Preliminary: Please do not cite or distribute.

The Effects of Differential Pay on Teacher Recruitment, Retention and Quality*

Carycruz Bueno
Department Economics
Andrew Young School of Policy Studies
Georgia State University
Atlanta, GA 30303
Email: cbueno1@student.gsu.edu

Tim R. Sass
Department of Economics
Andrew Young School of Policy Studies
Georgia State University
Atlanta, GA 30303
Email: tsass@gsu.edu

October 31, 2016

*The contents of this report were developed using data provided by Georgia's Academic and Workforce Analysis and Research Data System (GA•AWARDS). However, those contents do not necessarily represent the policy of GA•AWARDS or any of its participating organizations, and you should not assume endorsement by GA•AWARDS or any of its participating organizations. This research was funded in part by the National Center for the Analysis of Longitudinal Data in Education Research (CALDER). CALDER is supported by the Institute for Education Sciences Grant R305A060018. However, any opinions or errors are solely attributable to the authors.

I. Introduction

Traditionally, teachers have been paid according to fixed salary schedules, with wages determined solely by years of experience and educational attainment. Given variation in the opportunity cost of teachers and in the non-pecuniary characteristics of jobs, the fixed salary schedules have led to chronic shortages of teachers in particular subject areas, such as math, science and special education. Ingersoll and Perda (2009) find that roughly 3 to 4 times as many secondary schools report significant difficulty in filling positions in mathematics, special education and science relative to English or social studies. Similarly, Billingsley, Fall, and Williams (2006) report that high percentages of uncertified new special educators enter teaching each year.

Subject-specific teacher shortages which lead to placing out-of-field teachers in classrooms can have negative effects on students in both the short and long-run. While existing research does not find a strong link between teacher credentials and student achievement in general, there is both direct and indirect evidence that having math, science or special education courses taught by teachers with neither a relevant college major nor certification in math and science can have negative consequences for student achievement. The relative effectiveness in math and science of Teach-for-America (TFA) teachers, who have little formal training in education, but typically have strong academic backgrounds and subject area knowledge, suggests that content knowledge is particularly important in these fields. Boyd, et al. (2006) and Kane, Rockoff and Staiger (2006) find TFA teachers are more effective than traditionally prepared teachers in math initially, particularly at the middle school level, in New York City. Xu, Hannaway and Taylor (2011) analyze effectiveness of TFA teachers in North Carolina high schools and find TFA teachers are more effective on average over all subjects, with the biggest difference in science and math. The evidence is more direct in the case of special education, where Feng and Sass (2013) find that students with disabilities whose teacher is certified in special education have greater achievement in both math and reading than similar students whose teacher is not special-education certified. Over the longer term, Sass (2015) shows that students whose high school math and physics teachers have degrees in the relevant subject (rather than in education) are more likely to take STEM courses as college freshmen.

To combat subject-specific teacher shortages, a number of non-salary incentives have been employed, including scholarship programs for prospective teachers, housing subsidies, tuition subsidies for existing teachers changing fields and student loan forgiveness (Martin, 2007). We focus here on differential pay by subject: monetary compensation that is based on the subject area a teacher is trained and teaches in. Most such salary differentials are operated at the district level. Examples include Aldine, Texas, Hamilton County, Tennessee, and Mobile, Alabama (Martin, 2007). We are aware of only two statewide programs that have differentiated teacher pay by subject area: a bonus program in North Carolina that operated from 2001/02 to 2003/04 and a salary supplement for early-career teachers that has been in effect in Georgia since 2010/11.

In this paper we study the effects of Georgia's statewide salary differential program. We are interested in the impact of differential pay on the supply of new teachers as well as on the attrition of new teachers and ultimately the achievement of students. Our current analysis focuses on the attrition of existing teachers. We will address the supply of new teachers and impacts on the equilibrium distribution of teacher quality in future work.

The next section provides a review of prior research on subject-based compensation differentials and section 3 contains background information on Georgia's differential pay system and discusses the data we employ. Empirical methods and results are described in sections 4 and 5, respectively. The last section summarizes our findings thus far and discusses future work.

