to bias the estimated effect of the turnover. We then describe a test for bias from a one-time disturbance that might reflect district-level instability that may affect principal transitions and the outcomes, albeit indirectly. Finally, we explain our approach that eliminates the endogeneity of the turnover event by separating plausibly exogenous turnovers, defined by those who transfer to other schools or are promoted, and separately estimating the effects. This addresses the potential endogeneity from the removal of poor performing principals.

Primary analytic strategy. The central goals of our analytic strategy are to isolate the effect of the turnover event from the school-level characteristics and trends that are correlated with principal turnover and school outcomes, and to separately estimate the effects of within- and between-year turnover. Because school-level characteristics and trends may contribute to both principal turnover and school outcomes, the estimated effect of the turnover event will be endogenous if we do not control for these school-level influences that may be associated with the outcomes and principal turnover. Such influences include stable school characteristics, time varying covariates, the school's longer-term outcome trend, and a pretreatment dip that is associated with the principal departure and school outcomes. Even after addressing these three potential sources of bias, two additional mechanisms may contribute to the endogeneity of the turnover event estimates. First, a one-time disturbance outside the school—e.g., at the district level—might contribute to declining school outcomes in a given year. Second, a principal might leave or be dismissed because of underperformance, conflating the effect of the turnover event with the underperformance leading to the turnover event.

Table 1 ABOUT HERE

To address the challenge associated with school-level confounders shown in Columns 1 and 2 of Table 1, we fit a model with school and year fixed effects and a school-level spline, taking the form

$$y_{st} = \gamma_{00} + \gamma_{10}Year'_{st} + \gamma_{20}WithinYear_{st} + \gamma_{30}BetweenYear_{st} + \zeta_{0s} + \zeta_{1s}Year_{st} + \epsilon_{st} \,, \quad (1)$$

where γ_{00} represents the adjusted sample mean for schools in years when there was no within- or between-year turnover event; γ_{10} is the nonparametric time trend[1] in the study sample, γ_{20} is the average deviation from the school-level trend in years with within-year turnovers; and

γ_{30} is average deviation from the school-level trend associated with between-year turnovers. The school fixed effect, ζ_0, accounts for time-invariant school characteristics that might be endogenous to the turnover event. The school fixed effects strategy used in some prior research (Béteille et al., 2012; Dhuey & Smith, 2018; Miller, 2013; Rowan & Denk, 1984) controls for these stable school characteristics as well, but does not account for the school trends. We improve on this fixed effects approach by adding a spline for each school, ζ_1, which allows the underlying trend for each school to deviate from the overall sample trend. We can then estimate the deviation from each school's trend in the years of principal transitions.[2] To estimate the effect of overall turnover, we estimate the same model but with *WithinYear* and *BetweenYear* collapsed into a single variable for any transition. All subsequent models follow the same pattern, where we show the specification for the models estimating separate effects for within- and between-year turnover, but also estimate a separate model with a singular transition variable in their place.

Using this model, the estimated effect of a turnover event that follows a downward trend in school outcomes would not be confounded by the trend—but the model does not control for temporary deviations from the trend that may accompany principal turnover. For example, if a principal withdrew effort in the year prior to departure—i.e., an Ashenfelter dip—or micropolitical dynamics led the principal to turn over and to lower school outcomes, the temporary downturn shown in Column 3 of Table 1 would bias the longer-term trend downward and attenuate a negative turnover effect. To account for a possible pre-turnover dip that is not captured as part of the underlying trend, we add a leading indicator to the model that takes a value of 1 in the year prior to a transition. There are two central limitations to the addition of leads and lags, which we add later: first, they reduce parsimony by adding more indicators to the model and complicate the interpretation of the effect of the turnover event. Second, each additional indicator narrows the sample by a year and we can only model the underlying time trend with multiple years of data. Specifically, as we add leading and lagged turnover variables to the model, we restrict the sample to years in which we can observe these leads and lags. For example, a model with no leads and lags will include all eight years of outcomes, but a model with one year of leads and lags will include just five years of outcomes—from 2011-12 through 2015-16, and so on. We therefore test Model 1 above with the addition of one and two years of leads and lags, one at a time, and compare fit across specifications. The goal is to arrive at the most parsimonious model specification without introducing bias associated with a pre-transition dip or multiple turnover events. In this set of analyses, we restrict the sample to just those years in which we can observe two leads and two lags (2011-12 through 2014-15) so we can compare model fit across each of the five nested models. Because the models are nested, we can compare deviance statistics, which show how much worse each model is than a fully saturated model that perfectly predicts the data. The difference in deviance, ΔD, is distributed as a χ^2 distribution with degrees of freedom equal to the difference in parameters between models. While in the absence of school-level trends, Miller (2013) found evidence that the pre-turnover downturn begins two years prior to the principal transition, we find that the one- and two-year leads are not significant and do not improve model fit on the test score model—suggesting the school-level trend is capturing any decline in school outcomes prior to the turnover event. However, to improve precision and because a one-year lead does significantly improve model fit for some outcomes, we include a single lead to allow for the possibility of a pre-transition dip.

Table 2 ABOUT HERE

Miller (2013) also found that after a principal departs from a school, the test scores continue to fall in the first two years of the new principal and do not return to pre-turnover levels until four to five years later. To allow for a sustained effect of the principal transition, we also add indicators allowing for lagged effects. We consider these lags, which take the value of 1 in years following the transition, to represent the longer-term effect of the turnover event. The lags also control for the continued disruption from a previous turnover event in the case of multiple turnovers and therefore avoid confounding the continued effect of multiple prior turnovers into the estimated effect of a single turnover. We do not estimate separate lagged effects for within and between-year turnovers because the lagged effect applies to the full year subsequent to the turnover event—unlike the effect in the year of the transition, which may be different in the year of a within-year transition compared with the year following a summer transition.

As we did with the leads, we test the significance of a series of lags to ensure we capture the full effect of the turnover. We find that two years of lagged coefficient estimates are significant and that the second lag significantly improves model fit (Table 2). Including more than two years of lags would require limiting the sample even further, obviating the advantages of the school-level spline by reducing the span of the underlying time trend. We therefore include a one-year lead and two years of lags. Finally, we add a vector of time-varying school-level covariates and principal demographics, with the model taking the form

$$y_{st} = \gamma_{00} + \gamma_{10}\boldsymbol{Year'}_{st} + \gamma_{20}WithinYear_{st} + \gamma_{30}BetweenYear_{st} + \gamma_{40}NewPrincipal_{st+1} + \gamma_{50}NewPrincipal_{st-1} + \gamma_{60}NewPrincipal_{st-2} + \gamma_{70}\boldsymbol{S'} + \gamma_{80}\boldsymbol{P'} + \zeta_{0s} + \zeta_{1s}Year_{st} + \epsilon_{st} \text{ ,} \tag{2}$$

where γ_{40} is the leading effect of the principal transition one year prior to the transition, γ_{50} is the lagged effect one year after, and γ_{60} is the lagged effect two years after. The one-year lead will capture a pretreatment dip, while the coefficient estimates on the lagged indicators represent the continued effect of the principal turnover. The effect of turnover is therefore a linear combination of the main within- or between-year effect, γ_{20} or γ_{30}, and each of the overall lagged effects, γ_{50} and γ_{60}. Each of these coefficients represent the sample shift from a school's five-year trajectory. ***S'*** is a vector of time-varying school covariates and ***P'*** is a vector of principal gender and race dummies.

