Teacher Labor Market Responses to Statewide Reform: Evidence From Michigan

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We examine the effect of Michigan's 2011 reforms to teacher evaluation and tenure policies on teacher retention. Our data are drawn from administrative records containing the population of public school employees from 2005–2006 through 2014–2015. To identify the causal effects of these reforms on teacher attrition, we utilize a difference-in-differences (DD) strategy that compares the exit rates of teachers with the exit rates of other professional staff in the same school districts who were not affected by the policy changes. We find that, on average, Michigan's teacher reforms had little impact on teacher attrition overall. However, further analyses provide strong evidence that early-career teachers assigned to hard-to-staff districts were more likely to exit post-reform.

Keywords: *policy, educational reform, economics of education, econometric analysis, policy analysis, quasi-experimental analysis*

Introduction

Over the past decade policymakers in nearly every state have enacted reforms to the public school teaching profession and the teacher labor market. Many of these reforms include changes to long-standing policies that teacher advocates, most notably teachers' unions, have long defended (Marianno, 2016). Although the types of reforms introduced and enacted differ across states, new policies include limits on the scope of collective bargaining, changes to the tenure process, and teacher accountability systems based on high-stakes evaluation linked to student outcomes. Proponents argue that these reforms will make it easier to identify and remove ineffective teachers and reduce administrative constraints over human capital and resource allocation decisions, which in turn will lead to increased student performance.

Opponents counter that these reforms make teaching a less attractive profession, leading to an increase in attrition from the field as well as a decrease in the supply and/or the quality of individuals who elect to enter the profession in the future. To date, however, there has been little systematic research to inform this debate.

What evidence is available comes primarily from studies that examine the effect of specific reforms to the teacher evaluation or tenure process on existing teacher attrition or the supply of new teachers. Strunk, Barrett, and Lincove (2017) find that the removal of tenure protections in Louisiana led to an increase in teacher attrition. Similarly, Roth (2017) finds that the teacher labor market reforms implemented in Wisconsin under Act 10 led to a substantial increase in teacher attrition that was driven almost entirely by teachers over the minimum retirement age of 55 who

faced strong incentives to retire prior to any changes to their collective bargaining agreements (CBAs). Several studies have also found that the introduction of high-stakes evaluation systems led to increased attrition among lower performing teachers in urban school districts (Cullen, Koedel, & Parsons, 2016; Dee & Wyckoff, 2015; Loeb, Miller, & Wyckoff, 2015; Sartain & Steinberg, 2016). Finally, using nationally representative data, Kraft, Brunner, Dougherty, and Schwegman (2018) find that recent teacher accountability reforms led to a reduction in the supply of prospective teachers.

In this article, we contribute to the literature on how teacher labor market reforms affect teacher attrition by examining the effects of a set of reforms implemented in Michigan that involved not only reductions in teacher employment protections but also the simultaneous onset of teacher evaluation policies and changes to collective bargaining rights. Specifically, we focus on the implementation of a set of policies in Michigan that substantially diminished public school teachers' workplace protections and the collective bargaining rights of their unions.

In July 2011, Michigan established a system of teacher evaluation that provided districts with new ability to identify and remove ineffective teachers. These laws reduced teachers' tenure protections, increased the length of the probationary period from 4 to 5 years, increased reliance on multiple measure teacher evaluation systems that include student achievement, and prohibited local collective bargaining of topics including teacher transfer and reassignment, evaluation, performance-based compensation, classroom observations, the length of the school year, and teacher discipline (State of Michigan, 2011). These comprehensive changes to the rules governing teachers and teaching in the state were followed up in 2012 with the implementation of a Right-to-Work law that prohibited unions from collecting agency fees (membership dues paid to support union professional activity). As a result of these reforms, Michigan now has one of the most restrictive scopes of bargaining of any state in the country (Winkler, Scull, & Zeehandelaar, 2012) and offers an ideal test of the competing hypotheses offered by the advocates for such reforms and the defenders of union and teacher protections.

To examine whether and how these reforms affected teacher attrition, we use detailed administrative data on the universe of Michigan school employees from 2005–2006 through 2014–2015. These records include information on demographics, years of experience, certification, and other measures common to rich administrative unit-level data. We ask two research questions:

Research Question 1: What was the impact of Michigan's teacher reforms on teacher exit rates?

Research Question 2: Did Michigan's teacher reforms differentially affect teachers who (a) worked in harder-to-staff districts, (b) had greater out-of-teaching opportunities, or (c) were higher quality?

To identify the causal effects of Michigan's accountability reforms on teacher attrition, we utilize a difference-in-differences (DD) identification strategy that compares the exit rates of teachers with the exit rates of noninstructional professional staff who work in the same school districts as our sample of teachers but were not directly affected by the accountability reforms. In our baseline DD specifications, we find no evidence of any reform-induced changes in teacher exit rates. However, these overall results may mask important heterogeneity in exit rates if some teachers were more likely to be influenced by the reforms than others. For example, as noted by Clotfelter, Ladd, Vigdor, and Diaz (2004) and Dizon-Ross (2018), accountability reforms may make it more difficult to attract and retain high-quality teachers in low-performing schools. To explore that possibility, we estimate models that allow for heterogeneous treatment effects depending on whether teachers are assigned to "harder-to-staff" districts, namely, districts with high poverty or dropout rates or those with lower performing students. In contrast to our baseline DD results, we find strong evidence that early-career teachers (pretenure) in "harder-to-staff" districts were more likely to exit post-reform.

In what follows, we provide background on the education policy environment in Michigan during our study's time frame, including a description of the particular law changes that we consider. We proceed with a description of our data and associated descriptive statistics and

provide an overview of our empirical strategy. We then present the results of our analysis, followed by a discussion of both the implications and limitations of our approach.

Background: Teacher Labor Market Reforms in Michigan

After an initial attempt to introduce a performance-based teacher evaluation system in 2010, the state of Michigan implemented several laws beginning in the summer 2011 that substantially reduced teachers' protections and the rights of teachers' unions in collective bargaining. In July 2011 the Michigan legislature implemented Public Acts 100, 101, 102, and 103, followed by Public Act 349 in December 2012. Combined, these reforms served to diminish teachers' employment protections and the collective bargaining rights of their unions. Specifically, Public Act 102 required the immediate establishment of a high-stakes teacher evaluation system, mandating that local districts put into place evaluation systems in the 2011–2012 academic year. The key feature of this legislation was the inclusion of student achievement as a "significant" determinant of educator performance ratings and the eventual dismissal of teachers with three consecutive "ineffective" ratings.[1] In addition, PA 102 prohibited districts from using seniority as the primary determinant of layoff decisions (as is the case under typical Last-in-First-Out [LIFO] seniority-based layoff processes) and required districts instead to base layoff decisions on performance ratings stemming from the new evaluation system, although districts are still allowed to use seniority to determine layoffs between teachers of similar performance ratings.

To facilitate the implementation of the evaluation reforms, PA 103 prohibited CBAs bargained after 2011 from governing evaluation, teacher transfer and reassignment (which is traditionally based on seniority rather than performance or school need), performance-based compensation, classroom observations, the length of the school year, and discipline (State of Michigan, 2011).

To further aid districts' ability to use the new evaluation system to remove ineffective teachers, the legislature also concurrently passed Public Acts 100 and 101. These acts increased

the pretenure probationary period from 4 to 5 years and required that evidence of teacher effectiveness be the dominant factor in awarding tenure or professional status. Specifically, new teachers were required to be rated effective or higher in their final three consecutive probationary years before receiving tenure (State of Michigan, 2011).[2]

In addition, in December 2012, the state passed Public Act 349, which prohibited districts from requiring teachers to pay agency fees (funds designated for union activities related to the organization's professional purposes) as a condition of employment, shifting the state to Right-to-Work status (State of Michigan, 2012). This change foreshadowed the national shift to Right-to-Work conditions ushered in in 2018 by the Supreme Court's ruling in *Janus v. American Federation of State, County, and Municipal Employees.*

How might such reforms affect the teacher labor market? The logic behind tenure and evaluation reforms is that a shift to employment-at-will or performance-based job security will enable administrators to have more information about teacher performance while providing them with increased discretion over teacher retention and promotion. This should ultimately allow administrators to remove ineffective teachers (and provide a signal to ineffective teachers about a poor fit with the profession). However, if such reforms diminish other perceived benefits of public school teaching, they may induce adverse effects on the teacher labor market. Indeed, as research suggests, potential and existing teachers consider tenure part of their compensation package, especially if it is dependent on time-in-service as opposed to performance on the job (e.g., Brunner & Imazeki, 2010; Feinberg, 1981a, 1981b; Rothstein, 2014; Strunk et al., 2017). Other studies have also indicated that teachers value nonpecuniary benefits when they appraise their compensation packages (Loeb & Page, 2000), including job stability and mitigated risks to future employment (e.g., Murnane & Olsen, 1990; Rothstein, 2014). This suggests that weakening tenure protections and/or linking job security to classroom performance may disincentivize effective teachers from entering or remaining in the profession, especially without offsetting financial incentives (Kraft et al., 2018;

Rothstein, 2014). More generally, it is possible—and teacher advocates have strongly asserted—that such reforms lower morale and diminish satisfaction with the profession.

