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General Equilibrium Effects of Recruiting High-Performing Teachers for School Turnaround: Evidence from Tennessee

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Abstract

Many districts and states have begun implementing incentives to attract high-performing teachers to low-performing schools. Previous research has found that these incentives are effective. However, effects on the schools and students these teachers leave behind has not been examined. This study focuses on the general equilibrium effects of recruiting effective teachers to Tennessee's Innovation Zone (iZone) schools, one of the most successful turnaround initiatives in the nation (Zimmer, Henry, & Kho, 2017). While there is some variation in the effects of losing these teachers, we find they range between -0.04 and -0.12 standard deviations in student test score gains. However, an estimate including both these negative effects and the positive effects in iZone schools yields overall net positive effects.

In the early 21st century, No Child Left Behind (NCLB) shone a spotlight on the nation's lowest-performing schools, pressuring many schools, districts, and states to implement turnaround reforms aimed at improving the performance of these schools. Through School Improvement Grants and Race to the Top funding, the federal government provided a sizable infusion of funds to facilitate these turnaround initiatives, which has led to reforms ranging from intrusive state takeover to more collaborative partnerships between local education agencies and individual schools. A large number of these turnaround models have relied on recruiting and hiring high-performing teachers (USDOE, 2009; 2010). For example, many states and districts have attracted high-performing teachers to difficult-to-teach environments by offering recruitment, retention and performance incentives (Clotfelter et al. 2008; Cowan & Goldhaber, 2015; Glazerman, et al., 2013; Springer, Swain & Rodriguez, 2016; Steele, Murnane & Willett, 2010). While many low-performing schools have benefitted from the transfer and subsequent work of these teachers (Zimmer, Henry & Kho, 2017), research has not yet examined an unintended consequence of these turnaround efforts – the effects on schools those high-performing teachers left, henceforth referred to as "sending schools".

In this analysis, we utilize a statewide, student-level, longitudinal dataset to study the general equilibrium effects of teacher recruitment into Tennessee's district Innovation Zones (iZones). The iZones have been regarded as one of the most successful turnaround initiatives aimed at raising student achievement (Gonzales, 2016; Kebede, 2016; Tillery, 2017; Zimmer, Henry & Kho, 2017), and a prominent strategy for iZone schools has been to recruit and hire highly effective teachers ("iZone," 2017). Zimmer, Henry & Kho (2017; Henry et al., 2017) show that iZone schools have successfully recruited effective teachers; however, many of those teachers came from within-district transfers or from nearby districts. In this analysis, we ask: To what extent has the iZone schools' practice of recruiting high quality teachers affected the achievement of students in the sending schools? Descriptive findings suggest that teacher transfers from sending schools increased after the iZones were established. Using value-added measures of student performance in a series of fixed effect models that follow recent research on the effects of teacher turnover (Ronfeldt, Loeb & Wyckoff, 2013; Henry & Redding, 2018), we examine the changes in student test score gains in sending schools after the teachers left for an iZone school. In alignment with previous literature, we find that students entering grades and subjects that teachers left perform worse on standardized assessments. However, we estimate an overall net effect taking into account the negative effects in the schools from which these teachers transfer and the positive effects in schools receiving those teachers and find a positive effect overall. The results of this analysis have direct implications for the short-run unintended consequences of incentivizing teacher transfers and better understanding the general equilibrium effects from transfers of effective teachers into low performing schools.

In the next section, we draw upon the teacher incentive and teacher turnover literature to inform the discussion of general equilibrium effects of recruiting teachers for school turnaround programs. We then discuss the turnaround initiative implemented in Tennessee and the hiring and recruitment practices of the iZones, which leads to the research questions for this study. Next is a description of the data and the methods used, followed by the results of our analysis and our estimation of the net effect of the teacher transfers. We conclude with a discussion of our findings and suggest future research.

Literature Review

The literature on competition in schools typically highlights school choice markets in which students and their families can choose the schools that students attend. Schools must compete with one another to attract and recruit students in order to remain in operation. In doing so, school choice advocates hope that the competition for students would motivate all schools to improve their performance (Bettinger, 2005; Sass, 2006; Bifulco & Ladd, 2006; Hoxby, 2001; Imberman, 2011; Zimmer & Buddin, 2009). There is currently, however, a void in the literature regarding how schools compete for one of the key inputs in raising student achievement – teachers. Extant research unequivocally finds that teacher quality matters. Students taught by more effective teachers, as determined by various value-added measures, have higher test score gains, more positive non-cognitive outcomes (such as school attendance and behavior), and better long-term outcomes, including lowered likelihood of teenage pregnancies, higher likelihood of attending college, and earn higher salaries (Sanders, Wright & Horn, 1997; Rockoff, 2004; Rivkin, Hanushek & Kain, 2005; Aaronson, Barrow & Sander, 2007; Koedel & Betts, 2007; Hanushek, 2011; Jackson, 2012; Chetty, Friedman & Rockoff, 2014; Jackson, Rockoff & Staiger, 2014). Therefore, recruiting, hiring and retaining high quality teachers has become one of the primary strategies for schools to improve student performance. However, in contrast to school competition for students which only occurs in markets with options for school choice, competition for teachers occurs in all school markets, because teachers can choose the schools in which they will work, provided they meet the schools' hiring criteria. This is particularly true for highly effective teachers who are likely to meet those hiring criteria in more schools.

Unfortunately, research shows that schools with primarily underserved minority and lower-performing students employ less effective teachers. Steele and colleagues (2015) find that in one southern, large, urban school district, students in schools in the highest quartile of minority enrollment have teachers with value-added estimates that are 0.11 standard deviations lower than those in schools in the lowest minority quartile. This pattern extends to students in high-poverty elementary and middle schools throughout the nation (Glazerman & Max, 2011; Isenberg et al., 2013; Sass et al., 2012). Examining several measures of teacher quality, Goldhaber, Lavery & Theobald (2015) found that schools with high percentages of students eligible for free and reduced-price meal status, underrepresented minorities, and/or low prior academic performance had teachers with lower value-added scores, fewer years of experience, and lower licensure exam scores. Together, these studies show that, left to their own devices, effective teachers appear to naturally sort themselves away from schools with the most disadvantaged students.

A growing body of research provides credible evidence that financial incentives for effective teachers to work in high poverty, high minority, and low performing schools does increase the number of effective teachers in those schools, but findings about the retention of those teachers are mixed. Two recent studies (Steele, Murnane & Willett, 2010; Cowan & Goldhaber, 2015) showed that bonuses can attract more effective teachers into lower performing schools, but the bonuses did not affect retention of those teachers in the respective schools. In contrast, research by Clotfelter and colleagues (2008) and Springer, Swain & Rodriguez (2016) show that retention bonuses for effective teachers in low performing schools have had positive effects on teacher retention. Further, a large randomized experiment that provided bonuses to attract effective teachers into low-performing schools in ten large school districts across seven states found positive effects on teacher recruitment, teacher retention, and student achievement (Glazerman, et al., 2013). These prior studies have identified a plausible causal effect of teacher recruitment incentives into low-performing schools on teacher recruitment, teacher retention, and student achievement in the recruiting school, but, to date, no studies address general equilibrium effects that may result from the transfer of effective teachers. This study seeks to fill that void.

Financial incentives could have general equilibrium effects through teacher turnover. Redding and Henry (2018) highlight three mechanisms through which teacher turnover can impact student achievement. When teachers leave a school, the instability severs working relationships between those teachers and administrators, those teachers and other school staff, and connections built with students. A second mechanism, classroom disruptions, occurs when teachers leave through mid-year transitions and students have to acclimate to a different teacher and a new set of routines. Finally, teacher turnover changes the composition of teachers in a school. If a more effective teacher is replaced by a less effective teacher, student academic performance will suffer.

Previous research provides evidence that teacher turnover negatively impacts student achievement. Two studies (Ronfeldt, Loeb & Wyckoff, 2013; Hanushek, Rivkin & Schiman, 2016) find that students in grades in which all teachers turned over prior to the school year starting have reduced test score gains from 4 to 11 percent of a standard deviation on average. Henry & Redding (2018) find less substantial and inconsistent negative impacts when turnover during the prior summer and within the school year are combined. However, when disaggregating this by within-year and end-of-year turnover, the test score gains of students of a teacher who departs during the school year are reduced by 5 to 12 percent of a standard deviation but approach zero and even become positive in some cases of end-of-year moves. Lastly, prior literature also suggests that teachers who leave tend to be less effective than those who stay (Hanushek, Kain & Rivkin, 2004; Goldhaber, Gross & Player, 2007; Boyd et al., 2005; 2008a; 2008b; 2011; Henry, Bastian & Fortner, 2011; Henry, Fortner & Bastian, 2012; Hanushek, Rivkin & Schiman, 2016).