In controlling for stable school characteristics, observable time-varying school characteristics, the underlying school trend, a pre-turnover dip, and the continued disruptive effect of a turnover event, this model provides plausibly causal estimates of within- and between-year principal turnover. To examine the robustness of these estimates, we test two additional potential sources of endogeneity: a one-time disturbance at the district level and unobserved within-year confounders. As shown in Column 4 of Table 1, the estimated turnover effect may still be biased by a one-time disturbance that occurs contemporaneously with the turnover event and affects school outcomes. For example, instability in the district office might lead a principal to turn over and affect other school outcomes such as student achievement and teacher turnover. While we cannot control for all possible such disturbances, we add an indicator for superintendent turnover to capture the spillover effect of such a disruption in the district office. A significant coefficient estimate on the superintendent turnover variable would indicate that the one-year shock associated with superintendent turnover affected the school-level outcome, while a significant estimate coupled with a change in the principal turnover estimates from Model 2 would suggest the district-level shock mediated or suppressed the effect of the turnover event.

Unchanged estimates of γ_{20} and γ_{30} would provide some evidence that district-level disturbances such as a superintendent turnover are not biasing the estimated principal turnover effects.

Transitions out. Finally, we attempt to control for unobserved within-year dynamics that may be endogenously associated with the turnover event by estimating effects for more plausibly exogenous transitions. A principal who is promoted to a district office position is likely to be more effective than a principal who was demoted to an assistant principal or teacher position or who left the education system altogether (Grissom & Bartanen, 2018). We can also infer that principals who transfer to another school in the district as principals are less likely to have been forced out or to have chosen to leave because they were ineffective principals, and these transitions are more likely to be exogenous than demotions and leavers. We estimate separate within- and between-year turnover effects for plausibly exogenous pathways (i.e., promotions and intra-district transfers) and endogenous pathways (demotions, inter-district transfers, and leavers). This model therefore has four different treatment effects: one for each of the two types of transitions among within-year transitions and one for each of the two types of transitions among between-year transitions, taking the form

$$y_{st} = \gamma_{00} + \gamma_{10}\boldsymbol{Year'}_{st} + \gamma_{20}ExogWithinYear_{st} + \gamma_{30}ExogBetweenYear_{st} + \gamma_{40}EndogWithinYear_{st} + \gamma_{50}EndogBetweenYear + \gamma_{60}NewPrincipal_{st+1} + \gamma_{70}NewPrincipal_{st-1} + \gamma_{80}NewPrincipal_{st-2} + \gamma_{90}\boldsymbol{S'} + +\gamma_{100}\boldsymbol{P'} + \gamma_{110}Superintendent_{dt} + \zeta_{0s} + \zeta_{1s}Year_{st} + \epsilon_{st} \ , \quad (3)$$

where γ_{20} and γ_{30} represent the estimated effect of plausibly exogenous within- and between-year principal transitions, respectively. Estimates of γ_{20} and γ_{30} that diverge from the main effect estimates in Model 2 would imply that the original estimates were at least partially driven by endogenous turnover events.

Data and Sample

To construct the leading and lagged indicators and model the underlying school trends, we use eight years of North Carolina administrative data from 2009-10 through 2017-18. The 2009-10 data allows us to identify turnovers that occurred in summer 2010, the 2010-11 school year allows us to construct the one-year leading indicator, and the 2016-17 and 2017-18 school years provide staffing data necessary to construct the two years of lags and transitions out. We then observe outcomes for five years from 2011-12 through 2015-16. We exclude charter and other special schools, and restrict the sample to schools that were open for all eight years of the study period. The analytic sample for the school-level analysis includes 1,934 schools, of which 57 percent are elementary schools, 23 percent are middle schools, and 20 percent are high schools. North Carolina is a heavily rural state, and 57 percent of the schools are located in rural areas.

We draw from school-, principal-, teacher-, and student-level administrative data for covariates and outcome measures and collapse measures to the school-by-year level where necessary. To generate within- and between-year turnover variables, we use pay period-level data that includes all public school employees in the state in each of 12 pay periods. These pay period data include school codes as well as object codes for each payment, denoting the category for which the payment was made. Specifically, the data allow us to identify when individuals worked as principals, when they worked in other roles within the public school system, and when they did not work in North Carolina public schools at all in each of 12 pay periods.

Measures

Dependent variables. The primary dependent variable is the average end-of-grade or end-of-course test score, standardized by exam and year. Students in North Carolina take end-of-grade exams in math and reading in all years from third through eighth grade, and in science in fifth and eighth grade. There are three end-of-course exams aligned with required courses in the high school curriculum: Math I, English II, and Biology. We also measure these school-level average exam scores separately for math, including Math I; reading, including English II; and science, including Biology, to examine whether principal turnover affects test scores differently by subject area.

In addition, we examine the effect of principal turnover on school-level proficiency rate, which is calculated as the percentage of end-of-grade and end-of-course exams that were passed based on a cut score for proficiency. While this measure reduces the variation across the distribution of student achievement, it is relevant for policy considerations in North Carolina because the state uses proficiency rate to classify schools as low performing under the Elementary and Secondary Education Act (ESEA). To account for any possible annual disturbances on exams by school level and exam passage rates, we standardize the performance composite by year and school level. We standardize all remaining outcomes by year to simplify interpretation of results across outcomes and to facilitate the process of fitting splines for each school. In interpreting the effect on the standardized variable, it is useful to note the average proficiency rate across the five years of outcomes was 58.3 with a standard deviation of 17.7 (Table 3).

Table 3 ABOUT HERE

We examine student achievement growth using school-level value added. North Carolina uses the Education Value-Added Assessment System (EVAAS), calculated by the SAS Institute. The school-level EVAAS scores in theory can range from negative infinity to positive infinity, with values two standard deviations below the growth standard (centered at 0) representing schools that fail to meet expected growth, values two standard deviations above the growth standard representing schools that exceed expected growth, and values within two standard deviations of the growth standard representing schools that met expected growth. In practice, schools during the study period range from -26.3 to 28.9 on the EVAAS scale.

For the subset of high schools in the sample, we examine the effect of principal turnover on high school graduation rate, which Weinstein et al. (2009) found declined in the presence of multiple principal transitions. We use the four-year cohort graduation rate, which represents the percent of students who graduated with a high school diploma within four years of entering ninth grade. The mean graduation rate during the study period was 87.7 percent with a standard deviation of 8.0.

Existing research on both the determinants and effects of principal turnover has found evidence that principal turnover is associated with higher levels of teacher turnover (Béteille et al., 2012; Miller, 2013). We calculate school-level teacher turnover in three ways, in alignment with the approach to measuring teacher turnover introduced in Redding & Henry (2018). First, overall school-level teacher turnover is the percent of teachers in the school in a given year who left at any point during or after the school year. Second, between-year teacher turnover is the percent of teachers in the school in a given year whose final pay period in the school was in May, June, or July. Finally, within-year teacher turnover is the percent of teachers who left the school during any other month of the school year. We apply teacher turnover events to the last year of the teacher's tenure at that school, so a teacher who turned over in May 2013, for example, would be counted as a between-year turnover in the 2012-13 school year. During the study period, schools had a total teacher turnover rate of 21 percent and a standard deviation of 10.6, a between-year turnover rate of 16 percent (σ=8.9), and a within-year turnover rate of 5 percent (σ=4.4).

Principal turnover. We create two temporally distinct principal turnover indicators—one for within-year transitions and one for between-year transitions. We define within-year and between-year transitions using a similar approach to the calculation of the within- and between-year teacher turnover outcome variables. However, unlike the teacher turnover outcome variables, the principal turnover values are applied to the year of the new principal rather than the year of the departing principal. That means a school that gained a new principal in June, July, or August 2015 would be coded as having a between-year principal transition in the 2015-16 school year and a school that gained a new principal in any month from September 2015 through May 2016 would be coded as having a within-year principal transition in the 2015-16 school year.[3] While the modal start date occurs in the first month of the school year, principals continue to enter new schools throughout the school year. Most often, these within-year start dates occur in September (about 11% of all transitions), but about 4 percent of the principals who turn over do so in each subsequent month of the school year, with a spike at the beginning of the second semester as we show in Figure 1.