II. Literature Review

Prior research on subject-based incentive schemes is quite limited.[1] Only two previous studies analyze incentive programs targeting specific sub-disciplines for teachers. Clotfelter, Glennie, Ladd, and Vigdor (2008) examine the impacts of a statewide bonus scheme that existed in North Carolina from 2001/02 to 2003/04. To qualify for the program teachers had to be certified as a secondary teacher in math, science, or special education and also be working in a high-poverty or low-performing public school. Program participants could earn up to $1800 in annual bonuses. Exploiting the multiple eligibility criteria, they implement a triple difference analysis and find the bonus program lowered turnover rates for the targeted teachers by 17 percent.

Feng and Sass (2015) study Florida's Critical Teacher Shortage Program, which was in effect from 1986/87 through 2009/10. The program provided loan forgiveness for teachers who were certified and taught in "high-need" subjects, tuition reimbursement for existing teachers taking coursework that could lead to certification in a high-need subject and (for a brief time)

[1] There is also some existing research on incentives to teach in high need schools. Steel, Murnane and Willett (2009) study a California program that offered a $20,000 bonus to a select group of new teachers that agreed to teach in high-need schools. Glazerman, et al. (2013) conduct an experimental analysis of the "Teacher Transfer Initiative," a federally funded initiative to that offered $20,000 in incentives for high-quality teachers to teach in low-achieving schools for two years. Falch (2010, 2011) studies a decade-long bonus program for Norwegian teachers. The program paid wage premiums to teachers in schools with chronic staffing shortages.

retention bonuses. Employing a difference-in-difference estimator they find the loan forgiveness program decreased attrition of teachers in shortage areas, though the effects varied by subject. Allowing for variation in the size of payments, they find that the effects were more pronounced when loan forgiveness payments were more generous. A triple-difference estimate indicates the bonus program also substantially reduced the likelihood of teachers leaving the public school sector. In contrast, a panel probit analysis reveals that the tuition reimbursement program had only modest positive effects on the likelihood a teacher would become certified in a designated shortage area. Feng and Sass also present evidence that loan forgiveness recipients were of higher quality (as measured by value added) than non-recipients who taught in the same subject, but which were not certified and thus ineligible.

Outside of teaching, there is evidence that loan forgiveness programs in medicine have helped to retain physicians in rural and medically underserved areas (Pathman et al., 2004). However, loan forgiveness programs were shown to be less effective in attracting students into public interest law than tuition waivers of equivalent value (Field, 2009).

III. Background and Data

Driven by concerns over shortages of qualified math and science teachers and a lack of new teachers entering those fields, the 2009 Georgia legislature passed House Bill 280 (HB 280), which produced a de facto differential pay scale for early-career middle and high school math and science teachers.[2] The legislation increased the pay of new math and science teachers to make it equal to that of a teacher with six years of experience:

> "(1) On and after July 1, 2009, a secondary school teacher in a local school system who is or becomes certified in mathematics or science by the Professional Standards Commission shall be moved to the salary step on the state salary schedule that is applicable to six years of creditable service, unless he or she is already on or above such salary step. From such salary step, the teacher shall be attributed one additional year of creditable service on the salary schedule each year for five years.
>
> (2) After five years, such teacher may continue to be attributed one additional year of creditable service on the salary schedule each year if he or she meets or exceeds student achievement criteria established by the Office of Student Achievement.
>
> (3) Upon expiration of five years, or any year thereafter that the teacher does not meet or exceed student achievement criteria as required by paragraph (2) of this subsection, such teacher shall be moved to the salary step applicable to the actual number of years of creditable service which the teacher has accumulated."

The legislation also provided an annual stipend of $1,000 for kindergarten and elementary school teachers who possess an endorsement in mathematics or science. The K-5 incentive is not conditional on experience. Like the salary step increase for secondary math and science teachers, after five years, receipt of the K-5 stipend is conditional on student achievement criteria to be established by the Governor's Office of Student Achievement.