In this study, we investigate the general equilibrium effects of highly effective teachers leaving schools as a result of being recruited to teach in a low-performing school. To the extent that losing a highly effective teacher is more likely to influence each of the three mechanisms discussed previously than losing a less effective teacher, we would expect the impact estimates of teacher turnover in prior studies to underestimate the impact of turnover among highly effective teachers. Because highly effective teachers often serve in leadership roles, these teachers may have more institutional knowledge and may more often facilitate collaborative efforts. To the extent that this is true, the loss of a highly effective teacher would be more detrimental than the loss of a less effective teacher. Prior literature also shows that highly effective teachers are more likely to have a set of routines and procedures for their classrooms (Emmer & Stough, 2001; Oliver & Reschly, 2007). Therefore, losing a highly effective teacher can also create greater classroom disruption. Lastly, differences in quality of replacement and replaced teacher is more likely to have negative effects when the replaced teacher's effectiveness is high, as is the case with these incentive plans, rather than the departure of lower quality teachers that tends to occur when turnover is passive rather than strategic, given the same quality of replacement teacher. In summary, drawing these teachers from other schools may yield positive effects at the schools they are recruited to, but may also lead to negative effects from the turnover at the schools these teachers leave.

Lastly, it is important to investigate the characteristics of the school from which teachers are drawn. Previous analyses of heterogeneous effects by school characteristics have found that teacher turnover is more harmful for lower-achieving and highly-economically disadvantaged schools (Ronfeldt, Loeb & Wyckoff, 2013; Hanushek, Rivkin & Schiman, 2016). Therefore, if any of these highly effective teachers are being drawn from other low-performing schools in which these teachers may serve as mentors or hold leadership positions, the general equilibrium effects of the teacher recruitment strategies could be even more harmful to the students in the schools those teachers left.

The Tennessee Context

In 2011, Tennessee, like many states, applied for and was awarded a waiver from the NCLB goal of having 100% of students proficient in reading and math by 2014. As a part of that waiver, the state agreed to identify its lowest-performing 5% of schools, labeling them Priority schools. These schools reside primarily in the largest cities of the state – 69 in Memphis, six in Nashville, six in Chattanooga, and two in two smaller school districts. In addition to publicly labeling these low performing schools, the state decided that each of the Priority schools would be subject to one of three interventions to improve their status including district-within-a-district Innovation Zones (iZones).

Under the Race to the Top grant and previous School Improvement Grant guidelines, the federal government required states to choose one of four reform models to turnaround schools – transformation, turnaround, restart, and closure. The transformation model requires replacement of the principal, increased learning time, more rigorous teacher evaluation systems, and additional autonomy for schools, freeing them from district bureaucracy. The turnaround model requires even more drastic interventions, including all components of the transformation model but also replacement of at least 50% of the school staff. The restart model required the transfer of school management to a separate entity such as a charter management organization (CMO). Under this model, the majority, if not all, of the school staff would be replaced under a new manager and management system. The last model, closure, closed the low-performing school. Among previous School Improvement Grants, most schools chose the least intrusive model -

transformation (Dragoset et al., 2017). However, Tennessee's First to the Top legislation in 2010 and Race to the Top application in 2011 outlining its turnaround initiatives highlighted turnaround and restart reform models, proving that the state was prepared to confront the status quo in which these schools had been allowed to languish in the lowest rungs of performance and engage in major reforms. These commitments earned Tennessee one of two Race to the Top grants awarded in phase one of the federal competition.

Tennessee's iZone interventions, which encompassed the largest number of Priority schools, followed the federal turnaround model. The schools in these iZones would remain under the governance of the larger district but would be placed in a district-within-a-district and receive new leadership and increased autonomy. The three large cities housing the majority of Priority schools – Memphis, Nashville, and Chattanooga – all opened iZones. In the first year of Priority status, 2012-13, Nashville opened its iZone with four schools and Memphis opened its iZone with seven schools. The following year, Memphis added six more schools to their iZone, and Chattanooga began their iZone with five Priority schools. In the 2014-15 and 2015-16 school years, Memphis added four and one more school, respectively.[1]

One of the key strategies for turning around these low-performing schools was recruiting and retaining highly effective teachers (USDOE 2009; 2010). To assess teacher effectiveness, schools utilized the Tennessee Educator Assessment Model (TEAM), the state's teacher evaluation program. Tennessee's teachers are rated each year through both qualitative and quantitative measures, including classroom observations, individual conferences, student growth on the state standardized assessments, and other school-based student achievement measures. Together, scores from each of these components form an overall level of effectiveness (LOE)

[1] The Tennessee Department of Education released a new list of Priority schools in 2014, which allowed Knoxville to open an iZone as well. All but one of Knoxville's Priority schools were not on the original Priority list.

score for each teacher, ranging from 1 to 5. Table 1 shows the distribution of statewide LOE scores for the 2014-15 school year.

Table 1. Distribution of Teacher Level of Effectiveness Scores in 2014-15

Level of Overall Effectiveness	Description	Percent Receiving Score
1	Significantly Below Expectations	4%
2	Below Expectations	12%
3	At Expectations	26%
4	Above Expectations	32%
5	Significantly Above Expectations	26%

To attract high quality teachers into the state's lowest-performing schools, the Tennessee Department of Education offered signing and retention bonuses to teachers with proven effectiveness. Teachers who were rated level 5 in the previous year, the highest possible rating under Tennessee's teacher evaluation system, were eligible for a $7,000 signing bonus if they committed to working at a Priority school for at least two years (TDOE, 2013). Teachers who were rated level 5 in the previous year and were already teaching at a Priority school were offered $5,000 to continue working at a Priority school (TDOE, 2013; Springer et al., 2016). Memphis also offered up to $1,500 bonuses to Level 4 and 5 teachers who agreed to teach for three years with an additional $1,000 annual award if teachers met district benchmarks (Sullivan, 2013; Burnette, 2017). In addition, as of 2015-16, teachers statewide with a level 5, 4, or 3 rating received a $1,200, $1,000, or $800 increase in salary as well (USDOE, 2016).

Springer, Swain & Rodriguez (2016) evaluated the state's signing bonus and found that teachers in tested subjects and grades were 20% more likely to stay as a result of the bonus. While the effects of the other incentives have yet to be evaluated, descriptive analyses of the distribution of teacher quality and teacher mobility in the Achievement School District (ASD), the state-run school district with authority to takeover and restart Priority schools, and iZones have shown an increase in the hiring and retention of highly effective teachers, as determined by value-added measures. Zimmer, Henry & Kho (2017) found that in the first three years of implementation, iZone schools did a better job of hiring more highly effective teachers than other Priority schools and other Tennessee schools throughout the state. Using Tennessee's Teacher Value-Added Assessment System (TVAAS) score, an annual rating between 1 (least effective) and 5 (most effective) of teacher performance based on student-level value-added growth scores that serves as one component of the LOE score described previously, teachers hired into the iZone scored on average 3.37 over their first three years of implementation. This compares to 2.80 in other Priority schools and 3.18 in other non-Priority Tennessee schools in the same years. The iZone schools also did a better job at retaining more highly effective teachers with an average TVAAS score of 3.43 compared to 2.95 for other Priority schools. In a subsequent study, Henry and colleagues (2017) found that iZones not only hired more effective teachers, but also were able to develop retained teachers into the highest-performing category during their tenure at iZone schools. iZone schools also hired more experienced teachers than other Priority schools (Henry et al., 2015).

As Zimmer, Henry & Kho (2017) state, this ability to effectively recruit and retain high quality teachers may have been an important reason iZone schools were so effective at raising student achievement. In their evaluation of the ASD and iZones, Zimmer, Henry & Kho found that after three years of implementation, schools in iZones yielded, on average, student test score gains of 0.10 to 0.20 standard deviations larger than other Priority schools.