Figure 1 ABOUT HERE

We collapse the principal turnover variables to two dichotomous indicators at the school-by-year level, so a school that experiences more than one within-year turnover in a given year would have the same within-year turnover value as a school that experiences one within-year turnover. While this approach reduces some of the variability in the within-year turnover measurement, it allows for a more straightforward interpretation of the coefficient on within-year turnover that can be directly compared to the coefficient on between-year turnover. Under these definitions of within- and between-year principal transitions, on average about 15 percent of schools experienced between-year transitions each year and 8.7 percent experienced within-year principal transitions. To compare our results with prior research, we also construct a single principal turnover indicator that combines within and between-year turnover. The overall turnover rate is slightly lower than the sum of those two values at 23.3 percent because schools can experience both a within- and between-year transition in a given year.

Table 4 ABOUT HERE

To account for anticipatory effects and continuing effects of a turnover event, we create a one-year leading indicator and one-and two-year lag variables, respectively, as described in the empirical strategy section above. The leading indicator takes a value of 1 in the year prior to the new principal's first year in the school, and the lagged indicators take a value of 1 in the second and third year following the new principal's start year, respectively. For example, a school that had a new principal in the 2011-12 school year would be coded as having a one-year lead in 2010-11, a one-year lag in 2012-13, and a two-year lag in 2013-14.

Principal covariates. To account for observable differences in principals that might be correlated with effectiveness and probability of turnover, we control for principal gender and race, with white and male as the reference categories. In cases of within-year turnover, we weight these variables by the time each principal spent in the school during that school year. For example, if a school had two principals during a school year, one of whom was male and served for 25 percent of the school year, and another who was female and served for 75 percent of the school year, the female principal indicator for that school in that year would be (.25*0)+(.75*1)=.75.

Principal performance. Poor performance of an exiting principal may confound the estimate of the effect of turnover. To separate plausibly exogenous from endogenous turnover events, we construct variables representing the transition out of a school principalship. We construct four distinct pathways, expanding on the typology of principal turnover in reports based on the Schools and Staffing Survey (Battle, 2010; Goldring & Taie, 2014), which defines “stayers” as principals who remain at the same school, “movers” those who move to a principalship at another school, and “leavers” as those who leave the principalship altogether. We separate “leavers” into three distinct categories: “promotions” are those who are elevated to a role in the district, such as assistant superintendent or district supervisor; “demotions” are those who move to a lower-level role in a school, such as assistant principal, instructional coach, or teacher; and exiters are those who leave North Carolina Public Schools altogether. We also define two types of movers, with intra-district transfers to another principalship within the district and inter-district movers transferring outside the district. These pathways out reflect principal effectiveness; demotions and leavers tend to be lower performing, while promotions are associated with higher performance (Grissom & Bartanen, 2018). We combine promotions and intra-district transfers into a single category representing plausibly exogenous turnovers, and demotions, inter-district movers, and exiters as a category representing endogenous turnovers. Descriptively, the modal next destination for both between- and within-year turnovers is another principalship (movers), but principals who leave between years are more likely to transfer to another principalship while those who leave within year are more likely to leave the principalship due to a promotion or demotion (Figure 2).

School covariates. Time-varying school-level covariates include school minority percentage, percentage of students who are economically disadvantaged, average daily membership and average daily membership squared, and per pupil expenditures and per pupil expenditures squared.

Confounding event. Finally, we include a measure of superintendent turnover since it might plausibly lead to principal turnover and indirectly affect student, teacher, and school outcomes. The measure of superintendent turnover will allow a control for the potential confounding effect of such a disturbance at the district level. The superintendent turnover indicator that takes the value of 1 in the year of a between-year superintendent turnover and the year of a within-year superintendent turnover.

Findings

In this section, we begin by providing main effect estimates from Model 2 above of all within- and between-year turnovers for test scores and then each of the alternative outcomes, comparing each of those estimates to the estimated effect of all principal turnover. We then present findings from Model 3 to further isolate the plausibly exogenous turnovers from endogenous turnover events.

Main Effect Estimates

Test scores. We find that both within- and between-year turnover are associated with small but significant declines in test scores. Specifically, the effect of a within-year principal transition is estimated to be a 0.017 standard deviation decrease in test scores in the first year of the new principal, while a between-year transition is estimated to be a 0.013 standard deviation decrease. While the coefficient estimate on within-year turnover is slightly larger than on between-year turnover, a Wald test fails to reject the null that they are equal. The negative effect of turnover continues for two additional years, with a combined effect of a within-year transition over three years of -0.036 standard deviations, and a combined three-year effect of a between-year transition of -0.032 standard deviations. Regarding the second research question, the estimated effect of all principal turnover—Columns 3 and 4—is similar to the within- and between-year estimates at -0.016 standard deviations. This estimated effect on any turnover is similar to the findings in Miller (2013), in which estimates ranged from -0.021 to -0.041 standard deviations. The insignificant estimates on superintendent turnover and unchanged fit statistics in Columns 2 and 4 combined with the stable turnover effect estimates provide some evidence that the negative effects are not being driven by an endogenous external shock.

Table 5 ABOUT HERE

The negative effects of both within- and between-year turnover occur in all three subjects math, reading, and science, with the largest negative effects in science (Table A-1 through Table A-3). We also see evidence of a pre-turnover dip in science, with science scores declining by 0.012 standard deviations in the year before a transition.

School proficiency rates. Column 1 of Table 6 shows that both within- and between-year turnover are associated with small but significant declines in school proficiency amounting to -0.053 to -0.062 standard deviations, which represents a decrease in proficiency rate of about 1 point on the 0-100 percent scale. Again, these negative effects continue for two additional years following the first transition year, with the combined effect of -0.14 standard deviations for within-year transitions and -0.13 for between-year transitions—or about 2 points on the 0-100 percent scale. In real terms, the average sample school, which has 608 students, would have about six fewer pass the end-of-grade or end-of-course exam in the year of a principal transition and twice as many over the first three years of the transition. We find evidence of a pre-turnover dip, with school proficiency declining by about -0.024 standard deviations in the year prior to the principal transition.

Table 6 ABOUT HERE

School value-added. Within-year principal transitions have an estimated effect of -0.131 standard deviations on school value-added, while between-year transitions have an estimated -0.084 standard deviation. While the estimated effect for within-year transitions is qualitatively larger, a Wald test finds these estimates are not statistically different. As with the negative effects on test scores, these negative effects continue for two additional years, decreasing monotonically over time. We do not see evidence of a pre-transition dip.

High school graduation rate. We do not find significant effects of either within- or between-year turnover on high school graduation rate. While the power in this model is limited by the smaller number of high schools in the sample, the point estimate is close to zero for within-year transitions and positive for between-year transitions.

Teacher turnover. Both within- and between-year principal turnover are associated with significant increases in within-year teacher turnover, between-year teacher turnover, and overall teacher turnover. Specifically, we find that overall teacher turnover increases by about 0.16 standard deviations in years of within-year principal transitions and 0.18 in years of between-year transitions. These effect sizes translate into an approximately 1.7 percentage point increase in teacher turnover rate in the year of the transition. Increased teacher turnover continues for two additional years, with an estimated three-year cumulative effect of a principal transition of about 0.30 standard deviations, or about 3.2 percentage point increase in teacher turnover over three years. Effect sizes are similar for within- and between-year teacher turnover. Between-year teacher turnover appears to increase in the year prior to the principal turnover.