Our objective in this article, then, is to consider whether the package of reforms implemented by the Michigan state legislature in 2011 affected the teacher labor market by causing increased attrition as teachers respond to these reforms. In particular, teachers may be more likely to exit teaching if they feel that the reforms will result in substantial reductions in their job protections and in the ability of their local districts and unions to continue negotiating for enhanced job protections and other working conditions through collective bargaining and lobbying activities. In what follows, we aim to isolate the impact of Michigan's teacher policy reforms on teacher attrition by leveraging a variety of identification strategies that account for other factors, such as changing labor market opportunities, that occurred in close temporal proximity to the reforms introduced in Michigan and nationwide.

Data

Our primary source of data is administrative records for the population of Michigan's public school employees provided by the Michigan Department of Education (MDE) and the Center for Educational Performance and Information (CEPI) for the school years 2005–2006 through 2016–2017. These data include demographic and credential information for employees as well as descriptions of their assignments. Comprehensively, the data capture approximately 2.8 million employee-years. The 952,000 observations for instructionally focused teachers, representing 140,000 unique teachers, provide the core analytic sample.[3]

We use occupation and assignment codes for noninstructional staff to develop a comparison group for the analyses described below. Specifically, our comparison group consists of (a) social workers, (b) school nurses and other health services workers, (c) occupational and physical therapists, (d) school psychologists, (e) audiologists and speech pathologists, (f) accountants/bookkeepers, and (g) other professional nonteaching personnel.[4] As noted previously,

these noninstructional professional staff work in the same schools and districts as teachers and hold positions that require similar educational attainment and certification requirements as teachers. Importantly, however, our control group of professional staff received arguably no direct treatment from the teacher-specific reforms (i.e., tenure and evaluation). The only formal, direct treatment of reform that applied to all school staff in Michigan was the 2012 Right-to-Work legislation, but the effect of such a policy change is theoretically ambiguous apart from its coupling with the teacher-specific reforms. Thus, while we cannot rule out the potential that our comparison group received some spillover treatments from the teacher reforms, it is certainly true that teachers in Michigan received a far greater and more direct workplace intervention in the form of tenure and evaluation.

Our outcome of interest is a teacher/professional staff exit from the Michigan public school system. No description of the reason for exiting the Michigan school system is available in the state record. Instead, we infer exits from a date of termination indicator in the administrative record and the presence and then absence of a public school employee's unique identifier in the time series. Specifically, we define an exit as permanent disappearance after year *t* from the population of Michigan public school teachers and professional staff.[5] Using the full extent of our time series, we determined that the vast majority (72%) of short-term leaves are for only a single year. As such, we adjust our data to reflect that an individual must be absent for at least 2 years from the data before being identified as an exit. The implication of this restriction is that it removes the 2015–2016 and 2016–2017 exits from our analysis.

We also create a number of control variables that capture the demographic characteristics of teachers and staff in our sample, namely, (a) years of experience, (b) age, (c) an indicator for whether an individual has a master's degree or higher, (d) an indicator for whether an individual is female, and (e) indicators for whether an individual is Black, Hispanic, or some other race or ethnicity other than non-Hispanic White.

In some of our analyses, we are particularly interested in whether specific groups of teachers were more likely to exit post-reform than other

teachers. These groups are (a) teachers assigned to school districts that are arguably more challenging to teach in and harder to staff, (b) teachers with potentially better outside-of-teaching career options, and (c) teachers who graduated from more selective colleges and universities. Hanushek, Kain, and Rivkin (2004) find that teacher exit rates tend to be substantially higher in schools serving large numbers of disadvantaged students.[6] Consequently, we use the fraction of disadvantaged students in a school district in 2008 as our primary measure of a more challenging teaching environment.[7] In addition, we also use the average district-wide student performance on the math and English portions of the American College Test (ACT) and high school dropout rates as secondary measures of school districts with challenging teaching environments.[8] We obtain all of these measures from the MDE and CEPI administrative data described above.

To examine whether teachers with potentially better outside-of-teaching career options were more likely to exit post-reform, we use data from the MDE administrative records to create an indicator for whether a teacher was a certified secondary science, technology, engineering and mathematics (STEM) teacher. Our rationale for focusing on STEM teachers is that these teachers predominantly hold an undergraduate major, minor, or nondegree equivalent in math or science—training that tends to provide better outside-of-teaching options than other undergraduate majors that teachers typically pursue.[9]

We are also interested in whether exit rates among teachers differ depending on observable measures of teacher quality. While we do not have any individual-specific pre-reform measures of teacher quality, the MDE administrative records contain information on the college or university from which a teacher graduated. We therefore proxy for teacher quality using the observable characteristics of the college or university from which a teacher graduated. Specifically, we use the 75th percentile ACT score of incoming undergraduate students as our measure of college selectivity. We obtain data on college selectivity from the Integrated Postsecondary Education Data System (IPEDS) maintained by the National Center for Education Statistics (NCES).[10] Finally, to examine whether Michigan's teacher labor market reforms also had an impact on teacher compensation, we use the individual-level data on teacher and professional staff salaries between 2006 and 2014 from the administrative records described above.

We restrict our sample in a number of ways. First, we exclude from the sample all administrators and individuals younger than 21 or 65 or older.[11] Second, we drop individuals who work in charter schools as charter teachers were not subject to the reforms and pre-reform attrition trends for charter teachers differ substantially from those of traditional public school teachers.[12] Third, many small school districts employ very few noninstructional professional staff that belong to our comparison group. For example, many small school districts in Michigan do not have school nurses or occupational and physical therapists. As a result, we limit our sample to school districts with 500 students or more. We note, however, that even after imposing this restriction, we retain 97.7% of our sample of teachers and 98.6% of our sample of staff. Fourth, although exits due to retirement typically occur at well-defined points in an individual's age and experience profile (e.g., age 65 and/or 30 years of experience), in 2010, Michigan introduced a one-time retirement incentive for school employees whose age and experience levels added to 80 or who were age 60 and had at least 10 years of experience (State of Michigan, 2010). The retirement incentive led to a large spike in exit rates among teachers and professional staff with 10 or more years of experience that coincided quite closely with the adoption of Michigan's teacher evaluation and tenure reforms in 2011. Obviously, the timing of the early retirement incentive leads to concern that our results could be confounded by this concurrent policy. As a result, we restrict the sample to teachers and professional staff who were not eligible for the early retirement incentive. Specifically, we restrict the sample in two ways: (1) we drop teachers and professional staff with more than 20 years of experience, and (2) we drop teachers and professional staff with more than 10 years of experience if they are above the age of 55.

The final restriction relates to the establishment of emergency managers in several school districts during our sample time frame. For

example, in 2009, the Detroit school system faced approximately a US$400 million deficit, prompting Michigan's governor to replace the local school board with an appointed official and place the Detroit school system in emergency management status. Two other school districts—Highland Park Schools and Muskegon Heights—were placed in emergency manager status in 2012. The financial condition of these school districts relative to other school districts in Michigan, and the fact that Detroit is the largest school district in the state, raises the obvious concern that their inclusion in our sample may unduly influence our results. As a result, we drop emergency manager districts from the analysis.[13]

Table 1 provides summary statistics for the variables used in our analysis. For comparison purposes, we present these summary statistics separately for the sample of teachers and the sample of noninstructional professional staff. In addition, we present separate summary statistics for teachers and staff based on years of work experience in the Michigan public school system. On average, approximately 4% of teachers and professional staff exit after any given year, but exit rates vary by experience level, with exit rates being higher for less experienced teachers and staff. Professional staff are more likely than teachers to have an advanced degree, with the gap in educational attainment being larger for lower experience levels. Professional staff also tend to be somewhat older than teachers across all experience levels. We account for these differences in the empirical work that follows by controlling for age, experience, and educational attainment in our analyses. Finally, both teachers and professional staff tend to be predominantly non-Hispanic White and female.

Empirical Framework

To examine the effect of Michigan's 2011 reforms to teacher evaluation and tenure policies on teacher attrition, we estimate DD models of the following form:

$$Exit_{ijdt} = \gamma_0 + \gamma_1 Post_t * Teach_{idt} \\ + X_{ijdt}\theta + \lambda_t + \psi_j + \delta_d + \eta_{ijdt}, \quad (1)$$

where, $Exit_{ijdt}$ equals one if individual i, in occupation j and school district d, exits the public

school system in year t; $Post_t * Teach_{idt}$ is an interaction term between an indicator for teachers and an indicator for whether the observation is for a year in the post-reform period (i.e., 2011–2014); X_{ijdt} is a vector of individual characteristics; λ_t, ψ_j, and δ_d represent year, occupation (teachers and types of professional staff), and school district fixed effects, respectively; and η_{ijdt} is a random disturbance term. The coefficient of primary interest in Equation 1 is γ_1, which is the DD estimate of the effect of Michigan's teacher evaluation and tenure reforms on the attrition rate of teachers relative to noninstructional professional staff.[14]

In the empirical work that follows, we estimate Equation 1 separately for teachers and professional staff with 10 to 20, 6 to 9, and 1 to 5 years of experience. Our rationale for estimating separate equations based on experience groupings is twofold. First, Michigan's reforms had different implications for teachers with more or less experience. While the teacher evaluation reform affected all teachers, pretenure teachers (teachers in their first 5 years in a district) were affected by the increase in the length of the probationary period and the requirement that new teachers receive three consecutive performance ratings of "effective" to earn tenure protections. Second, from a policy perspective it is important to examine whether the effect of Michigan's teacher labor market reforms differed for early-, mid-, and later-career teachers.