The question we investigate in this paper is whether these positive results for iZone schools came at the expense of other schools. If the supply of effective teachers is fixed in the short term, the transfer of effective teachers from other schools necessarily means a loss in the quality of teachers at the schools they leave. Under this condition, the general equilibrium effect of effective teacher transfer can be expected, based on prior research, to lower student achievement at sending schools. However, the schools that lose effective teachers may have natural advantages in recruiting new effective teachers or providing conditions for increased effectiveness. If so, sending schools could maintain, or even improve, the overall effectiveness of their teachers. However, this would not be expected in other high minority, high poverty Priority Schools that lose effective teachers to an iZone school.

Across all three cohorts of iZone schools, 652 teachers transferred into one of 26 iZone schools in Memphis, Nashville, or Chattanooga within the first three years of iZone status, 234 of whom taught a tested subject or grade. Of these transferring teachers, 92% moved from other schools in the same district as the receiving iZone school, 4% came from nearby or bordering districts, and 3% moved from other districts throughout the state.

While the addition of these teachers were likely helpful to the iZone schools, the other side of the story remains. Other schools had to lose their highly effective teachers in order for the iZone schools to gain them. The 234 transferring teachers came from 142 different schools, averaging a loss of 1.6 teachers per school, though several schools lost as many as six teachers in one year and one up to 14 teachers over the three-year period. Thirty-nine of the schools that lost teachers were themselves Priority schools, meaning many schools that were already lower performing lost some of their best talent. Anecdotal evidence suggests that schools that lost teachers to the iZone have suffered losses in state assessments scores (Williams, 2016), but the effects of these teachers transferring have not yet been estimated.

Methods

Data & Measures

This study utilizes statewide administrative datasets spanning 2011-12 to 2014-15, provided by the Tennessee Department of Education (TDOE) and managed by the Tennessee Education Research Alliance (TERA) at Vanderbilt University. The first dataset is student-level and includes demographic data, standardized test scores, and school and grade assignment variables for all students in the Tennessee public school system for each school year. A second dataset is teacher-level and includes school assignments along with grade(s) and course(s) taught.

The key dependent variables in this analysis are student test scores. In Tennessee, all students in grades three to eight are tested on an annual basis in reading, math, and science using the Tennessee Comprehensive Assessment Program (TCAP). Students in high school are tested at the end of a select group of courses (English I, English II, English III, Algebra I, Geometry, Algebra II, Biology, and Chemistry). For this analysis, TCAP test scores are standardized by year, subject and grade; End of Course (EOC) test scores are standardized by year and subject.

In the dataset, we can track teachers' school assignments from year to year. Further, we can identify the grade(s) and subject(s) elementary and middle school teachers taught and the course(s) high school teachers taught. This allows us to create a continuous variable that identifies the proportion of teachers exiting grade g in school s in year $t-1$ to enter an iZone school. This grade-level teacher turnover proportion serves as the main independent variable.

As part of our overarching strategy to account for several factors correlated with both teacher transfer and student achievement, we include a series of covariates at the student and school levels. At the student level, these covariates include gender, race, free and reduced-price meal status, special education status, English language learner status, and mobility status, a binary indicator of whether the student was new to the school in the given year. We also include the student's prior year test scores for a value-added estimate of the effect. To account for school-level differences, we aggregate student-level data up to the school-level to include the percent of students that are economically disadvantaged, the percent of students of racial/ethnic minority status, and the percent of students that were mobile that year. We also control for school level (elementary, middle, or high).

In addition to teachers leaving for iZone schools, there may be other teachers that exit these schools for other reasons. To avoid misattributing the effects of other turnover to iZone schools, we include a teacher turnover control variable that excludes moves to iZones. By including this other teacher turnover variable, we can also assess whether the impact of losing teachers to the iZone schools, who are disproportionately effective teachers, is greater than typical teacher turnover.

One important limitation to note is the operationalization of the teacher turnover independent variables. Our data does not allow us to distinguish between the different reasons teachers leave their schools. Therefore, it is difficult to identify if teachers who left for the iZone would have left regardless of the iZone opportunity. However, we can examine turnover trends for the sending schools, displayed in Figure 1. If transfer rates remain flat in these schools in the years before iZones began operating and increase in the years when their teachers transferred to the iZone schools, we can have greater confidence that the additional turnover in the years these schools send teachers to iZone is attributable to the iZone itself.

Figure 1. Teacher Transfer Rates to iZone Schools Over Time by Sending Cohorts

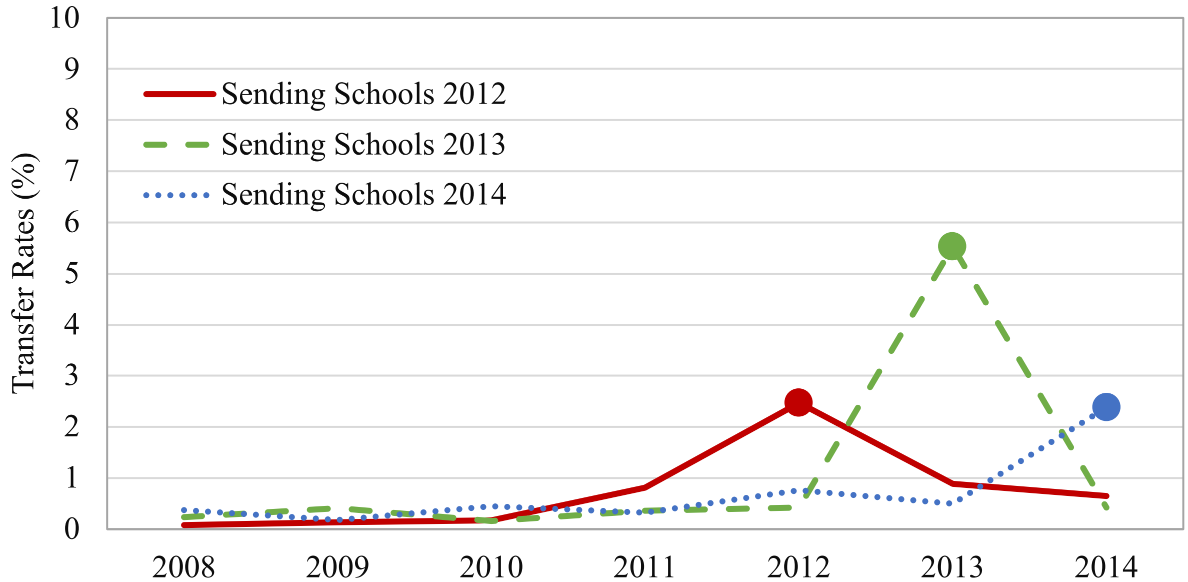


Figure 1 shows teacher turnover rates to iZone schools (or schools that would become iZone schools) for schools that lost teachers to the iZone in 2012 (solid line), 2013 (dashed line), and 2014 (dotted line) separately. For the cohort of 2012 sending schools, turnover rates to iZone schools remained between 0 and 1% for the four years before 2012. When teachers began to be recruited to the iZone, turnover rates jumped to 2.5%. Similarly, for both the 2013 and 2014 sending cohorts, turnover rates to iZone schools remained less than 1% until the respective "treated" years and jumped to approximately 5.5% and 2.5%, respectively.

To further explore these patterns, Table 2 shows results when we model teacher transfers with an interrupted time series. We include indicators for transferring out in each of the years 2012 through 2014, a trend variable (year centered) for years prior to sending teachers to the iZone, teacher covariates (race, years of experience, whether the teacher has a graduate degree) and school covariates (percent minority, percent economically disadvantaged, school average standardized reading, math, and science scores).

Table 2. Teacher Probabilities of Transferring to iZone Schools for Sending Schools

Variable	Probability of Transferring to an iZone School
Transferred out 2012	0.029***
	(0.003)
Transferred out 2013	0.050***
	(0.003)
Transferred out 2014	0.034***
	(0.003)
Year Centered	-0.001
	(0.0003)
Constant	-0.002
	(0.003)
N	36,684

Notes: Sample includes all schools that ever send teachers to the iZone. “Year centered” is centered such that zero is the year before the first year the school loses teachers to the iZone schools. Controls include teacher race/ethnicity, years of experience, and whether the teacher has a graduate degree, as well as school percent minority, school percent economically disadvantaged, and school average standardized reading, math, and science scores.