Transitions Out

The analysis of school-level outcomes by type of transition suggests that some but not all of the detrimental effects of principal turnover hold for plausibly exogenous within- and between-year transitions, although many of these estimates are smaller than the main effect estimates.

Table 7 ABOUT HERE

Both within- and between-year exogenous transitions are associated with about a -0.01 standard deviation effect on test scores, which indicates overall effects were primarily driven by endogenous transitions that have coefficients that are larger in magnitude. Proficiency rates also decrease in the presence of exogenous within- and between-year turnover, although the negative effects on these exogenous transitions are smaller than the main effects reported above. In particular, the schoolwide proficiency rate declines by 0.034 to 0.039 standard deviations—0.6 to 0.7 percentage points—in the first year of a new principal following an exogenous transition.

While we observe that the negative effects of principal turnover are attenuated for exogenous transitions, the effect on teacher turnover is similar for both exogenous and endogenous pathways out and for within- and between-year transitions. Meanwhile, the negative effect of within-year transitions on value-added appears to be driven by endogenous turnovers, while the negative value-added effect of between-year transitions holds across both types of transitions Consistent with estimates above, we again do not detect a significant effect on high school graduation rate.

Discussion and Conclusion

These results add to the emerging research base showing principal turnover has negative effects on school outcomes, but suggest that failing to account for endogenous turnover events may lead to overstating the negative effects of a principal turnover on test scores, teacher turnover, and short-term suspension rates. Additionally, these findings provide some affirmation for estimates that use annual measures to estimate the effects of principal turnover; the estimated effects of within-year turnover are not significantly different from the estimated effects of between-year turnover.

We find consistent evidence that both within- and between-year principal turnover have negative effects on test scores and proficiency rates, on plausibly exogenous transitions—although the estimated effects of these exogenous transitions are weaker than estimates from models that do not exclude endogenous transitions. Specifically, we find that an exogenous within- and between-year transitions are associated with about a .01 standard deviation decrease in test scores. While the estimated effects that do not account for pathway out are similar to those reported in Miller (2013), effect sizes from the model that isolates plausibly exogenous transitions are smaller and more in line with Béteille et al. (2012), who found that test scores declined by an estimated 0.007 standard deviations in Miami-Dade schools with principal transitions. This difference in effect size may be driven by the samples being studied—although Miller's analysis drew from North Carolina administrative data as well, it focused only on elementary and middle schools, while Béteille et al. examined effects across all school levels—or may suggest that estimates that fail to account for the endogeneity of some turnover may bias the estimates upward.

The estimated effect of exogenous principal turnover on school proficiency rate translates to less than a 1 point decrease in proficiency rate. While the estimated main effect of within-year turnover on school value-added is significant, the effect on exogenous transitions is attenuated and no longer significant. The analysis has sufficient statistical power to detect an effect size on exogenous transitions as small as 0.077. Effect sizes on school achievement measures are small, which is unsurprising since the effect of principals on students is likely to operate through mechanisms more proximal to their immediate sphere of influence, such as teacher mobility, instructional leadership, and school climate.

We find that one of those mechanisms—teacher turnover—does increase in the presence of principal transitions. The estimated effects on teacher turnover are significant for both within- and between-year principal transitions in our main effect estimates and in estimates that account for the type of transition. These estimated effects on overall turnover overlap with Miller (2013)'s findings in North Carolina elementary and middle schools, which estimated that 1.5 to 2.8 percent fewer teachers returned to the school in the first year of a new principal. However, Miller found that the significant effect continued only for one additional year while we find a sustained effect over two additional years. Our findings also are in agreement with Béteille et al. (2012), which found a 1.1 increase in odds of teacher turnover in the year of a new principal.

There are four plausible explanations for the lack of significant effects on high school graduation rates. First, it is possible that the effect of principal turnover does not extend to high school graduation rates. Second, any negative effect of principal turnover on high school graduation rates may occur when there are multiple turnover events, as Weinstein et al. (2009) found in a study of principal turnover in New York City schools. Third, it is possible the limited high school sample does not provide enough power to detect an effect that is small in magnitude, as we only have the power to detect an effect size of between-year turnover with this sample as small as 0.06-.07 standard deviations. Estimated effects of between-year transitions are consistently positive but nonsignificant across models. Fourth, negative effects of principal turnover may not register in a single year, making it difficult to detect in this analysis. A principal's influence on graduation is likely to occur over time rather than to have an immediate effect since we begin measuring graduation from the time students enter ninth grade. While small but negative effects of principal transitions may ultimately lead to lower graduation rates, it will likely take years for those effects to accumulate.

These findings are not without limitations. While the goal of this research is to provide a plausibly causal estimate of principal turnover, our measurement and estimation strategies may not fully purge the estimates of bias. The pathways out are only a proxy for the exogeneity of the turnover event and do not capture all possible reasons a principal may have left. For example, a principal coded as a promotion may have been reassigned to the district office due to underperformance in the school. In that case, the turnover event would be coded as exogenous when it is in fact endogenous. To the extent that these proxies have classical measurement error, the effects on the transition variables would be attenuated and the already small effect sizes may no longer be detectable. An additional limitation is the annual time trend: while we model the school's underlying trend by year, the within-year estimates do not control for within-year school trajectories that may be related to the turnover event. Still, our approach provides the reasonably plausible estimates of principal turnover that remove or reduce biases that may affect prior estimates.

Without isolating the disruptive effect of the turnover event from the compositional effect, the policy relevance of this analysis hinges on districts having knowledge of the relative effectiveness of the departing and replacing principals when making hiring and firing decisions. For example, a growing base of teacher turnover research suggests that some teacher turnover is good turnover. By systematically removing ineffective teachers, school districts may be able to nudge the distribution of teacher effectiveness in a positive direction (Adnot, Dee, Katz, &

Wyckoff, 2017; Dee & Wyckoff, 2015). Some principal turnover may similarly yield positive results. School districts deciding whether or when to replace a principal would therefore benefit from understanding the magnitude of the disruptive effects of the turnover event. They would also benefit from understanding how those disruptive effects vary based on the timing of the transition. We observe that North Carolina school districts transfer principals across schools during the school year, as shown by the transfers in Figure 2. Since within-year turnover is not more detrimental to school outcomes than between-year turnover, school districts might want to quickly replace underperforming principals rather than waiting for the end of the school year.

Districts would also benefit from understanding the mechanisms that may mediate or suppress the negative effects of principal turnover. Even when turnover is unavoidable, these mechanisms may provide levers through which district personnel can curb the negative effects of principal turnover on students and teachers. Understanding how these mechanisms operate is especially important in low-performing and high-poverty schools in which principal turnover is even more frequent. Future research should examine the heterogeneity of principal turnover effects across different types of schools and test mediators such as effectiveness and experience of the replacement principal.

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[1] We tested alternative parametric and semiparametric time trends. The nonparametric time trend provided a significant model fit improvement over alternatives.

[2] We fit the model using the xtmixed command in Stata 15, using full maximum likelihood estimation (FML) with an unstructured covariance matrix and clustering standard errors at the school level.

[3] These definitions align closely but not completely with the prior principal departure. For example, if a departing principal leaves in May of one school year and the replacing principal does not begin until October of the following school year, that school is coded as having a within-year principal transition.

Tables and Figures

Table 1. Confounders and analytic strategy

	(1)	*(2)*	*(3)*	*(4)*	*(5)*
Confounder	*Stable characteristics*	*School trend*	*Pre-turnover dip*	*One-time disturbances*	*Principal underperformance*
Model element	School fixed effect	School spline	Lead	Superintendent turnover	Pathway out

NOTE: Darker shading denotes cells in which the potential confounder is addressed by the analytic strategy. Text in cells describes the model component that accounts for the source of bias in the column. Half-shaded cells are those in which we account for some but not all sources of endogeneity. In addition, estimates conditioned on time-varying school covariates and student covariates when outcome measured at student-level.