To provide further evidence that the results based on Equation 1 have a causal interpretation, we also estimate event study models where we replace the $Post_t * Teacher_{idt}$ indicator in Equation 1 with a series of lead and lag treatment indicators that span the years both before and after the 2011 reforms. Specifically, we estimate models of the following form:

$$Exit_{ijdt} = \alpha_0 + \sum_{r=-6}^{3} I_{2011+r} * Teach_{idt}\alpha_r \\ + X_{ijdt}\theta + \lambda_t + \psi_j + \delta_d + \nu_{ijdt}, \quad (2)$$

where I_{2011+r} represents a series of year indicators that span the policy adoption year of 2011, ν_{ijdt} is a random disturbance term and all other terms are as defined in Equation 1. We include treatment–year interactions for each of the post-reform years

TABLE 1

Summary Statistics

Variables	(1) Exp. 10–20 Teachers	(2) Exp. 10–20 Staff	(3) Exp. 6–9 Teachers	(4) Exp. 6–9 Staff	(5) Exp. 1–5 Teachers	(6) Exp. 1–5 Staff
Exit	0.022	0.021	0.031	0.028	0.048	0.053
Experience	14.14	13.82	7.57	7.083	3.306	3.819
Master's degree or more	0.72	0.771	0.542	0.745	0.229	0.722
Age	41.89	45.23	36.70	40.75	31.65	36.93
Female	0.725	0.89	0.73	0.90	0.73	0.92
Black	0.02	0.05	0.03	0.04	0.02	0.04
Hispanic	0.008	0.010	0.009	0.010	0.011	0.011
Other Race	0.009	0.010	0.009	0.012	0.012	0.010
Secondary STEM Teacher	0.052	—	0.057	—	0.064	—
Attended selective college	0.487	—	0.503	—	0.524	—
District characteristics						
Fraction free lunch eligible	0.269	0.259	0.260	0.256	0.265	0.267
Combined ACT math and reading score	38.35	38.50	38.42	38.53	38.33	38.35
Dropout rate	0.111	0.117	0.110	0.115	0.114	0.121
Observations	230,660	17,935	128,424	11,928	102,236	10,243

Note. Table presents summary statistics for the sample of teachers and professional staff. Sample means and standard deviations are for the years 2005–2014. ACT = American College Test; STEM = science, technology, engineering, and mathematics.

and for the pre-reform years of 2005–2009. The omitted category is therefore the year just prior to the adoption of the reforms (2010). The pre-reform interactions provide evidence on whether the attrition rates of teachers relative to professional staff were trending higher prior to the introduction of the reforms. If our results have a causal interpretation the estimated coefficients on the pre-reform interactions should all be relatively small in magnitude and statistically insignificant. Similarly, the post-reform interactions allow the effect of the 2011 reforms on attrition rates to evolve slowly over time.[15] For example, any effect of Michigan's reforms on teacher attrition may not be immediate because both early- and later-career teachers may wait to see how the reforms affect their job security and job satisfaction prior to making a decision about whether to remain in the teaching profession. The event study specification allows for lags in the effects of the reforms and thus allows us to model longer term effects of the reforms on teacher attrition.

We also conduct analyses designed to examine whether certain subgroups of teachers were more likely to exit the teaching profession post-reform than other teachers. As noted previously, policymakers have raised concerns that accountability reforms may make it difficult to attract and retain high-quality teachers in low-performing schools. To explore that possibility, we estimate triple-difference (DDD) models that allow for heterogeneous treatment effects depending on whether teachers are assigned to a hard-to-staff (HS) school district. Specifically, we estimate DDD models of the following form:

$$
\begin{aligned}
Exit_{ijdt} = {} & \beta_0 + \beta_1 Post_t * Teach_{idt} \\
& + \beta_2 Post_t * Teach_{idt} * HS_d \\
& + \beta_3 Teach_{idt} * HS_d \\
& + \beta_4 Post_t * HS_d + X_{ijdt}\theta \\
& + \lambda_t + \psi_j + \delta_d + \varepsilon_{ijdt},
\end{aligned} \tag{3}
$$

where HS_d is a pre-reform measure of the socioeconomic or performance level of students in district d, ε_{ijdt} is a random disturbance term and all other terms are as defined in Equation 1. As noted previously, we operationalize HS_d with

three proxies for hard-to-staff districts: (a) the fraction of students classified as disadvantaged, (b) average student performance on the ACT exam, and (c) district dropout rates. The coefficients of primary interest in Equation 3 are β_1 and β_2. Specifically, β_1 is the DD estimate of the effect of the 2011 reforms on teacher attrition, whereas β_2 measures how the DD estimate changes if a teacher is assigned to a hard-to-staff district.

We are also interested in whether STEM-certified teachers (our proxy for teachers with better outside-of-teaching career options) or teachers who graduated from a more selective college or university were more likely to exit the profession post-reform. Thus, we also estimate variants of Equation 3 where we replace the interaction between the teacher post-reform indicator and HS_d with an interaction between the teacher post-reform indicator and an indicator for STEM-certified secondary teachers or an indicator for teachers who attended a selective college or university. In addition, to determine whether the reforms induced changes to teacher compensation—a possibility we discuss further below—we estimate a version of Equation 3 where we replace the dependent variable with the natural log of teacher salaries calculated using our administrative data.

Finally, we also estimate a fully flexible DDD event study version of Equation 3 that take the form:

$$
\begin{aligned}
Exit_{ijdt} &= \sum_{r=-6}^{3} I_{2011+r} * Teach_{idt}\kappa_r^1 \\
&+ \sum_{r=-6}^{3} I_{2011+r} * Teach_{idt} * HS_d\kappa_r^2 \\
&+ \sum_{r=-6}^{3} I_{,2011+r} * HS_d\kappa_r^3 + \kappa^4 Teach_{idt} \\
&* HS_d + X_{ijdt}\theta + \lambda_t + \psi_j + \delta_d + \xi_{ijdt},
\end{aligned}
\tag{4}
$$

where ξ_{ijdt} is a random disturbance term and all other terms are as defined in Equations 2 and 3. In Equation 4, the key parameters of interest are the leads and lags on the year indicators interacted with the teacher indicator, κ_r^1, and the leads and lags on the year indicators interacted with the Teacher $\times$ Hard-to-Staff interaction term, κ_r^2. Specifically, the κ_r^1s represent the

difference in attrition rates between teachers and professional staff in each year of sample, whereas the κ_r^2s measure how that difference in attrition rates changes if a teacher is assigned to a hard-to-staff district. Finally, $\kappa_r^1 + \kappa_r^2$ represents the total treatment effect for teachers assigned to hard-to-staff districts. As with the simpler DD event study, if our results have a causal interpretation, estimates of $\kappa_r^1 + \kappa_r^2$ should all be relatively small in magnitude and statistically insignificant in the pre-reform years.