Consistent with trends in Figure 1, Table 2 shows that prior to the existence of iZones, sending schools were unlikely to lose any teachers to future iZone schools (as indicated by the zero results for the “year centered” variable and the constant). However, in the years in which teachers transfer to iZone schools, the probability that a teacher transfers to an iZone school increased by 2.9, 5.0, and 3.4 percentage points in 2012, 2013, and 2014, respectively.

Together, Figure 1 and Table 2 show that until the iZones were created, teacher turnover rates to the iZone schools remained fairly stable. While this does not completely establish that the increases in teacher transfers from these schools in 2012, 2013, and 2014 were entirely attributable to transfers into iZone schools, it shows that transfers did in fact increase after the iZones began to use incentives to recruit teachers and that more transfers occurred in these years than would have been expected in the absence of the iZone reforms. Nonetheless, as stated previously, we also control for other teacher turnover (teachers who did not move to iZone schools) in these years in our main models.

Empirical Framework & Samples

The ideal method for evaluating the effect of the iZone teacher recruitment is an experiment that randomly assigns teachers to either transfer or not to transfer to an iZone school. The difference in achievement of the treatment group, students assigned to the grades/courses from which teachers transfer, and the control group, students assigned to the grades/courses from which teachers do not transfer, would yield the impact of the recruitment strategy. However, this experiment is infeasible as we cannot randomly assign teachers to work at specific schools. We, therefore, utilize what we believe to be the next best method to provide a causal impact of the iZone recruitment on the schools and students the teachers left – a series of value-added equations to estimate student achievement gains along with student-, school-, year- and grade-level fixed effects, similar to those used in two recent studies (Ronfeldt, Loeb & Wyckoff, 2013; Henry & Redding, 2018).

In particular, we are concerned with the endogeneity of teachers transferring from sending schools. In other words, the types of schools these teachers leave likely differ in terms of school environmental characteristics or neighborhood characteristics from other schools that did not lose teachers to the iZone. If these characteristics are unobserved and affect teacher turnover and student achievement, they confound the estimates of the effects of losing teachers to the iZone. To address these potential confounders, our preferred model utilizes a school-by-year fixed effect, which controls for time-invariant observed and unobserved school-by-year characteristics. We prefer a school-by-year fixed effect over a school fixed effect to leverage idiosyncratic variation in turnover by grade within the same school-by-year combination. This preferred specification allows us to control for possible temporal shocks that affect both teacher turnover and student achievement. For instance, principal turnover at a school in one particular year may simultaneously influence both student achievement and teacher turnover, biasing the estimate of the effects of turnover on achievement. By including a school-by-year fixed effect, we can control for this principal turnover and other omitted variables specific to the school and year. We model this approach as:

$$y_{igst} = \beta_0 + \beta_1\, iZoneTchrGradeTurnover_{gst-1} + \beta_2\, OtherTchrGradeTurnover_{gst-1} \qquad (1)$$
$$+ \beta_3\, y_{igst-1} + S_{igst}\,\mathrm{B_j} + \gamma_{st} + e_{igst}$$

where y represents the test score for student i in grade g, school s, and year t. *iZoneTchrGradeTurnover* is a continuous variable indicating the proportion of teachers who left grade g in school s in year $t - 1$, the year prior to a student entering the respective grade, to teach at an iZone school. β_1 is the key coefficient of interest and the magnitude of coefficient can be interpreted as the effect of losing all teachers in the grade to the iZone. $OtherTchrGradeTurnover_{gst-1}$ is a continuous variable indicating the proportion of teachers who left grade g in school s in year $t - 1$ for a school that is not an iZone school. This variable ensures that the effects of grade-level turnover for reasons other than leaving to join an iZone are not erroneously attributed to the effects of leaving for iZone schools. Additionally, because the recruitment of teachers to iZone schools specifically targeted high-performing teachers and the loss of a high-performing teacher is more harmful than losing a lower-performing teacher, we expect β_1 to be negative and larger in magnitude than β_2. y_{igst-1} represents the student's test score in the year prior, S_{igst} represents a vector of student characteristics (gender, race, economically disadvantaged status, special education status, English language learner status, and mobility status), γ_{st} represents the school-by-year fixed effect, and e_{igst} is an idiosyncratic error term. Standard errors are clustered at the school level.

This school-by-year fixed effect model will allow us to account for any time-varying confounding changes in schools by comparing the effects of teacher turnover that occurred in one grade due to a teacher transferring to an iZone school to other grades in the same school and year that did not lose teachers to the iZone, adjusted for any other teacher turnover within the grade in the prior year. In this model, the effect is identified for all tested students attending schools in any year following a year when the school lost a teacher to the iZone (regardless of grade).

This first model, however, could be biased by within-school grade-level differences. For example, a teacher may choose to transfer out of a school due to lack of effort on the part of her grade-level peers that other grades may not experience but is detrimental to student achievement. Therefore, we estimate a second model by replacing the school-by-year fixed effect with a school-by-grade fixed effect, which allows us to control for the characteristics of her peers that remain constant and other omitted variables specific to the grade and school and exploit the variance in turnover over time within the same grade and school:

$$y_{igst} = \beta_0 + \beta_1 \, iZoneTchrGradeTurnover_{gst-1} + \beta_2 \, OtherTchrGradeTurnover_{gst-1} \quad (2)$$

$$+ \beta_3\, y_{igst-1} + S_{igst}\, \mathrm{B_j} + X_{st}\, \mathrm{B_k} + \delta_{gs} + \theta_t + e_{igst}$$

In this specification, the within-school differences in student achievement gains before and after teachers transferred to the iZone are used to estimate the effects from losing a teacher to the iZone, which identifies the effect for all tested students enrolled in any school-grade combination in which a teacher, in any year, left for an iZone school. In addition to student characteristics, we control for school-level characteristics (percent economically disadvantaged, percent minority, and percent mobile) for school s at time t, which is represented by X_{st}, and employ a year fixed effect θ_t to adjust for overall yearly differences. δ_{gs} represents the school-by-grade fixed effect.

By including both approaches, we can examine whether our results are robust to the assumptions of each model. However, we identify the school-by-year fixed effect approach (equation 1) as our preferred model as we are most concerned with the endogeneity of teachers leaving schools and we believe the factors simultaneously affecting both student achievement and teacher transfers are more likely to occur in a school from year to year rather than between grades in a single year.

Finally, we extend these analyses by investigating whether the effects of teacher turnover to iZone schools has heterogeneous effects based on prior school-level characteristics – percent economically disadvantaged and prior performance level. Previous literature has found that teacher turnover is more harmful for students in more economically disadvantaged schools and lower-performing schools (Ronfeldt, Loeb & Wyckoff, 2013; Hanushek, Rivkin & Schiman, 2016). We test whether highly effective teacher turnover is more harmful for students in schools with these characteristics by interacting these moderating variables with $iZoneTchrGradeTurnover_{gst-1}$. For the school percentage of students who are economically disadvantaged, we compare the upper and lower quartiles of schools to the middle half of the distribution. For school performance level, we use an indicator identifying sending schools that are Priority schools (the state's lowest performing 5% of schools).

Results

Overall Results

In Table 3, we first compare the baseline school-level characteristics of sending schools and iZone schools. We also include the overall characteristics of all Memphis, Nashville, and Chattanooga schools (where most of the sending schools and iZone schools are located) and all Tennessee schools as a reference[2]. iZone schools were primarily elementary and middle schools. Therefore, most sending schools were also elementary and middle schools. Sending schools had smaller percentages of minority and economically disadvantaged students than iZone schools – 83% minority and 79% economically disadvantaged in sending schools compared to 97% minority and 92% economically disadvantaged in iZone schools – but greater than the average school in districts with iZones, which was 74% minority and 71% economically disadvantaged, and much greater than the average Tennessee school, 33% minority and 60% economically disadvantaged. Similarly, the sending schools, which scored 0.43 to 0.69 standard deviations below the state average depending on subject, were higher-performing on the state's standardized assessments than iZone schools, which scored 0.86 to 1.13 standard deviations below average, but worse than the average school in Memphis, Nashville, or Chattanooga (0.34 to 0.47 standard deviations below average), and much worse than the average Tennessee school (0.01 standard deviations) in the baseline year. In addition, approximately one-quarter of sending schools were also Priority schools (the state's lowest-performing 5% of schools).