Both the 6-12 step increases and K-5 endorsement stipends were "subject to appropriations of the General Assembly." This led the program to be implemented in such a way that the 6-12 salary-step increases became an experience-based bonus scheme that is not conditional on future

[2]When signing the legislation into law, Governor Sonny Perdue noted that "Last year, Georgia produced only one physics teacher. This legislation will help us address the shortage of math and science teachers in the state." (Badertscher, 2011).

employment. Eligibility for the program is determined by certification status and subject areas taught in October of each year. To be eligible for the grades 6-12 salary incentive, teachers must be certified in math or science, teach math or science in grades 6-12, and have between 0-5 years of experience. A teacher does not qualify for the salary incentives if he or she is teaching math or science under a temporary ("non-renewable") certificate.[3]

A list of eligible teachers is compiled by the end of the calendar year and forwarded to the legislature for funding. Funds are appropriated by the legislature during their regular legislative session in spring of the calendar year following the October employment report. Funds are typically received by the Georgia Department of Education (GaDOE) in July and then dispersed to individual school districts. Teachers receive checks in late August or early September, almost a year after their eligibility is determined. If an individual is no longer teaching in Georgia public schools they still receive the stipend.

The amount of the stipend is determined by the difference between the step on the state salary schedule based on a teacher's actual experience and the salary step for a teacher with six years of service. Even though some districts pay teachers more than was is stipulated in the state salary schedule, the amount of the bonus is determined by the applicable salary differences on the state salary schedule, not a teacher's actual salary.

Funds have never been allocated to implement the provision of the statute which extends salary incentives beyond five years of experience. Therefore, the bonus ends when a teacher has received bonuses for five years or has reached six years of experience, whichever comes first.

[3] Eligibility details are specified in Georgia Department of Education (2011) and Georgia Department of Education (2015a).

Since the current implementation of HB 280 does not extend bonuses beyond five years, the provisions that make future bonuses contingent on performance have never been implemented. An example of the bonuses a new secondary math or science teacher with a bachelor's would receive is provided in Table 1. The bonuses total nearly $20,000 over five years.

The total number of teachers who received the bonuses, broken down by year and type of supplement, is presented in Table 2A. The number of first-time recipients, also broken down by year and supplement type, is presented in Table 2B. Due to the greater number of middle and high school math and science teachers (relative to elementary school teachers with a math or science endorsement) and the more generous supplement to middle and high school math and science teachers, the size of the grades 6-12 program was much larger. After the initial year, about 1,100 to 1,200 middle and high school teachers receive the salary supplement for the first time each year. In contrast, the first-time K-5 supplement recipients have ranged from 85 to just over 200 teachers each year. We therefore focus our analysis on the salary supplements for middle and high school math and science teachers.

In order to estimate the effects of HB 280 on the supply of math and science teachers, we employ data from Georgia's new statewide longitudinal database, Georgia's Academic and Workforce Analysis and Research Data System (GA•AWARDS). GA•AWARDS combines data from all educational agencies in Georgia as well as unemployment insurance (UI) records from the Georgia Department of Labor. Thus individual students can be tracked from pre-K through post-secondary institutions and into the labor force. The database currently includes data from the 2006/07 through 2014/15 school years. Teachers can be linked to their college records and to the students they teach, though teacher-student linkages are only available for Race-to-the-Top participating districts in 2013/14 and 2014/15. Although student-teacher linkages are limited, we can link students and teachers to schools for all years. We therefore use school-level averages of student characteristics to control for working conditions that may influence teacher labor market decisions.

The GA•AWARDS data includes information on employee job codes, teacher certification and years of experience, which can be used to determine whether a teacher meets the requirements to qualify for a salary supplement. In addition, we received data from the GaDOE that indicate which teachers were designated to receive the supplement each year. The list of teachers who qualify (based on job, certification and experience information) does not always correspond to the list of recipients, however.[4] We therefore rely on the list of actual recipients to identify "treated" teachers.