Results

To provide some initial context on the evolution of attrition rates both before and after Michigan's adoption of teacher evaluation and tenure reforms, Figure 1a to 1c plots annual average attrition rates from 2005–2006 through 2014–2015 for teachers and professional staff. For both teachers and professional staff with 10 to 20 years of experience, Figure 1a reveals that attrition rates remained relatively stable both before and after the introduction of Michigan's teacher labor market reforms in 2011. In contrast, for both teachers and professional staff with 6 to 9 years of experience, Figure 1b reveals an increase in attrition rates from 2011 on. Similarly, for teachers and professional staff with 1 to 5 years of experience, Figure 1c shows some evidence of an increase in attrition rates starting in 2010, the year just prior to the reforms, and then a steady increase in attrition rates from 2011 on. Furthermore, Figure 1b and 1c both suggests that teachers and professional staff experienced very similar increases in attrition rates post-reform. Thus, the graphical analysis presented in Figure 1a to 1c provides little evidence that Michigan's 2011 reforms caused teachers to exit the public school system at higher rates than professional staff. Finally, in all three figures the pre-reform trends in attrition for teachers and noninstructional professional staff are broadly similar, providing initial evidence that the parallel trend assumption underlying DD models likely holds. The one exception is that the attrition rates of teachers and professional staff with 6 to 9 and 1 to 5 years of experience deviate to some degree during the years that span the Great Recession (2007–2009).[16]
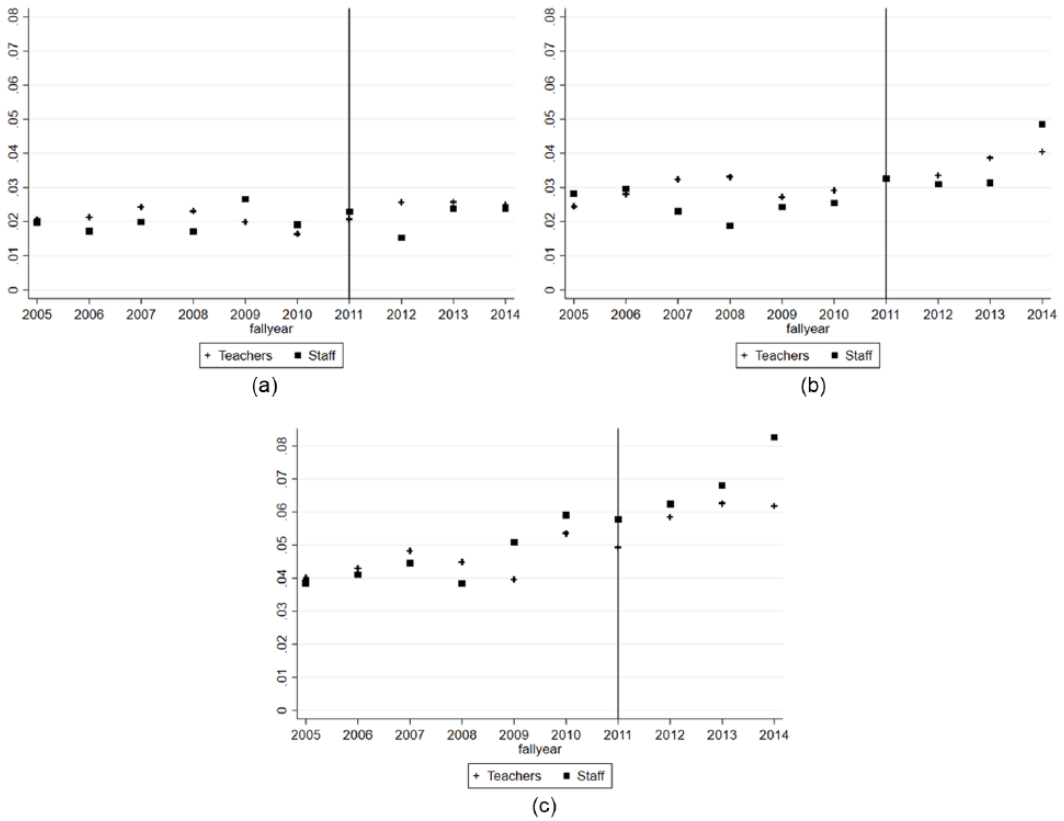
FIGURE 1. *Attrition rates for teachers and staff with (a) 10 to 20 years of experience, (b) 6 to 9 years of experience, and (c) 1 to 5 years of experience.*

We begin our empirical analysis by presenting estimates from our nonparametric event study specification. Figure 2a to 2c graphs the point estimates (solid lines) and associated 90% confidence intervals (CIs; dotted lines) obtained from the estimation of Equation 2. Consistent with the graphical evidence presented in Figure 1a to 1c, in all three event study graphs, there is little evidence that the attrition rate of teachers relative to professional staff was trending higher or lower prior to Michigan's adoption of teacher evaluation and tenure reforms in 2011. There is also little evidence that the attrition rate of teachers relative to professional staff rose following the 2011 reforms: the 90% CI lines reveal little evidence of a significant difference in attrition rates between teachers and staff within any experience band. Teacher attrition rates appear to rise slightly relative to staff in the first 2 years post-reform but decline during the latter post-reform years.

However, as is commonly found in fully flexible event study specifications, the point estimates in, Figure 2a to 2c, tend to be noisy and only one of the estimates is statistically different from zero (the coefficient on the indicator for the first year after the reforms for teachers with 10–20 years of experience).

Having found little evidence of pretrends in the attrition rate of teachers, to improve precision, in Table 2 we present standard parametric DD estimates based on Equation 1. The coefficients of interest in Table 2 are the teacher–post interactions, which provide the DD estimates of the differential change in attrition rates for teachers in the post-reform period. Across all three specifications, the estimated coefficients on the teacher–post interaction are close to zero and statistically insignificant, a result anticipated by Figures 1 and 2. Thus, we find little evidence that, on average, teachers were more
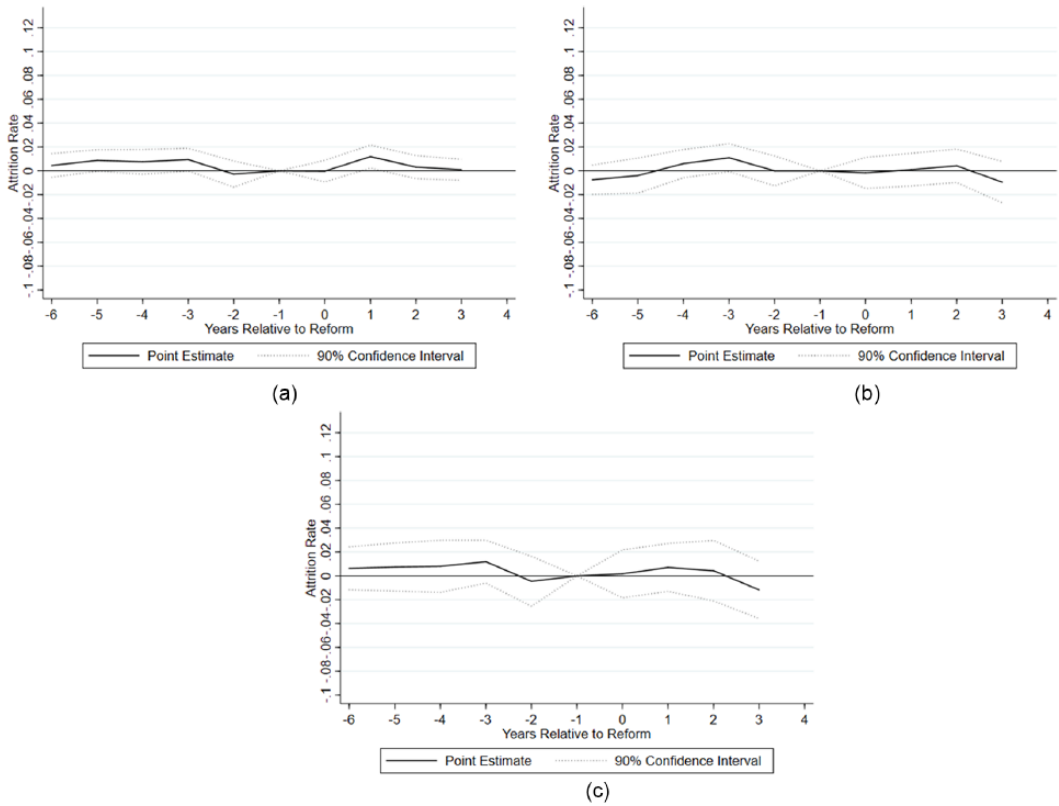
(a)

(b)

(c)

FIGURE 2. *Event study showing differential attrition for teachers versus staff with (a) 10 to 20 years of experience, (b) 6 to 9 years of experience, and (c) 1 to 5 years of experience.*

likely to exit Michigan public schools than their professional staff counterparts in the post-reform period.

Prior research has documented that teachers early or late in their careers are significantly more likely to exit the teaching profession than other teachers, a finding typically attributed to lower attachment to the profession among early- and late-career teachers (Boyd, Lankford, Loeb, & Wyckoff, 2005; Papay, Bacher-Hicks, Page, & Marinell, 2017). To examine that possibility, we created indicators for teachers with 15 to 20 and 1 to 3 years of experience and interacted those indicators with the teacher post-reform indicator. Results based on the specifications reported in columns 1 and 3 of Table 2 that include those interaction terms are reported in Table A1 of the appendix.[17] Once again, the results reported in Table A1 provide little evidence that teachers were more likely to exit Michigan public schools than their professional staff counterparts in the post-reform period.

Heterogeneous Effects

It is possible that the average results discussed above mask heterogeneity in attrition rates across subgroups of teachers. We explore that possibility in this section by turning to triple-difference estimates based on Equation 3, which interact the teacher post-reform indicator with other covariates that may lead to heterogeneous treatment effects.

The first issue we investigate is whether teachers assigned to "hard-to-staff" school districts were more likely to exit post-reform. As noted previously, we proxy for hard-to-staff districts using pre-reform measures of the fraction of disadvantaged students, combined student performance on the math and English portions of the ACT exam, and dropout rates. For ease of interpretation, we rescale all three of these variables so that they range in value from zero to one. Specifically, for the fraction of disadvantaged students and dropout rates, we rescale the

TABLE 2

DD Estimates of Probability of Attrition

Variables	Exp. 10–20	Exp. 6–9	Exp. 1–5
Teacher Post	−0.000	−0.002	−0.005
	(0.003)	(0.005)	(0.006)
Experience	−0.006***	−0.014**	−0.006**
	(0.001)	(0.006)	(0.003)
Experience squared	0.000***	0.001*	−0.000
	(0.000)	(0.000)	(0.000)
Age	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)
Female	0.004***	0.007***	0.005***
	(0.001)	(0.001)	(0.002)
Black	0.005**	0.007*	0.013**
	(0.003)	(0.004)	(0.006)
Hispanic	0.003	−0.002	0.012*
	(0.004)	(0.006)	(0.007)
Other race	−0.000	−0.005	0.039***
	(0.004)	(0.005)	(0.010)
Masters degree or higher	−0.003***	−0.001	0.009***
	(0.001)	(0.001)	(0.002)
Observations	270,356	135,051	108,928

Note. Table presents DD linear probability model estimates for the probability of teacher/staff exit. Each column presents results from a separate regression for the sample of teachers and staff listed in the top row. All specifications include district, year, and occupation fixed effects. Robust standard errors clustered at the district level in parentheses. DD = difference-in-differences. *significant at 10%. **significant at 5%. ***significant at 1%.

variables so that the district with the lowest fraction of disadvantaged students (lowest dropout rate) has an index value of zero and the district with the highest fraction of disadvantaged students (highest dropout rate) has a value of one. We rescale the combined test score index in the same manner but take 1 minus the standardized index so that larger values of the index are associated with lower achieving students.