[2] We exclude alternative schools.

Teachers that transferred to the iZone left slightly less disadvantaged and lower-performing schools than the iZone schools they entered.

Table 3. Baseline School-Level Characteristics of Sending Schools, iZone Schools, Districts with iZones, and All Tennessee Schools

Characteristics	Sending Schools	iZone Schools	Memphis, Nashville & Chattanooga	Tennessee
Total Schools	142	26	478	1,615
Elementary	35%	50%	55%	59%
Middle	45%	35%	24%	24%
High	20%	15%	21%	17%
Percent Minority	83%	97%	74%	33%
Percent Economically Disadvantaged	79%	92%	71%	60%
Priority Schools (Lowest-Performing)	27%	100%	17%	5%
Reading Score*	-0.58	-1.03	-0.35	0.01
Math Score*	-0.43	-0.86	-0.34	0.01
Science Score*	-0.69	-1.13	-0.47	0.01

Alternative schools are excluded.
*Test scores represent average standardized test scores in years prior to teacher recruitment/loss and are standardized at the state level.

In Table 4, we display the estimated effects of teachers leaving for the iZone on student test scores of the grades and subjects in the sending schools in the year after teachers leave. Columns 1, 3, and 5 provide the results of our preferred model – the school-by-year fixed effect model; columns 2, 4, and 6 provide the results of the school-by-grade fixed effect model for reading, math, and science, respectively. For each model, we also display the coefficient for other teacher turnover as a comparison and indicate in bold coefficient estimates that are statistically different from the coefficient estimates for teacher turnover to the iZone[3]. Each of the coefficient estimates should be interpreted as the change in test score gains for students

[3] We test this at the 95% confidence level.

entering a grade in which all teachers left the previous year. On average, grades that lost reading, math, and science teachers to the iZone lost 53%, 62%, and 65% of their grade-level teachers to iZone schools, respectively.

Our preferred model shows that students in grades that lost 100% of their reading teachers to the iZone scored 0.10 standard deviations lower on their reading assessment than students in the same school in the same year that did not lose any teachers to the iZone. Considering that grades that lost reading teachers to the iZone lost 53% of their grade-level teachers on average, in actuality, the average effects is estimated to be -0.053 standard deviations in reading (-0.10 x 0.53). In the school-by-grade model, our key coefficient of interest is statistically significant at the 10% alpha level – students in grades that lost 100% of their reading teachers to the iZones scored 0.07 standard deviations lower on their reading assessments, which translates to approximately 0.037 standard deviations considering the average amount of teacher transfers to iZone schools. In neither model did we find any positive or negative effects of losing reading teachers for reasons other than transferring to the iZones.

In math, we find null effects in our preferred model. In the school-by-grade fixed effect model, however, we find that students in grades that lost 100% of their math teachers to the iZone scored 0.14 standard deviations lower than they did in years in which none of their grade-level math teachers left for the iZone. Taking into account the average percent of grade-level teachers lost, 62%, this translates to a 0.087 standard deviation loss. The effect of losing teachers to other reasons is similar in magnitude to the effect of turnover to iZone schools but not statistically distinguishable from zero. In general, the negative effects from other teacher turnover is larger for math than in reading (or science), which is consistent with the teacher turnover results found in the study by Ronfeldt, Loeb & Wyckoff (2013).

In science, both models yield statistically significant negative effects that are the largest of all three subjects. Students entering grades that lost 100% of their science teachers to the iZone scored 0.14 to 0.19 standard deviations lower than the respective comparison groups, which translates to about 0.091 to 0.124 standard deviations in this context. This is statistically larger than the effect of other teacher turnover in the school-by-year fixed effect models.

Table 4. Estimates of the Effects of Teacher Turnover to iZone Schools on Student Achievement

Variable	Reading		Math		Science	
	(1)	(2)	(3)	(4)	(5)	(6)
Teacher Turnover to iZone	-0.10**	-0.07^{+}	-0.07	-0.14*	-0.14*	-0.19**
	(0.04)	(0.04)	(0.09)	(0.07)	(0.05)	(0.06)
Other Teacher Turnover	-0.02	-0.01	-0.13	-0.14	**0.04**	-0.05
	(0.05)	(0.05)	(0.11)	(0.12)	**(0.10)**	(0.09)
School x Year FE	X		X		X	
School x Grade FE		X		X		X
R squared	0.63	0.62	0.48	0.50	0.55	0.53
N	17,419	21,293	17,048	20,415	14,414	18,193

$^{+}$ p < 0.10, * p<0.05, ** p<0.01, *** p<0.001

Student Controls: Gender, Race, FRPL status, Special Education status, ELL status, Mobility Status, Prior Reading Test Score, Pric Score, Prior Science Test Score
School Controls: Percent Minority, Percent FRPL, Percent Student Mobility, School Level

Previous work by Zimmer, Henry & Kho (2017) found positive effects in all three iZones (Memphis, Nashville, and Chattanooga). However, the strongest and most consistent effects were in Memphis. Therefore, we conducted another set of analyses restricting the sample to only Memphis iZone's sending schools. To conserve space, we do not include the results here, but we find comparable results with this restricted sample. Due to low power, we are unable to conduct similar analyses with Nashville and Chattanooga's iZones.

Heterogeneous Effects

Previous literature (Ronfeldt, Loeb & Wyckoff, 2013; Hanushek, Rivkin & Schiman, 2016) has found that teacher turnover is more harmful for students in more economically disadvantaged schools and lower-performing schools. We test these hypotheses using our preferred model (school-by-year fixed effect) in table 5. The first three columns display the effect estimates of losing teachers to the iZone based on the percentage of students that are economically disadvantaged in the sending school. We compare schools in the top quartile (most economically disadvantaged) and bottom quartile (least economically disadvantaged) of sending schools to the middle half of economically disadvantaged sending schools (our omitted group). In reading, students attending the most economically disadvantaged schools performed 0.17 standard deviations worse as a result of losing 100% of grade-level teachers to the iZone than those in the middle half of economically disadvantaged sending schools. Our estimates are statistically indistinguishable from zero in math and science. However, this appears to be driven by imprecision of the estimates, particularly in math where the coefficients are large, but the standard errors are also large.

Table 5. Examining Moderating Effects by School Characteristics

Variable	**By Percent ED**			**By Priority Status**		
	Reading	Math	Science	Reading	Math	Science
Teacher Turnover to iZone	0.01	0.14	-0.13	-0.12*	-0.13	-0.17*
	(0.07)	(0.21)	(0.15)	(0.05)	(0.10)	(0.07)
Teacher Turnover to iZone * Top 25% (Most Economically Disadvantaged)	-0.17*	-0.25	-0.04			
	(0.08)	(0.23)	(0.16)			
Teacher Turnover to iZone * Bottom 25% (Least Economically Disadvantaged)	-0.04	-0.16	0.08			
	(0.08)	(0.26)	(0.15)			

Teacher Turnover to iZone * Priority School				0.06	0.27	0.07
				(0.08)	(0.22)	(0.11)
R squared	0.63	0.48	0.55	0.63	0.48	0.55
N	17,419	17,048	14,414	17,419	17,048	14,414

* p<0.05, ** p<0.01, *** p<0.001
Student Controls: Gender, Race, FRPL status, Special Education status, ELL status, Mobility Status, Prior Reading Test Score, Prior Math Test Score, Prior Science Test Score
School Controls: Percent Minority, Percent FRPL, Percent Student Mobility, School Level
All models include school-by-year fixed effects.

The remaining columns of table 5 examine if the effects of teacher turnover to iZone differentially affect lower-performing schools. In particular, we compare sending schools that have been labeled as part of the bottom 5% of schools in the state (Priority schools) to other sending schools. Priority schools generally have larger proportions of minority and economically disadvantaged students. Whereas non-Priority sending schools are 77% minority and 75% economically disadvantaged, Priority sending schools are 98% minority and 89% economically disadvantaged. Further, whereas students in non-Priority sending schools scored 0.32 to 0.50 standard deviations below the state average at baseline, students in Priority sending schools scored 0.84 to 1.12 standard deviations below average, depending on the subject. Therefore, based on previous literature, Priority sending schools should experience substantially larger negative effects than non-Priority sending schools. On the contrary, we find no differential effects for sending Priority schools relative to sending non-Priority schools. It is important to note, however, that the coefficient in math is quite large for Priority schools but is imprecisely calculated such that we cannot rule out these large effects.