Table 2. Model fit comparisons by inclusion of leads and lags

	(1)	(2)	(3)	(4)	(5)	(6)
	No leads, lags, or covariates	Covariates only	Covariates + 1 year lag	Covariates + 1 year lag and lead	Covariates + 2 years lag 1 year lead	Covariates + 2 years lag and lead
Significant 1-year lag			No	No	Yes	Yes
Significant 1-year lead				No	No	No
Significant 2-year lag					Yes	Yes
Significant 2-year lead						No
Observations	5958	5958	5958	5958	5958	5958
AIC	-4693.450	-6157.784	-6157.751	-6158.177	-6167.013	-6165.034
BIC	-4633.218	-6057.397	-6050.671	-6044.404	-6046.549	-6037.877
Deviance	-4711.450	-6187.784	-6189.751	-6192.177	-6203.013	-6203.034

Standard errors in parentheses. Sample is restricted to years during which we can observe 2 years of leads and lags. Difference in deviance between model 4 and 5 is significant (p<.001).
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 3. Descriptive statistics, all study outcomes

	Mean	SD	Min	Max
Scores (std)	-0.04	0.360	-1.23	1.73
Math (std)	-0.06	0.391	-1.61	1.31
Reading (std)	-0.04	0.354	-1.77	1.58
Science (std)	-0.02	0.423	-1.82	1.69
Overall performance composite	58.29	17.707	9.00	100.00
Four-year HS graduation rate	87.67	8.001	0.00	100.00
EVAAS Growth Index	0.32	4.673	-26.26	28.94
Attrit, any	0.21	0.106	0.00	1.00
Attrit, within year	0.05	0.044	0.00	0.44
Attrit, between year	0.16	0.089	0.00	1.00
Short-term suspension rate	13.63	17.722	0.00	176.42
Chronic absenteeism	0.09	0.067	0.00	1.00
Observations	11604			

Table 4. Principal transition variables

	Proportion (SD)	Count
New principal, within year	0.087 (0.283)	1015
New principal, between year	0.154 (0.361)	1787
New principal, any[1]	0.233 (0.423)	2707
Observations	11604	

[1]Doesn't sum due to both within & between year in same school.

Table 5. Estimated effect of principal turnover on test scores

	(1)	(2)	(3)	(4)
New principal, any			-0.016***	-0.016***
			(0.0029)	(0.0029)
New principal, within year	-0.017***	-0.017***		
	(0.0037)	(0.0037)		
New principal, between year	-0.013***	-0.013***		
	(0.0030)	(0.0030)		
1-year lag	-0.012***	-0.012***	-0.013***	-0.013***
	(0.0027)	(0.0027)	(0.0028)	(0.0028)
2-year lag	-0.007**	-0.007**	-0.008**	-0.008**
	(0.0026)	(0.0026)	(0.0026)	(0.0026)
1-year lead	-0.003	-0.003	-0.004	-0.004
	(0.0024)	(0.0024)	(0.0025)	(0.0025)
Superintendent turnover (year t)		-0.002		-0.002
		(0.0022)		(0.0022)
Constant	0.425***	0.426***	0.425***	0.426***
	(0.0338)	(0.0340)	(0.0338)	(0.0340)
Observations	11604	11604	11604	11604
AIC	-15222.833	-15221.335	-15228.629	-15227.127
BIC	-15024.137	-15015.280	-15037.293	-15028.431
Deviance	-15276.833	-15277.335	-15280.629	-15281.127

Standard errors in parentheses, clustered at the school level. All models include school and principal covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 6. Estimated effect of within- and between-year principal turnover on school-level outcomes (std)

	(1) Performance composite	(2) HS graduation rate	(3) School EVAAS	(4) Teacher turnover, any	(5) Teacher turnover, within year	(6) Teacher turnover, between year
New principal, within year	-0.062***	-0.003	-0.131***	0.156***	0.113***	0.133***
	(0.0123)	(0.0378)	(0.0296)	(0.0294)	(0.0319)	(0.0310)
New principal, between year	-0.053***	0.012	-0.084***	0.175***	0.129***	0.149***
	(0.0100)	(0.0298)	(0.0239)	(0.0233)	(0.0252)	(0.0245)
1-year lag	-0.047***	0.002	-0.052*	0.098***	0.104***	0.069***
	(0.0088)	(0.0262)	(0.0205)	(0.0195)	(0.0224)	(0.0203)
2-year lag	-0.027**	0.019	-0.046*	0.039	0.054*	0.023
	(0.0083)	(0.0248)	(0.0202)	(0.0199)	(0.0226)	(0.0210)
1-year lead	-0.024**	0.008	-0.023	0.185***	0.041	0.201***
	(0.0082)	(0.0253)	(0.0204)	(0.0198)	(0.0215)	(0.0208)
Superintendent turnover (year t)	0.010	0.023	-0.056**	-0.028	-0.002	-0.027
	(0.0074)	(0.0217)	(0.0204)	(0.0193)	(0.0216)	(0.0206)
Constant	1.559***	1.390***	0.736***	-0.660***	-0.711***	-0.447**
	(0.1051)	(0.4146)	(0.1350)	(0.1504)	(0.1353)	(0.1482)
Observations	11604	2294	11217	11604	11604	11604

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7. Estimated effect of exogenous and endogenous within- and between-year principal turnover on school-level outcomes (std)