IV. Econometric Methods

Below we describe our empirical strategy for estimating the effects of Georgia's differential pay system (HB 280) on the supply of new teachers and retention of existing teachers. Currently, only evidence on the effects of HB 280 on retention is available, however. The models of teacher labor supply, teacher credentials, and teacher attrition will be estimated in later work.

[4] There are a number of interesting anomalies in the program's implementation. Teacher experience is based on Certified/Classified Personnel Information (CPI) data from the GaDOE. The CPI data track "credible years of service, not actual years of service. For example, a teacher may not have received a step increase because of poor performance or insufficient funding and thus have fewer reported years of service than their actual years of classroom experience. There is also some evidence that some districts may have miscoded science teachers as teaching social science. See Griffin and McGuire (2015) and Georgia Department of Education (2015b).

A. *Teacher Supply*

There are two ways to become a public school teacher in Georgia. Potential teachers can complete a state-approved certification program, meet content assessment requirements, and then obtain a renewable professional teaching certificate. Alternatively, candidates with a bachelor's degree can obtain a three-year non-renewable teaching certificate and begin teaching. In order to transition to a renewable teaching certificate individuals must either complete a traditional university based preparation program or an alternate state approved educator preparation program. Thus one measure of the supply of potential new math and science teachers is the number of graduates of approved teacher training programs with a major in math education or science education. To assess the impact of HB 280 on the number of secondary math and science education baccalaureate recipients we will estimate a simple interrupted time series of the form:

$$N_t^M = \alpha + \beta_1 Z_t + \beta_2 X_t \qquad (1)$$

where N_t^M equals the number of secondary math and science education degree recipients in year t, Z_t is an indicator for years in which the HB 280 program was in place and X_t is a vector of general teacher supply and demand determinants, such as high school enrollment, total number of baccalaureate degrees awarded and the general unemployment rate.

The number of new math and science teachers also depends on whether qualified college graduates decide to enter the teaching profession and are hired. To assess the effect of HB 280 on teacher hiring we estimate the following probit "difference-in-differences" model on the sample of all baccalaureate degree recipients with a major in education:

$$Prob[T_{it} = 1] = \Phi\left[\alpha + \beta_1 D_{it}^{MS} + \beta_2 Z_t + \beta_3 \left(D_{it}^{MS} \times Z_t\right) + \beta_4 X_t + \beta_5 Y_{it}\right] \qquad (2)$$

where T_{it} indicates individual i becomes a public school teacher in year t, D_{it}^{MS} indicates that individual i earned a baccalaureate degree in math or science education in year t, Z_t is an indicator for years in which the HB 280 program was in place, X_t is a vector of general teacher supply and demand determinants and Y_{it} is a vector of individual-specific characteristics that could influence the relative rewards of teaching and non-teaching careers such as college entrance exam scores and post-secondary institutional quality. The first difference in the likelihood of becoming a public-school teacher is between individuals earning a degree in math or science education and others with a degree in other areas of education and is represented by the coefficient β_1. The second difference is between the pre- and post-HB 280 periods (i.e. before and after 2010), β_2. The coefficient of interest is β_3, which represents how the difference between math and science education majors and other education majors in their likelihood of becoming a public-school teacher changed once HB 280 took effect.

B. Teacher Qualifications

It is possible that differentiated pay could change the composition of potential teachers. For example, an individual who is studying education could change their coursework track and obtain more math and science classes. The change in policy could also attract individuals with greater abilities (as measured by college entrance exam scores or college selectivity), to become math and science teachers. To determine if differentiated pay has led to changes in the qualifications of math and science teachers we can perform a linear regression difference-in-differences analysis and estimate the following equation:

$$Q_{it} = \alpha + \beta_1 D_{it}^{MS} + \beta_2 Z_t + \beta_3 \left(D_{it}^{MS} \times Z_t \right) + \beta_4 X_t + \beta_5 Y_{it} \qquad (3)$$

Similar to equation (2), the coefficient of interest is β_3, which measures how the difference in the qualifications of math and science education graduates vis-à-vis other education graduates change when the HB 280 differential pay system is active.