Assessing Overall iZone Effects

Given the positive effects found in previous research evaluating the iZone schools (Zimmer, Henry & Kho, 2017) and the resulting negative effects on sending schools discussed above, it is reasonable to ask what the net impact of the iZone intervention might be. However, for a number of reasons, it is difficult to directly compare the results from this analysis with the results from previous work highlighting the positive effect of iZone schools. First, the number of students in the iZone schools is not the same as the number of students impacted by the loss of a teacher to an iZone school. Second, the types of students affected are different. As shown in Table 3, iZone schools have a greater proportion of minority and economically disadvantaged students, and many of these students have been served by one of the state's lowest-performing schools for multiple years. Third, the effects evaluated in this study are short-term effects assessed in the year after teachers leave, while the effects evaluated in previous work spanned one to three years of the intervention. Fourth, the findings above consider the effects of all teachers who left the sending schools for iZone schools, while the positive effects of the iZone schools from prior research may only be partially attributable to the teachers hired. iZone schools also employed a number of other interventions, including changes in leadership, instructional coaching, and extending the school day, all of which may have contributed to the positive effects previously found. Finally, some of the teachers who left for iZone schools may have left their prior schools for other schools if the incentives to transfer to the iZone schools were not available.

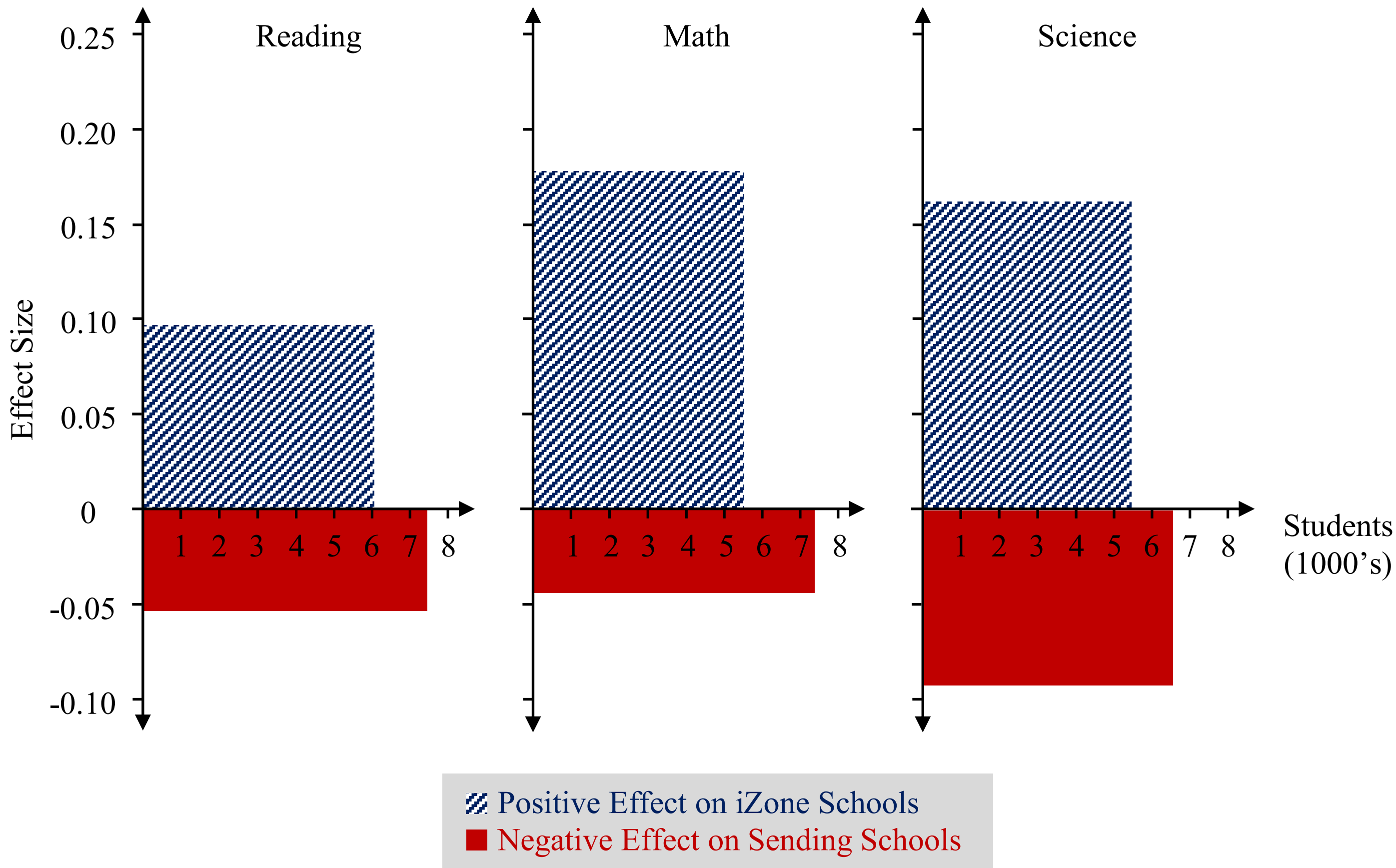
Given these concerns, it is difficult to precisely calculate the net impact of iZone schools as a whole. Nonetheless, we account for a number of these concerns and make several assumptions to conduct an informal, back-of-the-envelope calculation of the impact of the iZone intervention net of the effects on the sending schools. In particular, we have not made a value judgment based on students' backgrounds. In other words, the gain (or loss) in one student's test score is not weighted any differently from the gain (or loss) of any other student's test score. We also assume that recruiting effective teachers accounts for 80% of the positive impact in iZone schools. Previous research evaluating the iZone schools identified separate effects for each of the three cohorts of iZone schools in their first year. In each of our calculations below, we assume the smallest of the three. We also account for the number of students impacted in our estimate and assume all of the teachers who left for the iZone schools would not have left in the absence of the incentives.

Figure 2 depicts the overall effect of iZone schools on reading, math, and science student achievement, taking into account the effect on both iZone schools and sending schools (on the y-axis) and the number of students impacted in each (x-axis). In Figure 2a, the positive effects at iZone schools are depicted by the striped blue block, and the negative effects at sending schools are depicted by the solid red block. Note that the negative effects displayed represent the effect after accounting for the average proportion of grade-level teachers that left[4]. In Figure 2b, we multiplied the size of the effect (y-axis value in Figure 2a) by the number of students affected (x-axis value in Figure 2b) and found the difference between these positive and negative effects to identify the net impact of the iZone schools. The figure shows a substantial positive net impact of the iZone schools in all subjects with the greatest net impact in math. Note that we used the effect estimates without regard to statistical significance.

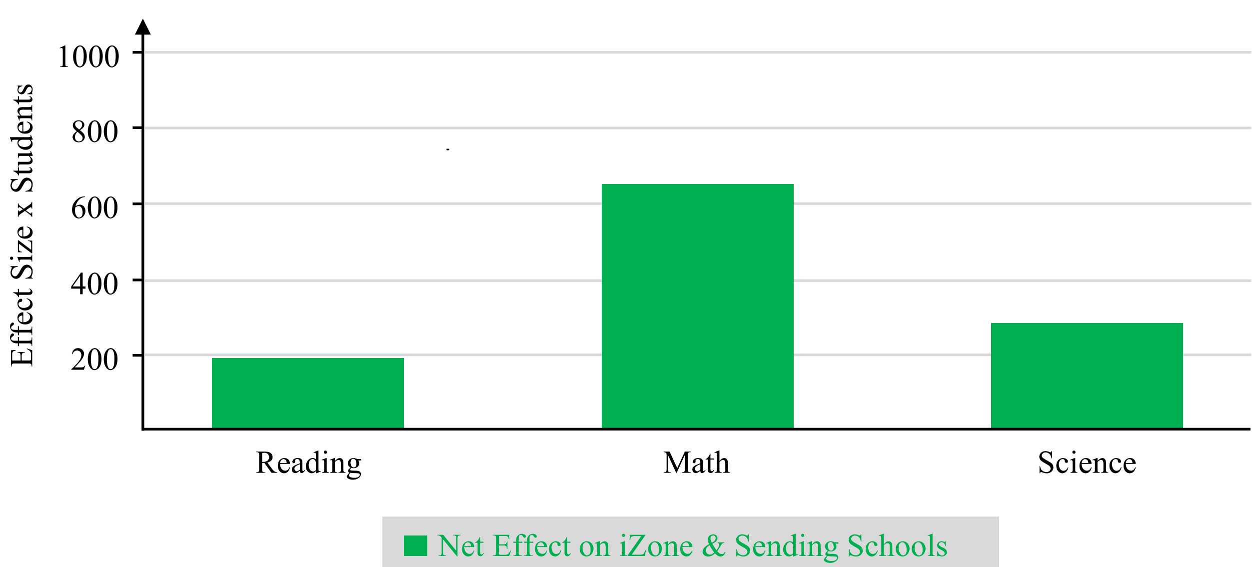
[4] The effect sizes depicted in figure 2 represent the full effect displayed in columns 1, 3, and 5 of table 4 multiplied by the average proportion of grade-level teachers that left. Therefore, the effects in figure 2 represent the negative effect for the average grade that lost teachers.