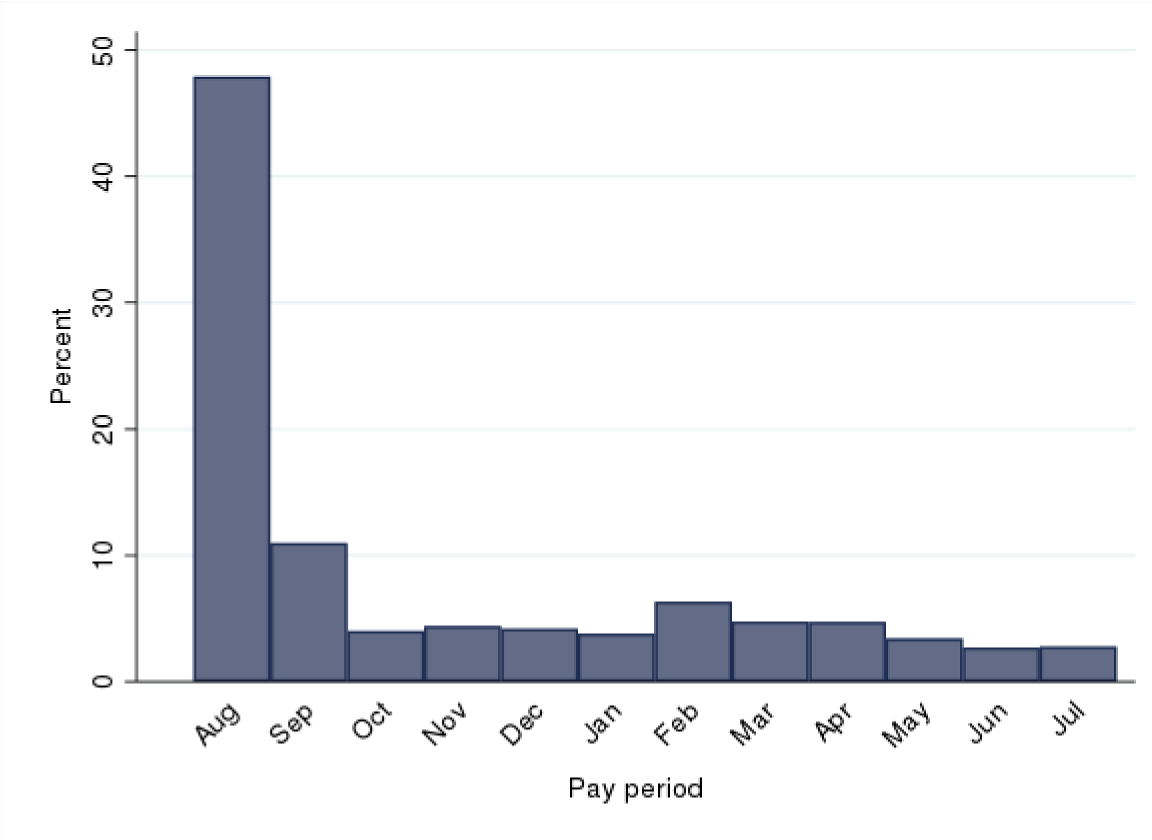
	(1) Test scores	(2) Performance composite	(3) School EVAAS	(4) HS graduation rate	(5) Teacher turnover, any	(6) Teacher turnover, within year	(7) Teacher turnover, between year
Exogenous principal transition (within year)	-0.010* (0.0046)	-0.039* (0.0154)	-0.052 (0.0392)	-0.018 (0.0425)	0.151*** (0.0385)	0.063 (0.0406)	0.144*** (0.0396)
Exogenous principal transition (between year)	-0.009* (0.0038)	-0.034** (0.0121)	-0.074* (0.0305)	0.018 (0.0373)	0.155*** (0.0295)	0.114*** (0.0320)	0.129*** (0.0309)
Endogenous principal transition (within year)	-0.020*** (0.0048)	-0.072*** (0.0166)	-0.176*** (0.0390)	0.031 (0.0483)	0.159*** (0.0403)	0.137** (0.0454)	0.129** (0.0440)
Endogenous principal transition (between year)	-0.016*** (0.0037)	-0.066*** (0.0128)	-0.089** (0.0333)	0.019 (0.0368)	0.183*** (0.0321)	0.134*** (0.0366)	0.158*** (0.0340)
1-year lag	-0.011*** (0.0027)	-0.044*** (0.0087)	-0.050* (0.0205)	0.005 (0.0259)	0.097*** (0.0195)	0.102*** (0.0224)	0.069*** (0.0203)
2-year lag	-0.007* (0.0026)	-0.025** (0.0082)	-0.045* (0.0202)	0.022 (0.0246)	0.039* (0.0199)	0.054* (0.0226)	0.024 (0.0210)
1-year lead	-0.003 (0.0024)	-0.022** (0.0082)	-0.021 (0.0203)	0.011 (0.0249)	0.185*** (0.0198)	0.040 (0.0214)	0.202*** (0.0208)

Superintendent turnover (year t)	-0.002	0.010	-0.056**	0.024	-0.028	-0.002	-0.027
	(0.0022)	(0.0074)	(0.0204)	(0.0218)	(0.0193)	(0.0216)	(0.0206)
Constant	0.426***	1.560***	0.737***	1.385***	-0.663***	-0.710***	-0.450**
	(0.0338)	(0.1053)	(0.1347)	(0.4136)	(0.1493)	(0.1349)	(0.1474)
Observations	11604	11604	11217	2294	11604	11604	11604

Standard errors in parentheses, clustered at the school level. All models include school and principal covariates. Exogenous turnovers are promotions and intra-district transfers, while endogenous turnovers are demotions, leavers, and inter-district movers.

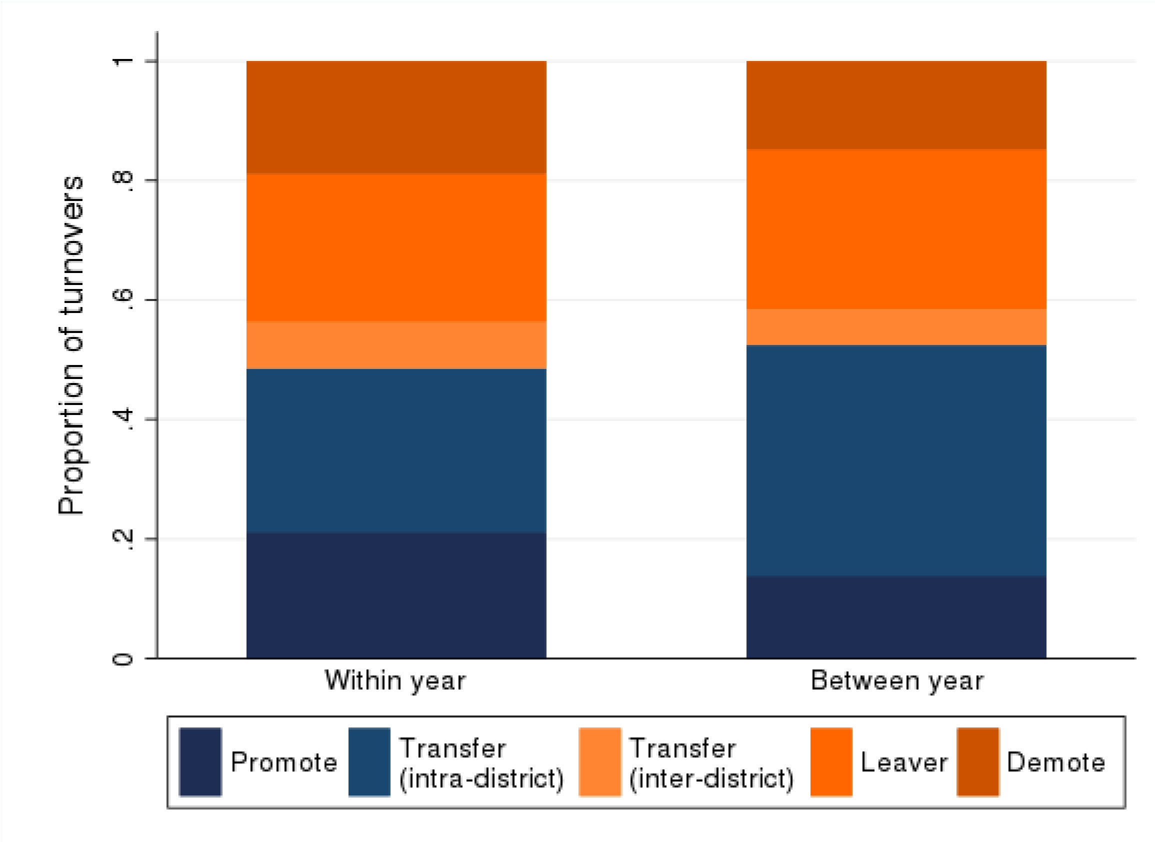
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Figure 1. New principal start date, by month



NOTE: Percentages are of all principals across all years. Bars represent percent of principals who were new to the principalship in their school beginning in the specified month.

Figure 2. Pathway out by principal turnover timing



NOTE: Blue-shaded regions are coded as plausibly exogenous pathways and orange-shaded regions are coded as endogenous pathways. Movers are defined as moving to a principalship at another public school in North Carolina. Principals who leave are those who do not continue working in North Carolina public schools in any capacity. Promotions are district office positions such as supervisor, assistant superintendent, or superintendent. Demotions are positions such as assistant principal, instructional coach, and teacher.