C. Teacher Retention

To address the effect of differentiated pay on teacher retention we exploit the fact that teachers had to be both eligible for the differential pay program and the program had to be in place in order to receive payment. The program had three eligibility criteria: an individual had to be teaching secondary math or science, they had to be certified in the subject they were teaching, and they had to have less than six years of credible service. Given that middle and high school math and science teachers can possess very different characteristics (both observed and unobserved) than elementary teachers or teachers in other disciplines, we limit our analysis to teachers who ever taught middle or high school math or science. Among this subsample, there are two qualification criteria: possessing certification in the relevant subject and having less than six years of experience. We initially estimate a simple difference-in-difference model of the duration of teaching in Georgia public schools. Specifically, we estimate a Cox proportional hazard model of the form:

$$logit[\lambda(t_i)] = \alpha + \beta_1 E_i^{MS} + \beta_2 Z_t + \beta_3 (E_i^{MS} \times Z_t) + \gamma(X_{it}) \quad (4)$$

where $\lambda(t_i)$ is the probability that a teaching spell ends at the close of period t for teacher i, conditional on that spell lasting through period t.[5] E_i^{MS} is an indicator for teachers who ever meet the HB 280 criteria of being certified and teaching in either secondary math or science and having

[5] We determine the end of a spell based on whether a teacher is teaching in a Georgia public school in period t+1.

less than six years of experience. Z_t is an indicator that signifies the salary differential program was in place in year t. X_{it} is a vector of teacher and school characteristics that typically impact teacher attrition decisions (e.g. demographic characteristics of students at the school, teacher race and gender, etc.). The set of coefficients β_1 represent the difference in the hazard rates between ever-eligible teachers (those with less than six years of experience who are certified and teaching secondary math or science) and never-eligible teachers. β_2 represents the impact of being in the period in the differential pay program was in place (years 2010/11 and later). The coefficient of interest is β_3, which represents the effect of being eligible for the differential pay program and being in a year in which the program was in effect.[6] β_3 therefore provides the simple difference-in-difference estimate of the impact of the differential-pay program on the exit hazard.

We can also break down the eligibility criteria into its separate components, certification and less than six years of experience, and estimate a "triple difference" model of teacher attrition:

$$logit[\lambda(t_i)] = \alpha + \beta_1 C_i^{MS} + \beta_2 E_{it}^{lt6} + \beta_3 Z_t + \beta_4 \left(C_i^{MS} \times E_{it}^{lt6}\right) + \beta_5 \left(C_i^{MS} \times Z_t\right) + \beta_6 \left(E_{it}^{lt6} \times Z_t\right) + \beta_7 \left(E_i^{MS} \times E_{it}^{lt6} \times Z_t\right) + \gamma(X_{it}) \quad (5)$$

where C_{it}^{MS} indicates teachers who were teaching and certified in math or teaching and certified in science, E_{it}^{lt6} indicates teachers who have not reached their sixth year of service and Z_t indicates the years the program was in effect. The three two-way interaction terms in equation (5) represent: (i) the differential impact of being certified and teaching secondary math and science and having five or fewer years of service ($C_i^{MS} \times E_{it}^{lt6}$), (ii) the impact of being certified and teaching secondary math or science in a year when the differential pay program was in effect $\left(C_i^{MS} \times Z_t\right)$,

[6] Note, as described above, we use an indicator for actual recipients in place of the interaction term.

and (iii) the impact of being a teacher with less than six years of experience in the period the differential pay program existed $\left(C_{it}^{lt6} \times Z_t\right)$. Lastly, the three-way interaction term, $\left(C_i^{MS} \times E_{it}^{lt6} \times Z_t\right)$, represents the differential hazard rate of teachers who were certified and teaching secondary math and science and possessed less than six years of experience during years in which the differential pay program existed. The coefficient β_7 is thus the difference-in-difference-in-difference estimate of the differential pay program's impact on the exit hazard.