Figure 2. Estimation of the Net Effects of iZone Schools

(a)



(b)



The largest assumption we make in this comparison is that 80% of the positive impact of iZone schools is attributable to the high-quality teachers that were recruited. However, even if we assume that these teachers only explained 60% of the positive impact of iZone schools, the net impact would still be positive in all three subjects, though almost negligible in reading and science. For the negative effects on the students in sending schools to completely cancel out the positive effects on students in iZone schools, only 54% of the positive reading effect in iZone schools could be attributable to recruiting effective teachers from other schools in Tennessee. In math, this percentage would be 26%; in science, 54%.

Discussion

High-performing schools generally have a competitive advantage in the teacher labor market. These schools typically have better working conditions, less accountability pressure, and students generally viewed as easier to educate. Research shows that financial incentives have been a successful recruitment strategy for leveling the playing field and making low-performing schools more competitive in attracting high-quality teachers. States and districts across the nation are relying on highly effective teachers to help turnaround their lowest-performing schools. In fact, two of the three federally-approved reform strategies previously discussed (that allow schools to continue to operate) require or, in practice, result in at least half of the teaching staff being replaced – turnaround and restart models. However, if the number of effective teachers in local teacher labor markets is fixed at least in the short term, transfers of these teachers may positively affect the students who they now instruct but the turnover may negatively affect the students in the sending schools.

This study examined the general equilibrium effects of teacher recruitment into Tennessee's iZone schools on the students in sending schools. While there is some variation across subjects and models, the estimates are consistently negative. Five out of six estimates were statistically significant ranging from a -0.04 to -0.12 standard deviation change in student test scores after taking into account average teacher turnover rates in these schools, depending on model and subject. The remaining estimate found null results or perhaps no effect of teacher turnover to iZone schools. Overall, these effects are greater than those found in prior research on teacher turnover (Ronfeldt, Loeb & Wyckoff, 2013; Hanushek, Rivkin & Schiman, 2016), which found negative effects of 0.04 to 0.11 standard deviations assuming *full* grade-level teacher turnover. (For comparison, assuming full grade-level turnover, this study found negative effects ranging from 0.07 to 0.19 standard deviations.) These differences may be explained by the fact that the iZone's recruitment of teachers focused on hiring effective teachers, while these prior studies examined the effect of teacher turnover regardless of teacher effectiveness.

To further understand the impact of the iZone schools specifically and the practice of creating incentives to recruit high quality teachers into turnaround schools more generally, it is important to examine the characteristics of the schools from which teachers were drawn, and whether these general equilibrium effects vary across different school characteristics. If high quality teachers were pulled from other schools with large economically disadvantaged populations or low-performing schools, the unintended consequences of the teacher recruitment strategies for school turnaround could be more harmful than productive. Consistent with previous literature, our analysis finds that schools in the top quartile of economically disadvantaged students (most economically disadvantaged) suffered greater losses than the middle half, particularly in reading where students in the most economically disadvantaged schools performed 0.17 standard deviations worse.

Particularly relevant to the Tennessee context are Priority schools, the state's lowest performing 5% of schools. Roughly, a quarter of sending schools were also Priority schools. If iZone schools were simply recruiting the best teachers from other Priority schools, the school turnaround strategy could be counter-constructive if the sending Priority schools were performing even worse without these teachers. Our results, however, suggest that grades in the sending Priority schools were not performing any better or worse than those grades which did not lose teachers to the iZone. This finding could be partially explained by regression artifacts – the performance of Priority schools may have been so low that they cannot perform much worse. Nonetheless, it does not appear that the students in state's lowest-performing schools are adversely affected due to the loss of their highest quality teachers to the iZone.

Our results lead us to conclude that any gains that iZone schools may be experiencing from the recruitment of high quality teachers is being partially offset by weaker performance in the sending schools. In an informal, net-effect calculation, we compare the positive effect previously found in iZone schools to the negative effect in sending schools to estimate the net impact of the iZone initiative. Under reasonable assumptions, we find that there is a net positive effect in all three subjects. Thus, while some students experienced achievement losses, the gains acquired overall were more than enough to counterbalance those losses. However, further work may want to consider the types of students benefitting and harmed by the teacher transfers.

Lastly, the longer-term effects of incentives for teachers to transfer into low-performing schools should be examined. While schools may experience a loss in achievement gains in the year immediately after a teacher exits the school, schools may be able to recover over time by hiring an effective teacher or developing other teachers. Particularly for higher-performing schools, this recovery period may be rather short. If sending schools are able to rebound quickly, there may be an even greater basis for supporting incentives for recruiting highly effective teachers into low-performing schools.

References

Aaronson, D., Barrow, L., & Sander, W. (2007). Teachers and student achievement in the Chicago public high schools. Journal of labor Economics, 25(1), 95-135.

Bettinger, E.P. (2005). The Effect of Charter Schools on Charter Students and Public Schools. *Economics of Education Review* 24(2):133–47.

Bifulco, R., & Ladd, H. F. (2006). The impact of charter schools on student achievement: Evidence from North Carolina. *Journal of Education Finance and Policy*, *1*(1), 50–90.

Boyd, D., Grossman, P., Lankford, H., Loeb, S., & Wyckoff, J. (2008a). *Who leaves? Teacher attrition and student achievement* (No. w14022). National Bureau of Economic Research.

Boyd, D., Lankford, H., Loeb, S., Ronfeldt, M., & Wyckoff, J. (2011). The role of teacher quality in retention and hiring: Using applications to transfer to uncover preferences of teachers and schools. *Journal of Policy Analysis and Management*, *30*(1), 88-110.

Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2005). Explaining the short careers of high-achieving teachers in schools with low-performing students. *The American economic review*, *95*(2), 166-171.

Boyd, D., Lankford, H., Loeb, S., & Wyckoff, J. (2008b). The impact of assessment and accountability on teacher recruitment and retention: Are there unintended consequences?. *Public Finance Review*, *36*(1), 88-111.

Burnette II, D. (2017). A Passion for Saving Schools on the Brink. *Education Week*. Retrieved from https://leaders.edweek.org/profile/sharon-griffin-chief-of-schools-school-turnaround/

Chetty, R., Friedman, J. N., & Rockoff, J. E. (2014). Measuring the impacts of teachers II: Teacher value-added and student outcomes in adulthood. The American Economic Review, 104(9), 2633-2679.

Clotfelter, C. T., Glennie, E. J., Ladd, H. F., & Vigdor, J. L. (2008). Teacher bonuses and teacher retention in low-performing schools: Evidence from the North Carolina $1,800 teacher bonus program. Public Finance Review, 36(1), 63-87.

Cowan, J., & Goldhaber, D. (2015). Do bonuses affect teacher staffing and student achievement in high-poverty schools? Evidence from an Incentive for National Board Certified Teachers in Washington State. Center for Education Data & Research.

Dragoset, L., Thomas, J., Herrmann, M., Deke, J., James-Burdumy, S., Graczewski, C., ... & Giffin, J. (2017). School Improvement Grants: Implementation and Effectiveness. NCEE 2017-4013. *National Center for Education Evaluation and Regional Assistance*.

Emmer, E. T., & Stough, L. M. (2001). Classroom management: A critical part of educational psychology, with implications for teacher education. *Educational psychologist*, *36*(2), 103-112.