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Appendix

Table A-1. Main effects of principal turnover on math scores (std)

	(1)	(2)	(3)	(4)
New principal, any			-0.017***	-0.017***
			(0.0040)	(0.0040)
New principal, within year	-0.016**	-0.016**		
	(0.0051)	(0.0051)		
New principal, between year	-0.013**	-0.013**		
	(0.0043)	(0.0043)		
1-year lag	-0.013***	-0.013***	-0.014***	-0.014***
	(0.0038)	(0.0038)	(0.0038)	(0.0038)
2-year lag	-0.011**	-0.011**	-0.012***	-0.012***
	(0.0036)	(0.0036)	(0.0036)	(0.0036)
1-year lead	-0.001	-0.001	-0.002	-0.002
	(0.0033)	(0.0033)	(0.0034)	(0.0034)
Superintendent turnover (year t)		-0.006		-0.006
		(0.0030)		(0.0030)
Constant	0.454***	0.458***	0.455***	0.459***
	(0.0496)	(0.0496)	(0.0495)	(0.0496)
Observations	10847	10847	10847	10847
AIC	-8155.111	-8156.301	-8160.849	-8162.044
BIC	-7958.237	-7952.135	-7971.266	-7965.170
Deviance	-8209.111	-8212.301	-8212.849	-8216.044

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-2. Main effects of principal turnover on reading scores (std)

	(1)	(2)	(3)	(4)
New principal, any			-0.014***	-0.014***
			(0.0029)	(0.0029)
New principal, within year	-0.010**	-0.010**		
	(0.0036)	(0.0036)		

New principal, between year	-0.013*** (0.0032)	-0.013*** (0.0032)		
1-year lag	-0.011*** (0.0027)	-0.011*** (0.0027)	-0.012*** (0.0027)	-0.012*** (0.0027)
2-year lag	-0.006* (0.0026)	-0.006* (0.0026)	-0.006* (0.0026)	-0.006* (0.0026)
1-year lead	-0.003 (0.0025)	-0.003 (0.0025)	-0.004 (0.0025)	-0.004 (0.0025)
Superintendent turnover (year t)		0.001 (0.0022)		0.001 (0.0022)
Constant	0.441*** (0.0427)	0.440*** (0.0428)	0.442*** (0.0426)	0.441*** (0.0427)
Observations	11223	11223	11223	11223
AIC	-14713.465	-14711.748	-14718.294	-14716.580
BIC	-14515.671	-14506.628	-14527.825	-14518.785
Deviance	-14767.465	-14767.748	-14770.294	-14770.580

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-3. Main effects of principal turnover on science scores (std)

	(1)	(2)	(3)	(4)
New principal, any			-0.027*** (0.0058)	-0.027*** (0.0058)
New principal, within year	-0.027*** (0.0079)	-0.027*** (0.0079)		
New principal, between year	-0.023*** (0.0063)	-0.023*** (0.0063)		
1-year lag	-0.023*** (0.0055)	-0.023*** (0.0055)	-0.024*** (0.0056)	-0.024*** (0.0056)
2-year lag	-0.015** (0.0056)	-0.015** (0.0056)	-0.016** (0.0056)	-0.016** (0.0056)
1-year lead	-0.011* (0.0052)	-0.011* (0.0052)	-0.012* (0.0052)	-0.012* (0.0052)

Superintendent turnover (year t)		-0.001		-0.001
		(0.0050)		(0.0050)
Constant	0.666***	0.666***	0.666***	0.667***
	(0.0572)	(0.0573)	(0.0572)	(0.0573)
Observations	11120	11120	11120	11120
AIC	84.515	86.442	80.195	82.124
BIC	282.061	291.304	270.424	279.670
Deviance	30.515	30.442	28.195	28.124

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-4. Main effects of principal turnover on school proficiency rate (std)

	(1)	(2)	(3)	(4)
New principal, any	-0.065***	-0.064***		
	(0.0095)	(0.0095)		
New principal, within year			-0.062***	-0.062***
			(0.0123)	(0.0123)
New principal, between year			-0.054***	-0.053***
			(0.0100)	(0.0100)
1-year lag	-0.050***	-0.049***	-0.047***	-0.047***
	(0.0089)	(0.0089)	(0.0088)	(0.0088)
2-year lag	-0.029***	-0.029***	-0.027**	-0.027**
	(0.0083)	(0.0083)	(0.0083)	(0.0083)
1-year lead	-0.026**	-0.026**	-0.024**	-0.024**
	(0.0083)	(0.0083)	(0.0082)	(0.0082)
Superintendent turnover (year t)		0.010		0.010
		(0.0074)		(0.0074)
Constant	1.567***	1.560***	1.565***	1.559***
	(0.1048)	(0.1051)	(0.1048)	(0.1051)
Observations	11604	11604	11604	11604
AIC	11849.012	11849.276	11857.772	11858.046
BIC	12040.349	12047.972	12056.468	12064.101
Deviance	11797.012	11795.276	11803.772	11802.046

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-5. Main effects of principal turnover on high school graduation rate (std)

	(1)	(2)	(3)	(4)
New principal, any	0.002 (0.0272)	0.004 (0.0271)		
New principal, within year			-0.005 (0.0380)	-0.003 (0.0378)
New principal, between year			0.011 (0.0298)	0.012 (0.0298)
1-year lag	-0.001 (0.0263)	0.000 (0.0263)	0.001 (0.0262)	0.002 (0.0262)
2-year lag	0.017 (0.0247)	0.018 (0.0247)	0.019 (0.0247)	0.019 (0.0248)
1-year lead	0.006 (0.0256)	0.006 (0.0256)	0.007 (0.0253)	0.008 (0.0253)
Superintendent turnover (year t)		0.023 (0.0218)		0.023 (0.0217)
Constant	1.389^{***} (0.4142)	1.390^{***} (0.4146)	1.390^{***} (0.4143)	1.390^{***} (0.4146)
Observations	2294	2294	2294	2294
AIC	3864.658	3865.594	3866.464	3867.405
BIC	4008.109	4014.783	4015.653	4022.333
Deviance	3814.658	3813.594	3814.464	3813.405

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-6. Main effects of principal turnover on school value added (std)

	(1)	(2)	(3)	(4)
New principal, any	-0.106^{***} (0.0211)	-0.106^{***} (0.0210)		
New principal, within year			-0.131^{***} (0.0296)	-0.131^{***} (0.0296)
New principal, between year			-0.083^{***} (0.0239)	-0.084^{***} (0.0239)

1-year lag	-0.052*	-0.053*	-0.052*	-0.052*
	(0.0206)	(0.0206)	(0.0205)	(0.0205)
2-year lag	-0.047*	-0.047*	-0.046*	-0.046*
	(0.0203)	(0.0203)	(0.0203)	(0.0202)
1-year lead	-0.025	-0.024	-0.024	-0.023
	(0.0204)	(0.0204)	(0.0204)	(0.0204)
Superintendent turnover (year t)		-0.056**		-0.056**
		(0.0204)		(0.0204)
Constant	0.716***	0.736***	0.717***	0.736***
	(0.1345)	(0.1350)	(0.1345)	(0.1350)
Observations	11217	11217	11217	11217
AIC	29128.586	29123.105	29128.277	29122.783
BIC	29319.041	29320.885	29326.057	29327.888
Deviance	29076.586	29069.105	29074.277	29066.783

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-7. Main effects of principal turnover on teacher turnover, any (std)

	(1)	(2)	(3)	(4)
New principal, any	0.180***	0.180***		
	(0.0206)	(0.0206)		
New principal, within year			0.156***	0.156***
			(0.0294)	(0.0294)
New principal, between year			0.175***	0.175***
			(0.0233)	(0.0233)
1-year lag	0.100***	0.099***	0.098***	0.098***
	(0.0196)	(0.0196)	(0.0195)	(0.0195)
2-year lag	0.040*	0.040*	0.039	0.039
	(0.0200)	(0.0200)	(0.0199)	(0.0199)
1-year lead	0.186***	0.187***	0.185***	0.185***
	(0.0199)	(0.0199)	(0.0198)	(0.0198)
Superintendent turnover (year t)		-0.028		-0.028
		(0.0193)		(0.0193)