Panel A of Table 3 reports results based on specifications in which we interact the teacher post-reform indicator with the disadvantaged student index. For more experienced teachers (10–20 or 6–9 years of experience), we find no evidence that teachers assigned to districts with higher shares of disadvantaged students were more likely to exit the teaching profession post-reform. In contrast, for early-career teachers (1–5 years of experience) we find that the estimated coefficient on the triple interaction term is positive, relatively large in magnitude and statistically significant. In terms of magnitude, the

results reported in column 3 suggest that teachers assigned to the district with the highest share of disadvantaged students (District Disadvantaged Index = 1) were 2.7 percentage points (−0.022 + 0.049) more likely to exit the teaching profession post-reform.

In Panel B, we replace the interaction between the teacher post-reform indicator and the disadvantaged student index with an interaction between the teacher post-reform indicator and the test score index. Recall that we take 1 minus the standardized test score index so that larger values of the index represent districts with lower performing students. Similar to the results reported in Panel A, we once again find that for early-career teachers (column 3) the estimated coefficient on the triple interaction term is positive, relatively large in magnitude and statistically significant, suggesting that less experienced teachers assigned to districts with lower performing students were more likely to exit Michigan schools post-reform.

TABLE 3

Heterogeneity Analysis

	(1)	(2)	(3)
	Exp. 10–20	Exp. 6–9	Exp. 1–5
Panel A: District Disadvantaged Index			
Teacher Post	−0.003	0.003	−0.022**
	(0.005)	(0.008)	(0.010)
Teacher Post × Disadvantaged	0.008	−0.017	0.049**
	(0.012)	(0.022)	(0.025)
Panel B: District Test Score Index			
Teacher Post	−0.003	0.008	−0.036**
	(0.008)	(0.012)	(0.018)
Teacher Post × Test Scores	0.007	−0.022	0.061*
	(0.014)	(0.024)	(0.032)
Panel C: District Dropout Rate Index			
Teacher Post	0.004	0.007	−0.022**
	(0.005)	(0.007)	(0.010)
Teacher Post × Dropout Rate	−0.018	−0.042	0.080**
	(0.019)	(0.031)	(0.037)
Panel D: Secondary STEM teachers			
Teacher Post	−0.001	−0.003	−0.005
	(0.003)	(0.005)	(0.006)
Teacher Post × STEM	0.005*	0.006	0.009
	(0.003)	(0.005)	(0.007)
Panel E: Teachers From Above Median Act Score Colleges			
Teacher Post	−0.000	−0.002	−0.006
	(0.003)	(0.005)	(0.006)
Teacher Post × ACT75th	0.001	−0.001	0.002
	(0.001)	(0.002)	(0.003)
Panel F: Standardized 2009 County Unemployment Rate			
Teacher Post	−0.000	−0.002	−0.005
	(0.003)	(0.005)	(0.006)
Teacher Post × Unemployment	−0.000	0.000	−0.000
	(0.003)	(0.004)	(0.005)
Observations	270,356	135,051	108,928

Note. Table presents DDD linear probability model estimates for the probability of teacher/staff exit. Teacher Post is an indicator variable that takes the value of unity for teachers in the post-reform years of 2011–2014. Teacher Post × Characteristic is an interaction between the Teacher Post indicator and the characteristic listed in each panel. In Panel B, we take 1 minus the test score index so that larger values of the index represent districts with lower performing students. Each column presents results from a separate regression for the sample of teachers and staff listed in the top row. All specifications include the full set of individual control variables plus district, year, and occupation fixed effects. Robust standard errors clustered at the school district level in parentheses. ACT = American College Test; DDD = triple difference; STEM = science, technology, engineering, and mathematics.
*significant at 10%. **significant at 5%. ***significant at 1%.

Also consistent with the results reported in Panel A, we find that for more experienced teachers (columns 1 and 2) the estimated coefficient on the triple interaction term is small in magnitude and statistically insignificant. Finally, as shown in Panel C, we find similar results when we proxy for hard-to-staff districts using district dropout rates.

One possible concern with the results reported in Panels A to C of Table 3 is that we are interacting the teacher post-reform indicator with a continuous variable and thus imposing linearity on how higher exposure to disadvantaged students, lower performing students, or higher dropout rates affects attrition rates. As a sensitivity check, we therefore also estimated models where we interacted the teacher post-reform indicator with an indicator that takes the value of unity if a district is at or above the 75th percentile of the share of disadvantaged students or dropout rates or at or below the 25th percentile of combined district math and English ACT scores. As shown in Table A2 of the appendix, we once again find that all of the estimated coefficients on the triple-difference interaction terms are positive and statistically significant for early-career teachers and statistically insignificant for more experienced teachers.

Panels D and E of Table 3 report estimates that examine whether secondary STEM teachers or teachers who graduated from more selective colleges or universities were more likely to exit post-reform. Specifically, in Panel D we interact the teacher post-reform indicator with an indicator for whether a teacher is a certified secondary STEM teacher. Similarly, in Panel E we interact the teacher post-reform indicator with an indicator for teachers who graduated from a college or university where the 75th percentile ACT composite score of incoming undergraduate students was above the median in our sample.[18] In both Panels D and E, we find little evidence that STEM teachers or teachers who attended more selective colleges were more likely to exit the teaching profession post-reform: all but one of the estimated coefficients in Panels D and E are small in magnitude and statistically insignificant. The one exception is the coefficient on the interaction between STEM teachers and the teacher post-reform indicator in column 1. However, even in that case, the point estimate on this interaction term is relatively small in magnitude and only significant at the 10% level.

The final issue we investigate is whether there was heterogeneity in exit rates depending on the impact of the Great Recession on local labor markets. Specifically, one possibility is that teachers assigned to districts that were hardest hit by the Great Recession may have delayed their decision to exit the teaching profession until after the Great Recession, when improvements in labor market conditions may have led to better alterative employment options. To examine that possibility, we collected data on average county-level unemployment rates in 2009 and 2010 and created a standardized unemployment rate with a mean of zero and a standard deviation of one. We then interacted county unemployment rates with the teacher post-reform indicator to estimate specifications based on Equation 3. Results are reported in Panel F of Table 3. There is little evidence of heterogeneity in exit rates that stems from differences in county unemployment rates: The estimated coefficients on the interaction term are all small in magnitude and statistically insignificant.

Finally, in results not reported, we also examined two additional sources of potential heterogeneity. First, we examined whether teachers assigned to districts with higher shares of Black and Hispanic students were more likely to exit Michigan schools post-reform. Similar to the results reported in Table 3, we found that teachers with 1 to 5 years of experience (but not other teachers) assigned to districts with higher shares of Black and Hispanic students were significantly more likely to exit Michigan schools post-reform. Second, we examined whether teachers located close to a state border were more likely to exit Michigan schools post-reform. Specifically, we created an indicator for districts that were within 25 miles of a state border and interacted that variable with the teacher post-reform indicator. Results based on this specification provided little evidence of heterogeneity based on distance to a state border: all of the estimates on the interaction term were statistically insignificant and relatively small in magnitude.