V. Empirical Results

Descriptive Analyses

In Figure 1 we provide a graphical comparison between attrition of early-career teachers in general and early-career secondary math and science teachers. Annual attrition rates for both groups fall in the 10-13 percent range. Consistent with higher opportunity costs, attrition rates are higher for secondary math and science teachers in all but one year.

Figure 2 provides a comparison of attrition between middle and high school math and science teachers who received salary supplements as a result of HB 280 and those which never received a supplement, using a survival analysis framework. Teachers could be in the latter group for four reasons. First, some of these teachers entered teaching and left the Georgia public schools prior to the implementation of HB 280 in 2010/11 and thus never received a bonus. Second, some may have begun their careers as secondary math and science teachers but switched to other grades or subjects before the implementation of HB 280. Third, some math and science teachers may never have obtained non-temporary certification during the period of analysis. Forth, there are some teachers who met the criteria for eligibility, but due to implementation issues, may have been left off the list of teachers who were to receive a bonus. In order to compare time until departure from Georgia public schools, only teachers observed during their first year of teaching are included in the sample.

The survival plots indicate that bonus recipients tended to have lower attrition than teachers who did not receive bonuses, particularly in the early years of their career, when supplements were the greatest. After five years of experience (when teachers could no longer receive the supplements) the two groups exhibit similar survival patterns. One potential problem with comparing ever and never-recipients is that non-receipt is partly a function of when a teacher entering the Georgia public school system. Given the sample starts in 2006/07 and program implementation began in 2010/11, teaching spells greater than five years are only observed for teachers who had prior experience when the program began. In order to disentangle these cohort effects, we also present survival estimates for the subset of teachers who began teaching in 2010/11 or later. The results, provided in Figure 3, are similar to those for the full sample.

Quantitative Analyses

In order to estimate the difference-in-difference and triple-difference hazard models, we must restrict the sample to teachers for which we observe their first year as a teacher (i.e. "rookies"). Figure 1. As shown in Table 3, this eliminates about two-thirds of teachers who taught middle/high school math or science during the sample period. Descriptive statistics for this subsample are presented in Table 4. For the subsample of 8,914 teachers observed as rookies, roughly half ever received a salary supplement as a result of HB 280. One potential source of misclassification among these teachers are anomalies in reported teacher experience. As a check, we also estimate models for the subsample of teachers who are observed as rookies and whose reported experience increases by one for every year they taught.

Estimates from the difference-in-difference and triple-difference hazard models of exit from Georgia public schools are reported in Table 5. For the full sample of all middle/high school math or science teachers observed as rookies and beyond, the hazard ratio on the indicator for receipt of a supplement is 0.746, indicating that receiving differential pay reduced the probability of exit by 25 percent. The estimate is significantly different from zero at better than a 99 percent confidence level. Limiting the sample to teachers with consecutive reported experience yields an even higher estimated reduction in the probability of exit, 35 percent. Applying the triple-difference technique to the full sample also yields an estimated impact of the differential pay program equal to a 35 percent reduction in the probability of exit.

VI. Summary and Next Steps

There is growing concern over shortages of teachers, though there is considerably variability in hiring and retaining teachers across disciplines. Finding and keeping teachers in secondary math and science and in special education is much more problematic than teachers in other subjects or grade levels. The cause of the shortages seems clear; the opportunity cost of teachers depends on the alternative wage they could earn in jobs outside of public school teaching and thus the equilibrium wage varies across disciplines. Teachers with expertise in math and science are likely to garner relatively higher wages outside of teaching and thus a uniform pay scale is likely to produce shortages of teachers in those subject areas. An obvious solution would be to raise the wages of math, science and special education teachers relative to the wages of other teachers. Little is known, however, about what impact differential pay would have on the supply of new teachers and the attrition of existing teachers.