Constant	-0.670***	-0.662***	-0.668***	-0.660***
	(0.1502)	(0.1502)	(0.1504)	(0.1504)
Observations	11604	11604	11604	11604
AIC	28828.099	28828.044	28832.316	28832.286
BIC	29019.436	29026.740	29031.011	29038.341
Deviance	28776.099	28774.044	28778.316	28776.286

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-8. Main effects of principal turnover on teacher turnover, within year (std)

	(1)	(2)	(3)	(4)
New principal, any	0.135***	0.135***		
	(0.0219)	(0.0219)		
New principal, within year			0.113***	0.113***
			(0.0319)	(0.0319)
New principal, between year			0.129***	0.129***
			(0.0252)	(0.0252)
1-year lag	0.105***	0.105***	0.104***	0.104***
	(0.0224)	(0.0224)	(0.0224)	(0.0224)
2-year lag	0.055*	0.055*	0.054*	0.054*
	(0.0226)	(0.0226)	(0.0226)	(0.0226)
1-year lead	0.042	0.042	0.041	0.041
	(0.0215)	(0.0215)	(0.0215)	(0.0215)
Superintendent turnover (year t)		-0.002		-0.002
		(0.0216)		(0.0216)
Constant	-0.713***	-0.713***	-0.711***	-0.711***
	(0.1352)	(0.1352)	(0.1353)	(0.1353)
Observations	11604	11604	11604	11604
AIC	31194.488	31196.480	31199.396	31201.389
BIC	31385.824	31395.175	31398.092	31407.444
Deviance	31142.488	31142.480	31145.396	31145.389

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-9. Main effects of principal turnover on teacher turnover, between-year (std)

	(1)	(2)	(3)	(4)

New principal, any	0.152***	0.152***		
	(0.0213)	(0.0213)		
New principal, within year			0.133***	0.133***
			(0.0310)	(0.0310)
New principal, between year			0.149***	0.149***
			(0.0245)	(0.0245)
1-year lag	0.070***	0.070***	0.069***	0.069***
	(0.0204)	(0.0204)	(0.0203)	(0.0203)
2-year lag	0.024	0.024	0.023	0.023
	(0.0211)	(0.0211)	(0.0210)	(0.0210)
1-year lead	0.202***	0.202***	0.201***	0.201***
	(0.0209)	(0.0209)	(0.0208)	(0.0208)
Superintendent turnover (year t)		-0.028		-0.027
		(0.0206)		(0.0206)
Constant	-0.455**	-0.448**	-0.454**	-0.447**
	(0.1481)	(0.1481)	(0.1482)	(0.1482)
Observations	11604	11604	11604	11604
AIC	29900.199	29900.401	29902.479	29902.698
BIC	30091.536	30099.097	30101.175	30108.753
Deviance	29848.199	29846.401	29848.479	29846.698

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-10. Main effects of principal turnover on short-term suspension rate (std)

	(1)	(2)	(3)	(4)
New principal, any	0.041*	0.041*		
	(0.0165)	(0.0165)		
New principal, within year			0.014	0.014
			(0.0224)	(0.0224)
New principal, between year			0.048**	0.048**
			(0.0183)	(0.0184)
1-year lag	0.020	0.020	0.018	0.018
	(0.0166)	(0.0166)	(0.0165)	(0.0165)

2-year lag	-0.007	-0.007	-0.008	-0.009
	(0.0165)	(0.0165)	(0.0164)	(0.0164)
1-year lead	0.033*	0.033*	0.032*	0.032*
	(0.0164)	(0.0164)	(0.0164)	(0.0164)
Superintendent turnover (year t)		-0.014		-0.014
		(0.0143)		(0.0142)
Constant	-1.249***	-1.243***	-1.246***	-1.240***
	(0.1278)	(0.1281)	(0.1281)	(0.1283)
Observations	11604	11604	11604	11604
AIC	24222.504	24223.611	24223.946	24225.055
BIC	24413.841	24422.307	24422.642	24431.110
Deviance	24170.504	24169.611	24169.946	24169.055

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-11. Main effects of principal turnover on chronic absenteeism (std)

	(1)	(2)	(3)	(4)
New principal, any	-0.003	-0.003		
	(0.0191)	(0.0191)		
New principal, within year			0.039	0.039
			(0.0258)	(0.0258)
New principal, between year			-0.028	-0.028
			(0.0215)	(0.0215)
1-year lag	0.018	0.018	0.017	0.018
	(0.0177)	(0.0177)	(0.0176)	(0.0176)
2-year lag	0.017	0.017	0.017	0.017
	(0.0203)	(0.0203)	(0.0203)	(0.0203)
1-year lead	0.026	0.026	0.024	0.024
	(0.0184)	(0.0184)	(0.0183)	(0.0183)
Superintendent turnover (year t)		0.015		0.015
		(0.0191)		(0.0191)
Constant	-1.968***	-1.972***	-1.968***	-1.973***
	(0.1723)	(0.1729)	(0.1717)	(0.1722)

Observations	11604	11604	11604	11604
AIC	28111.368	28112.717	28108.711	28110.062
BIC	28302.705	28311.413	28307.407	28316.117
Deviance	28059.368	28058.717	28054.711	28054.062

Standard errors clustered at the school level. All models include school- and principal-level covariates.
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table A-12. Estimated effect of exogenous and endogenous within- and between-year principal turnover by subject (std)

	Math		Reading		Science	
	(1)	(2)	(3)	(4)	(5)	(6)
Exogenous within-year turnover	-0.006	-0.007	-0.003	-0.003	-0.017	-0.017
	(0.0068)	(0.0068)	(0.0043)	(0.0043)	(0.0102)	(0.0102)
Exogenous between-year turnover	-0.008	-0.008	-0.009*	-0.009*	-0.012	-0.012
	(0.0050)	(0.0049)	(0.0037)	(0.0037)	(0.0079)	(0.0079)
Endogenous within-year turnover	-0.021**	-0.021**	-0.015**	-0.015**	-0.031**	-0.031**
	(0.0064)	(0.0063)	(0.0048)	(0.0048)	(0.0102)	(0.0102)
Endogenous between-year turnover	-0.019***	-0.019***	-0.017***	-0.017***	-0.031***	-0.031***
	(0.0054)	(0.0054)	(0.0044)	(0.0044)	(0.0081)	(0.0081)
1-year lag	-0.012**	-0.012**	-0.011***	-0.011***	-0.022***	-0.022***
	(0.0037)	(0.0037)	(0.0027)	(0.0027)	(0.0055)	(0.0055)
2-year lag	-0.011**	-0.011**	-0.005*	-0.005*	-0.015**	-0.015**
	(0.0036)	(0.0036)	(0.0026)	(0.0026)	(0.0055)	(0.0055)
1-year lead	-0.001	-0.001	-0.003	-0.003	-0.010*	-0.010*
	(0.0033)	(0.0033)	(0.0025)	(0.0024)	(0.0052)	(0.0052)
Superintendent turnover (year t)		-0.005		0.001		-0.001
		(0.0030)		(0.0022)		(0.0050)
Constant	0.454***	0.458***	0.442***	0.441***	0.666***	0.667***
	(0.0495)	(0.0496)	(0.0424)	(0.0425)	(0.0568)	(0.0569)
Observations	10847	10847	11223	11223	11120	11120
AIC	-8156.093	-8157.195	-14715.747	-14714.061	85.844	87.782

BIC	-7944.636	-7938.446	-14503.301	-14494.290	298.023	307.277
Deviance	-8214.093	-8217.195	-14773.747	-14774.061	27.844	27.782