Triple-Difference Event Study Specifications

One potential concern with the results reported in Table 3 is that the attrition rate of early-career teachers (those with 1–5 years of experience) assigned to hard-to-staff districts may have been trending higher prior to the adoption of teacher evaluation and tenure reforms in 2011. If that were the case, then our triple-difference estimates
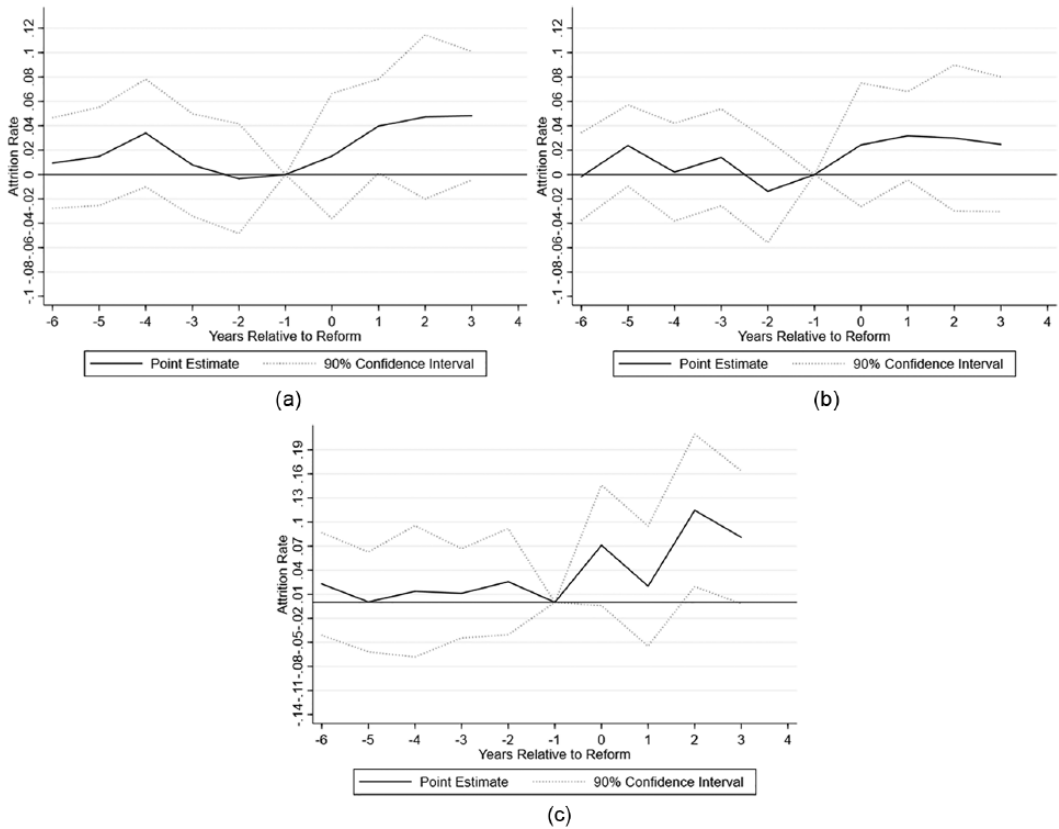
FIGURE 3. *DDD event study for teachers versus staff with 1 to 5 years of experience based on (a) disadvantaged index, (b) test score index, and (c) dropout rate index.*
Note. DDD = triple difference.

would not have a causal interpretation. In this section, we conduct several tests for preexisting trends.

We begin by presenting estimates based on the fully flexible DDD event study specification given by Equation 4. Figure 3a to 3c graphs the point estimates of the total treatment effect (i.e., estimates of $\kappa_r^1 + \kappa_r^2$) and associated 90% confidence intervals (dotted lines) obtained from the estimation of Equation 4 for the sample of early-career teachers. While the estimates are unsurprisingly noisy, in all three figures there is clear evidence of an upward trend in attrition rates for teachers assigned to hard-to-staff districts following Michigan's adoption of teacher evaluation and tenure reforms in 2011. Importantly, there is also little evidence that the attrition rate of teachers assigned to hard-to-staff districts was trending higher or lower prior to 2011, which further

supports the causal interpretation of the DDD estimates reported in Table 3.[19]

Falsification Tests

In addition to the DDD event study analysis, we also conduct several falsification tests for our core findings related to post-reform exit rates among early-career teachers in hard-to-staff districts. In our first falsification test, we create a pseudo reform year by moving the actual reform year (2011) back to 2008. We then estimate an expanded version of Equation 3 that has two sets of triple-difference effects. Specifically, we expand Equation 3 to include both the actual 2011 triple-difference interaction and a pseudo triple-difference interaction. We create the pseudo triple-difference interaction by setting the date of the policy reform to 2008 and interacting an indicator that takes the

TABLE 4

Falsification Estimates for New Teachers (Experience: 1–5 Years)

	(1)	(2)	(3)
	Disadvantaged index	Test score index	Dropout rate index
	Panel A: 2008 Placebo Policy Included in Main Specification		
Teacher Post	−0.024**	−0.037*	−0.019*
	(0.012)	(0.021)	(0.011)
Teacher Post × HS	0.060*	0.067*	0.076*
	(0.032)	(0.038)	(0.044)
Placebo Teacher Post	0.003	0.001	−0.006
	(0.012)	(0.019)	(0.010)
Placebo Teacher Post × HS	−0.019	−0.009	0.009
	(0.030)	(0.035)	(0.040)
Observations	108,928	108,920	108,926
	Panel B: 2008 Placebo Policy Excluding Actual Policy Years		
Placebo Teacher Post	0.002	−0.000	−0.007
	(0.012)	(0.019)	(0.010)
Placebo Teacher Post × HS	−0.022	−0.009	0.010
	(0.030)	(0.035)	(0.040)
Observations	77,121	77,113	77,119
	Panel C: 2007 Placebo Policy Excluding Actual Policy Years		
Placebo Teacher Post	−0.003	0.006	−0.004
	(0.009)	(0.017)	(0.009)
Placebo Teacher Post × HS	0.002	−0.015	0.007
	(0.025)	(0.032)	(0.039)
Observations	77,121	77,113	77,119

Note. Table presents falsification estimates for results reported in column 3 of Table 3. Panel A augments the specifications in column 3 of Table 3 by including an indicator equal to one in the placebo policy year of 2008 and all subsequent years interacted with the teacher indicator and that variable interacted with the variable listed in the top row. Panel B drops all observations from the actual policy reform years of 2011 forward and sets the placebo policy reform year to 2008. Panel C drops all observations from the actual policy reform years of 2011 forward and sets the placebo policy reform year to 2007. All specifications include the full set of individual control variables plus district, year, and occupation fixed effects. Robust standard errors clustered at the school district level in parentheses. HS = hard-to-staff.
*significant at 10%. **significant at 5%. ***significant at 1%.

value of unity in 2008 and all subsequent years with the teacher indicator and with the disadvantaged student index, the test score index, or the dropout rate index. We also include the pseudo double-difference interaction between the indicator for the pseudo policy reform year and the teacher indicator. In our second falsification test, we once again move the actual reform year back to 2008 and create the same pseudo double- and triple-difference interactions, but this time drop all observations associated with actual reform years (i.e., drop observations from 2011 to 2014). Finally, our third falsification test is identical to our second

test except we move the actual reform year back to 2007. The idea behind all of these falsification tests is that if our results have a causal interpretation, the estimated coefficients on the pseudo post-reform interactions should be small in magnitude and statistically insignificant as they are based on years prior to the actual adoption of Michigan's teacher labor market reforms.

Results from our falsification tests are reported in Table 4. Results from the first falsification test, where we expand our main specifications to include the pseudo triple-difference effect, are reported in Panel A. There we find no
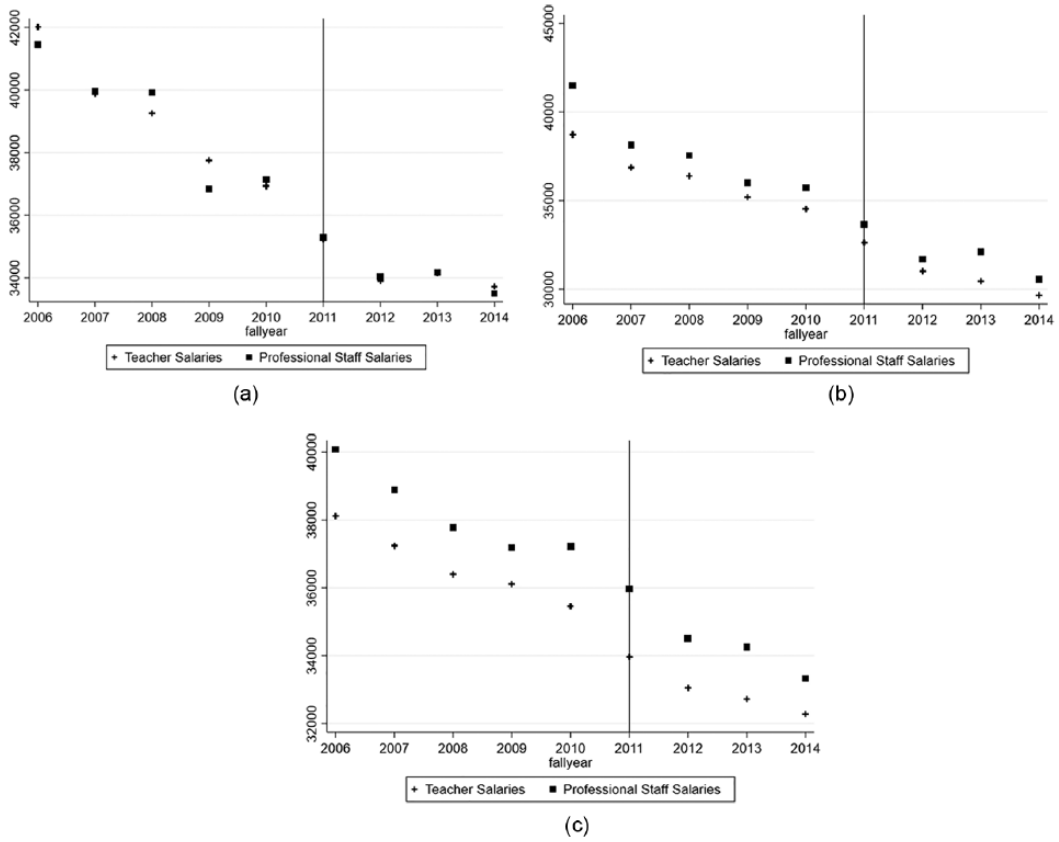
FIGURE 4. *Salary comparisons for teachers and staff with (a) 10 to 20 years of experience, (b) 6 to 9 years of experience, and (c) 1 to 5 years of experience.*

evidence of differential effects in the period preceding the actual reform year of 2011 but continue to find estimates of similar magnitude and significance to those reported in Table 3 for the actual reform year. Panels B and C report results based on specifications where we move the actual reform year back to either 2008 or 2007 and drop all the actual post-reform observations. Once again, we find no evidence of differential effects using the pseudo reform years. Overall, the results of our triple-difference event studies and falsification tests provide compelling evidence that our Table 3 results have a causal interpretation.