Glazerman, S., & Max, J. (2011). Do low-income students have equal access to the Highest-performing teachers? (No. b5869da6f9a54ef09fcd97be781b8a33). Mathematica Policy Research.

Glazerman, S., Protik, A., Teh, B. R., Bruch, J., & Max, J. (2013). Transfer Incentives for High-Performing Teachers: Final Results from a Multisite Randomized Experiment. NCEE 2014-4004. National Center for Education Evaluation and Regional Assistance.

Goldhaber, D., Gross, B., & Player, D. (2007). Are Public Schools Really Losing Their Best? Assessing the Career Transitions of Teachers and Their Implications for the Quality of the Teacher Workforce. Working Paper 12. National Center for Analysis of Longitudinal Data in Education Research.

Goldhaber, D., Lavery, L., & Theobald, R. (2015). Uneven playing field? Assessing the teacher quality gap between advantaged and disadvantaged students. Educational Researcher, 44(5), 293-307.

Gonzales, J. (2016, February 17). Memphis iZone schools outpaced state-run turnaround efforts. *The Tennessean*. Retrieved from http://www.tennessean.com/story/news/education/2016/02/17/memphis-izone-schools-outpace-state-run-turnaround-efforts/78693182/

Hanushek, E. A. (2011). The economic value of higher teacher quality. Economics of Education Review, 30(3), 466-479.

Hanushek, E. A., Kain, J. F., & Rivkin, S. G. (2004). Why public schools lose teachers. Journal of human resources, 39(2), 326-354.

Hanushek, E. A., Rivkin, S. G., & Schiman, J. C. (2016). Dynamic effects of teacher turnover on the quality of instruction. Economics of Education Review, 55, 132-148.

Henry, G. T., Bastian, K. C., & Fortner, C. K. (2011). Stayers and leavers: Early-career teacher effectiveness and attrition. *Educational Researcher*, *40*(6), 271-280.

Henry, G. T., Fortner, C. K., & Bastian, K. C. (2012). The effects of experience and attrition for novice high-school science and mathematics teachers. *Science*, *335*(6072), 1118-1121.

Henry, G. & Redding, C. (2018). Explaining the Effects of Teacher Turnover on Student Achievement. *Education Finance and Policy* (forthcoming).

Henry G., Zimmer, R., Attridge, J., Kho, A. & Viano, S. (2015). Teacher and student migration in and out of Tennessee's Achievement School District. Retrieved from *https://peabody.vanderbilt.edu/research/tnedresearchalliance/files/ASD_Teacher_Student_Migration.pdf*

Henry, G., Zimmer, R., Kho, A. & Pham, L. (2017) Recruitment and Retention of Teachers in Tennessee's Achievement School District and iZone Schools. Retrieved from https://peabody.vanderbilt.edu/research/tnedresearchalliance/files/Teacher_Retention_in_ASD_and_iZone_vF.pdf

Hoxby, C. M. (2001). How School Choice Affects the Achievement of Public School Students. Paper prepared for Koret Task Force meeting, Hoover Institution, Stanford, Calif., 2001.

Imberman, S. (2011). "The Effect of Charter Schools on Achievement and Behavior of Public School Students" Journal of Public Economics 95(7-8).

Isenberg, E., Max, J., Gleason, P., Potamites, L., Santillano, R., Hock, H., & Hansen, M. (2013). Access to Effective Teaching for Disadvantaged Students. NCEE 2014-4001. Institute of Education Sciences.

iZone: About Us. (2017). *Shelby County Schools*. Retrieved from http://www.scsk12.org/izone/

Jackson, C. K. (2012). Non-cognitive ability, test scores, and teacher quality: Evidence from 9th grade teachers in North Carolina (No. w18624). National Bureau of Economic Research.

Jackson, C. K., Rockoff, J. E., & Staiger, D. O. (2014). Teacher effects and teacher-related policies. Annu. Rev. Econ., 6(1), 801-825.

Kebede, L. F. (2016, May 2). iZone chief Sharon Griffin on fixing Memphis' most challenging schools. *Chalkbeat*. Retrieved from http://www.chalkbeat.org/posts/tn/2016/05/02/izone-chief-sharon-griffin-on-fixing-memphis-most-challenging-schools/

Koedel, C., & Betts, J. R. (2007). Re-examining the role of teacher quality in the educational production function (pp. 2007-03). National Center on Performance Incentives, Vanderbilt, Peabody College.

Oliver, R. M., & Reschly, D. J. (2007). Effective Classroom Management: Teacher Preparation and Professional Development. TQ Connection Issue Paper. *National Comprehensive Center for Teacher Quality*.

Redding, Christopher & Henry, Gary T. (2018). Leaving School Early: An Examination of Novice Teachers' Within- and End-of-Year Turnover. *American Educational Research Journal*, https://doi.org/10.3102/0002831218790542.

Rivkin, S. G., Hanushek, E. A., & Kain, J. F. (2005). Teachers, schools, and academic achievement. Econometrica, 73(2), 417-458.

Rockoff, J. E. (2004). The impact of individual teachers on student achievement: Evidence from panel data. The American Economic Review, 94(2), 247-252.

Ronfeldt, M., Loeb, S., & Wyckoff, J. (2013). How teacher turnover harms student achievement. *American Educational Research Journal*, *50*(1), 4-36.

Sanders, W. L., Wright, S. P., & Horn, S. P. (1997). Teacher and classroom context effects on student achievement: Implications for teacher evaluation. Journal of personnel evaluation in education, 11(1), 57-67.

Sass, T. R. (2006). Charter schools and student achievement in Florida. *Education Finance and Policy*, *1*(1), 91-122.

Sass, T. R., Hannaway, J., Xu, Z., Figlio, D. N., & Feng, L. (2012). Value added of teachers in high-poverty schools and lower poverty schools. Journal of Urban Economics, 72(2), 104-122.

Springer, M. G., Swain, W. A., & Rodriguez, L. A. (2016). Effective teacher retention bonuses: Evidence from Tennessee. Educational Evaluation and Policy Analysis, 38(2), 199-221.

Steele, J. L., Murnane, R. J., & Willett, J. B. (2010). Do financial incentives help low-performing schools attract and keep academically talented teachers? Evidence from California. Journal of Policy Analysis and Management, 29(3), 451-478.

Steele, J. L., Pepper, M. J., Springer, M. G., & Lockwood, J. R. (2015). The distribution and mobility of effective teachers: Evidence from a large, urban school district. Economics of Education Review, 48, 86-101.

Sullivan, K. (2013). One to Watch: Memphis iZone. *The New Teacher Project*. Retrieved from https://tntp.org/blog/post/one-to-watch-memphis-izone

Tennessee Department of Education [TDOE]. (2013). Tennessee Department of Education to Grant Signing and Retention Bonuses to Highly Effective Teachers. Retrieved from http://www.tennessee.gov/news/34146.

Tillery, A. (2017, January 17). The iZone, How School Districts are Closing the Achievement Gap. *Ebony*. Retrieved from http://www.ebony.com/news-views/izone-schools-memphis-philadelphia#axzz4dEDmiuzp

United States Department of Education [USDOE]. (2010). 2010 SIG Final Requirements. Retrieved from https://www2.ed.gov/programs/sif/index.html

United States Department of Education [USDOE]. (2009). Race to the Top Program Executive Summary. Retrieved from https://www2.ed.gov/programs/racetothetop/executive-summary.pdf

United States Department of Education [USDOE]. (2016). Teacher Incentive Fund – Year 5 Grantee Profiles: Shelby Count Board of Education, Tennessee. Retrieved from https://www2.ed.gov/programs/teacherincentive/memphispro.pdf

Williams, R. (2016, May 17). Memphis iZone Belieber? Not me…yet. *A Disgruntled Republican in Nashville.* Retrieved from http://www.adisgruntledrepublican.com/2016/05/ memphis-izone-belieber-not-meyet.html

Zimmer, R. & Buddin, R. (2009). Is charter school competition in California improving the performance of traditional public schools?. *Public Administration Review*, *69*(5), 831-845.

Zimmer, R., Henry, G. & Kho, A. (2017) The Effects of School Turnaround in Tennessee's Achievement School District and Innovation Zones. *Educational Evaluation and Policy Analysis*, 0162373717705729.