Teacher Compensation

The results presented thus far provide rather compelling evidence that, on average, Michigan's teacher accountability and tenure reforms had little impact on the attrition rates of teachers relative to professional staff. At the same time, however, Figure 1b and 1c, clearly shows that, on average, teacher and professional staff attrition rates began to rise in Michigan right around the time of the policy reform year of 2011.[20] One potential explanation for these findings concerns teacher and professional staff compensation. Specifically, declines in compensation may have led many teachers and professional staff to exit the public school system once alternative job opportunities arose. Such declines in compensation may have resulted from budgetary pressure arising during the Great Recession or be linked to declines in collective bargaining rights and the adoption of a Right-to-Work law that accompanied Michigan's teacher evaluation and tenure reforms.

We examine that possibility in Figure 4a to 4c, where we plot trends in the covariate adjusted annual real salaries of teachers and professional staff.[21] Specifically, we first regressed annual real salaries (measured in constant 2015 dollars)

TABLE 5

DD Salary Estimates for Subgroups

	(1)	(2)	(3)
	Exp. 10–20	Exp. 6–9	Exp. 1–5
	Panel A: District Disadvantaged Index		
Teacher Post	0.022	0.027**	−0.008
	(0.020)	(0.012)	(0.013)
Teacher Post × Free Lunch	−0.065	−0.099**	−0.001
	(0.061)	(0.040)	(0.034)
	Panel B: District Test Score Index		
Teacher Post	0.041	0.046**	−0.015
	(0.027)	(0.018)	(0.020)
Teacher Post × Test Scores	−0.081	−0.102***	0.012
	(0.053)	(0.039)	(0.037)
	Panel C: District Dropout Rate Index		
Teacher Post	0.005	0.012	−0.019
	(0.017)	(0.011)	(0.013)
Teacher Post × Dropout	−0.027	−0.080	0.047
Rate	(0.083)	(0.056)	(0.048)
Observations	196,304	92,402	68,850

Note. Dependent variable in all specifications is the log of teacher/staff salaries. Each column presents results from a separate regression for the sample of teachers/staff listed in the top row. All specifications include the full set of individual control variables plus district, year, and occupation fixed effects. Robust standard errors clustered at the school district level in parentheses. DD = difference-in-differences.
*significant at 10%. **significant at 5%. ***significant at 1%.

on our set of control variables and occupation group-by-year fixed effects. We then saved the estimated coefficients on the fixed effects and plot the covariate adjusted average salaries for teachers and staff separately for each year from 2006 to 2014. As Figure 4a to 4c reveals, both teachers and professional staff experienced a steady decline in real average salaries over the time period of our sample. Specifically, teachers and professional staff with 10 to 20 years of experience witnessed approximately a US$8,000 decline in real covariate adjusted salaries over the time period. Similarly, teachers with 6 to 9 and 1 to 5 years of experience witnessed approximately US$9,000 and US$6,000 decline, respectively.[22] Thus, Figure 4a to 4c is consistent with the notion that both teachers and professional staff may have chosen to exit Michigan's public school system after the Great Recession due to declines in compensation.

The salary trends reported in Figure 4a to 4c also raise the possibility that our Table 3 results for early-career teachers are being driven by the fact that teachers in hard-to-staff districts saw even larger reductions in compensation post-reform than their professional staff counterparts or teachers and staff in other districts, which could lead to relative increases in teacher attrition. To examine that possibility, we estimated DDD models that are identical to those reported in Table 3, except we used the natural log of teacher salaries as the dependent variable. Results are reported in Table 5. For teachers with 10 to 20 and 6 to 9 years of experience, we find some evidence that teachers assigned to hard-to-staff districts experienced larger salary declines post-reform than professional staff assigned to the same districts or to teachers and staff assigned to other districts, although the estimated coefficient on the triple-difference interaction is only significant in two cases. More importantly, among early-career teachers, for whom we see an increase in attrition rates post-reform in hard-to-staff districts, there is no evidence that teachers in hard-to-staff districts experienced larger reductions in compensation

than professional staff in the same districts or teachers and staff in other districts. Thus, it appears unlikely that differential changes in teacher and staff compensation across districts are driving our Table 3 results.

Conclusion

States across the country have made substantial changes to basic conditions of teacher employment in public schools. Rights to collectively bargain, tenure protections, seniority-based staffing routines, and walls between student outcomes and assessments of teacher performance have all weakened in recent years, with teachers in some states essentially serving as long-term at-will employees in their local school districts. Most recently, in *Janus v. AFSCE*, the Supreme Court restricted unions from requiring dues and agency fees from their members, potentially limiting these organizations' ability to advocate on teachers' behalf. Opponents of these reforms to the teacher labor market have argued that they will make teaching a less attractive profession, resulting in an increase in teacher attrition and a reduction in the quantity and quality of individuals who elect to enter the profession in the future. There remains, however, limited systematic evidence to support this assertion.

In this article, we examine nearly 10 years of data on the population of teachers in Michigan, where reforms introduced midway through our time frame added new hurdles to achieving tenure, a new system of teacher evaluation, and changes to teachers' collective bargaining rights and union dues collection. To identify the causal effects of Michigan's accountability reforms on teacher attrition, we utilize a DD identification strategy that compares the exit rates of teachers with the exit rates of noninstructional professional staff who work in the same school districts as our sample of teachers but were not directly affected by the 2011 teacher accountability reforms.

In our baseline DD specifications, we find no evidence that Michigan's teacher labor market reforms increased the attrition rates of late-, middle-, or early-career teachers relative to professional staff in the short run. Thus, although teachers have been exiting Michigan schools at

higher rates, our results suggest that teacher-specific reforms had no particular impact on teacher exits apart from whatever forces were affecting employees in public schools more generally.

In contrast, we find strong evidence that that early-career teachers in hard-to-staff schools (proxied by poverty rates, student performance, and dropout rates) were more likely to exit the public school system after the reforms than their peers in wealthier and higher performing districts. We also find little evidence that the reforms increased the attrition rates of late- or mid-career teachers in hard-to-staff schools. Our finding that the reforms primarily affected early-career teachers is perhaps not too surprising given that prior research has documented that teachers early in their careers are significantly more likely to exit the teaching profession than other teachers due to their lower attachment to the profession. Furthermore, while the teacher evaluation reforms affected all teachers in Michigan public schools, the tenure reforms only affected pre-tenure teachers. Specifically, most of the early-career teachers in our sample were immediately affected in 2011 by an increase in the length of the tenure period and the requirement that new teachers receive three consecutive performance ratings of "effective" to earn tenure protections.

Our results have several important policy implications. First, our results cast doubt on the claims made by opponents of high-stakes teacher evaluation systems and other recent reforms that such reforms would significantly increase teacher attrition. Michigan serves as an important case to test this hypothesis because the package of "antiteacher" and/or "antiunion" reforms implemented in quick succession was greater than those passed in most other states. Therefore, we might expect to see a greater response in Michigan than in other states that only implemented evaluation *or* tenure reform *or* limited the scope of collective bargaining. In fact, we find compelling evidence that teachers overall were no more likely to exit Michigan's schools post-reform relative to their professional staff counterparts. This suggests that recent reforms to the teacher labor market may not depress teacher morale to the point where they result in a large loss (at least in the short run) of teachers from the profession.

However, our results regarding teachers in hard-to-staff schools also raise the concern that teacher labor market reforms like those implemented in Michigan may disproportionately affect the poorest schools and school districts—those already facing staffing constraints. Consequently, perhaps the most important conclusion from this work is that policymakers should be attuned to the ways in which any major changes to the public education system affect different teachers and different children in different ways. Policymakers may wish to consider ways to minimize the attrition rates of teachers willing to teach in high-poverty or low-performing schools by pairing reforms with other ways to compensate such educators.

Our results are subject to several important caveats. First, as noted previously, it is possible that individuals in our control group, which comprised noninstructional professional staff working in the same schools and districts as teachers, were at least indirectly affected by the teacher labor market reforms introduced in Michigan. As a result, our baseline DD estimates may understate the effect of the reforms on teacher attrition, if, for example, the reforms also reduced the morale or perceived working conditions of professional staff working in the same schools and districts as teachers. Importantly, however, this also suggests that our estimates may understate the already relatively large effects we find the reforms had on the attrition rates of early-career teachers assigned to hard-to-staff districts.

Finally, due to data limitations, we are only able to examine how Michigan's teacher labor market reforms affected the career decisions of *current* teachers and not *prospective* teachers. It seems likely that current teachers are more attached to the profession than prospective teachers, suggesting that the reforms introduced in Michigan may have had a bigger impact on the career decisions of prospective teachers. Consistent with that notion, using national data on the timing of teacher evaluation reforms across states, Kraft et al. (2018) find that evaluation reforms reduced the supply of new teaching candidates by 16%. This suggests an important direction for future research involves examining how the teacher labor market reforms introduced over the past decade has affected the quality of prospective teachers.

Appendix

TABLE A1

DD Estimates of Probability of Attrition

Variables	Exp. 15–20	Exp. 1–5
Teacher Post	0.003	−0.003
	(0.003)	(0.006)
Teacher Post × Exp. 15–20	−0.006***	
	(0.001)	
Teacher Post × Exp. 1–3		−0.001
		(0.003)
Observations	270,356	108,928

Note. Table presents DD linear probability model estimates for the probability of teacher/staff exit. Each column presents results from a separate regression for the sample of teachers and staff listed in the top row. Teacher Post × Exp. 15–20 is the interaction between the Teacher Post indicator and an indicator for teachers with 15 to 20 years of experience. Teacher Post × Exp. 1–3 is the interaction between the Teacher Post indicator and an indicator for teachers with 1 to 3 years of experience. All specifications include district, year, and occupation fixed effects as well as the full set of controls listed in Table 2. Specification in column 2 also includes an indicator for teachers and staff with 15 to 20 years of experience and that indicator interacted with an indicator for teachers. Specification in column 3 also includes an indicator for teachers and staff with 1 to 3 years of experience and that indicator interacted with an indicator for teachers. Robust standard errors clustered at the district level in parentheses. DD = difference-in-differences.

*significant at 10%. **significant at 5%. ***significant at 1%.

TABLE A2

Heterogeneity Analysis, Using Treatment Indicators for 75th Percentile

	(1)	(2)	(3)
	Exp. 10–20	Exp. 6–9	Exp. 1–5
Teacher Post	−0.000	0.002	−0.011*
	(0.003)	(0.005)	(0.007)
Teacher Post ×	0.002	−0.015	0.020*
Disadvantaged	(0.007)	(0.012)	(0.012)
Teacher Post	−0.000	0.002	−0.012*
	(0.003)	(0.005)	(0.007)
Teacher Post × Test Scores	0.002	−0.015	0.025**
	(0.006)	(0.011)	(0.013)
Teacher Post	0.003	0.002	−0.013*
	(0.003)	(0.005)	(0.007)
Teacher Post × Dropout	−0.009	−0.013	0.025**
Rate	(0.007)	(0.011)	(0.012)
Observations	270,356	135,051	108,926

Note. Table presents DDD linear probability model estimates for the probability of teacher/staff exit. Teacher Post is an indicator variable for teachers in the post-reform years of 2011–2014. Teacher Post × Characteristic is an interaction between the Teacher Post indicator and indicators for being at or above the 75th (or at or below 25th for test scores) percentile of the characteristic listed in each panel. Each column presents results from a separate regression for the sample of teachers and staff listed in the top row. All specifications include the full set of individual control variables plus district, year and occupation fixed effects. Robust standard errors clustered at the school district level in parentheses. DDD = triple difference.
*significant at 10%. **significant at 5%. ***significant at 1%.

Notes

1. In November 2015, the state passed subsequent legislation to allow individual districts wide discretion in the implementation of this policy over time, with student achievement remaining an important feature (State of Michigan, 2015). On average, only 1.8% of teachers received ratings below "effective" in each year of data we analyze. However, 5.5% of teachers received a below-effective rating during this same time frame. We argue, however, that the presence of a credible removal threat—one where teachers no longer have recourse to third-party arbitration of evaluation decisions—is the key mechanism by which districts may remove teachers. This may mitigate the need to formally rate individual teachers ineffective to induce exit and create separation between formal and informal evaluations (e.g., Grissom & Loeb, 2016).

2. The tenure reforms associated with PA 100 and 101 applied to all newly hired teachers starting in 2011. However, for teachers hired prior to 2011, the teacher evaluation and collective bargaining reforms associated with PA 102 and 103 did not take effect until each district's pre-reform collective bargaining agreement (CBA) had expired. Approximately 60% of all pre-reform CBAs expired in 2011 (or just before), whereas almost all of the remaining pre-reform CBAs expired in either 2012 (29%) or 2013 (11%).

3. Descriptions of employee assignments were used to identify teachers with primary duty as lead classroom instructors. Individuals with primary assignments in comparatively administrative areas (such as curriculum) and teachers' aides were excluded.

4. Our comparison group is similar to the one suggested by Harris and Adams (2007) who use the Current Population Survey (CPS) to compare turnover rates among teachers with those of nurses, social workers, and accountants; a group of professional they argue is similar along multiple dimensions to teachers. Their results suggest that teachers and individuals in their comparison group exhibit similar turnover rates.

5. The administrative data allow us to observe teachers and professional staff as long as they remain employed in the Michigan public school system. Thus, our measure of exit rates is not contaminated by teachers or staff simply switching schools or moving to a new district within the state. Note that teachers and professional staff moving from the public sector to private schools or to another state are not observable to us and will be interpreted as exits.

6. Also see Boyd, Lankford, Loeb, and Wyckoff (2005), Scafidi, Sjoquist, and Stinebrickner (2007), Falch and Strøm (2005), and Ingersoll (2001), among others, for further evidence on factors that affect teacher attrition.

7. The Michigan Department of Education defines disadvantaged students as those eligible for free- or reduced-price meals under the National School Lunch program, are in households receiving food (SNAP) or cash (TANF) assistance, are eligible under Medicaid, are homeless, are migrant, or are in foster care.

8. Michigan administers the ACT exam statewide in all districts as part of its student evaluation system. We use data on average district-wide performance on the ACT in 2009, rather than a more recent year to ensure that test results are measured prior to Michigan's 2011 reforms. Starting in 2017, the ACT exam was replaced by the SAT.

9. For example, Dolton and van der Klaauw (1999) find that teachers with an education degree rather than a specific college major like mathematics are less likely to exit teaching for a nonteaching job. Similarly, Stinebrickner (1998) finds that science teachers are more likely to exit teaching than other teachers.

10. Several studies have documented a positive, albeit weak, relationship between undergraduate selectivity and proxies for teacher quality (Boyd, Lankford, Loeb, Rockoff, & Wyckoff, 2008; Clotfelter, Ladd, & Vigdor, 2006; Jacob, Rockoff, Taylor, Lindy, & Rosen, 2018; Rockoff, Jacob, Kane, & Staiger, 2011). Furthermore, if college selectivity is positively correlated with outside-of-teaching career opportunities, this additional analysis provides another mechanism to observe any heterogeneity in teacher exits for those who may have better outside employment opportunities.

11. We exclude individuals age 65 or older to reduce variation in exit rates due primarily to normal retirement decisions.

12. We calculate teacher exits prior to dropping the charter teachers, however. Thus, a teacher exiting a traditional school for a charter school is not considered an exit from teaching.

13. Results based on specifications that include the emergency manager districts tend to be quite similar to the main results presented in Tables 2 and 3 and are available upon request.

14. One potential concern is that our data straddle the Great Recession. We note, however, that as long as the Great Recession had similar effects on exit rates for teachers and noninstructional professional staff, our DD specifications should properly control for any effects of the Great Recession on exit rates.

15. This is in contrast to the standard DD model given by Equation 1 which assumes an immediate impact of the policy on turnover that remains relatively constant over time.

16. Although the trends in Figure 1b and 1c appear to deviate in 2007 and 2008, they return to parallel and are nearly equivalent in the years immediately prior to the reform. Moreover, results presented in Figure 2a to 2c show that these deviations are not statistically significant or even very large in magnitude once controls are included in the model.

17. We also include indicators for teachers and staff with 15 to 20 and 1 to 3 years of experience and those indicators interacted with an indicator for teachers to allow for differential attrition rates among these groups.

18. The 75th percentile ACT composite score of colleges and universities in our sample ranges from 19 to 33. The median score is a 25 so our indicator takes the value of one if a teacher graduated from a college or university with a composite 75th percentile ACT score of 26 or higher.

19. We also estimated DDD event study models for the sample of teachers with 10 to 20 and 6 to 9 years of experience. Consistent with the DDD estimates reported in Table 3, there is little evidence that Michigan's 2011 reforms led to an increase in the attrition rate of more experienced teachers assigned to hard-to-staff districts. Results are available upon request.

20. Indeed, the increase in teacher attrition rates right around the time of the of policy reform year of 2011 is what motivates our DD identification strategy. Specifically, our DD identification strategy is motivated by the fact that the increase in teacher attrition could simply be attributable to a more general trend of increasing attrition among all public sector workers in Michigan.

21. The salary data we employ come from the administrative records provided by the Michigan Center for Educational Performance and Information (CEPI). The set of control variables includes experience, experience squared, gender and race indicators, and an indicator of individuals with a master's degree or higher.

22. Note that there appears to be a larger decline in teacher salaries in 2011 than in other years. This may have resulted from the fact that approximately 60% of districts had pre-reform CBAs that expired in 2011, implying that school districts could renegotiate salary schedules in that year.

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