In this paper we have taken an initial step at understanding the consequences of differential pay by analyzing the only current statewide differential pay system based on subject area, Georgia's HB280 supplemental pay for math and science teachers. Our preliminary findings indicate that Georgia's differential pay system has led to a substantial reduction in attrition rates for secondary math and science teachers. Further work needs to be done to investigate differences between the pool of teachers who appear to have been eligible for the program and the set of teachers who actually received the salary supplements. In addition, a cost-benefit analysis must be done in order to determine if the benefits from retaining teachers longer (and thus having a more experienced stock of teachers) exceed the cost of the salary supplements.

In future work we plan to estimate "difference in differences" probit models of becoming a public school teacher to gauge the casual effects of differential pay on entry into the teaching profession. We also plan to apply the difference-in-differences approach to a linear models of teacher qualifications in order to determine if differential pay leads to better qualified entry-level teachers. An interrupted time-series analysis will be employed to see what effect differential pay has on the number of students who choose to major in fields that are relevant to the subjects areas receiving differential pay.

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Table 1. Salary Supplement for a 6-12 Math/Science Teacher in Georgia

Years of Experience	Statewide Salary Schedule (Teacher with a Bachelor's Degree)		
	Salary Based on Actual Years of Experience	**Salary Based on Year 6**	**Supplement**
0	$33,424	$37,985	$4,561
1	$33,424	$37,985	$4,561
2	$33,424	$37,985	$4,561
3	$34,427	$37,985	$3,558
4	$35,460	$37,985	$2,525
5-Year Total			**$19,766**

Table 2A. Number of Teachers Receiving Differential Pay by Year

	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Did Not Receive	118,434	122,274	122,474	118,170	109,404	107,246	104,718	102,991	102,863
Received K-5 Bonus	0	0	0	0	0	149	208	380	530
Received 6-12 Bonus	0	0	0	0	3,765	3,266	3,100	3,072	3,178
Total	118,434	122,274	122,474	118,170	113,169	110,661	108,026	106,443	106,571

Table 2B. Number of Teachers Receiving Differential Pay for the First Time by Year

	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13	2013/14	2014/15
Did Not Receive	118,434	122,274	122,474	118,170	109,404	107,246	104,718	102,991	102,863
Received K-5 Bonus	0	0	0	0	0	149	85	189	204
Received 6-12 Bonus	0	0	0	0	3,765	1,289	1,137	1,080	1,162
Total	118,434	122,274	122,474	118,170	113,169	110,661	108,026	106,443	106,571

Table 3. Number of 6-12 Math and Science Teachers Receiving Bonus by Sample Type

Received Supplement	Ever a 6-12 Math or Science Teacher			
	All	Observed as a Rookie	Observed as a Rookie and Consecutive Experience Reported Each Year	Total
No	28082 (93.52)	4252 (47.70)	2612 (61.55)	34946 (80.92)
Yes	1945 (6.48)	4662 (52.30)	1632 (38.45)	8239 (19.08)
Total	30027 (100.00)	8914 (100.00)	4244 (100.00)	43185 (100.00)

Note: Percent in Parentheses

Table 4. Means of Characteristics of Rookie 6-12 Math and Science Teachers

	All 6-12 Math and Science Teachers Observed as Rookies	6-12 Math and Science Teachers Who Received Bonus	6-12 Math and Science Teachers Who Did Not Receive Bonus
	Mean	Mean	Mean
Female	0.7166	0.7031	0.7314
Black	0.2704	0.2355	0.3086
Hispanic	0.0137	0.0129	0.0146
White	0.6868	0.7259	0.6439
Asian/Pacific Islander	0.0201	0.0174	0.0230
Multi-racial	0.0038	0.0049	0.0026
Other	0.0031	0.0017	0.0047
Clear Renewable Certificate	0.2060	0.1956	0.2173
Nonrenewable Certificate	0.2186	0.1823	0.2585
Clinical Practice Certificate	0.0010	0.0013	0.0007
Standard Professional Certificate	0.1923	0.2739	0.1028
Induction Pathway Certificate	0.0000	0.0000	0.0000
Intern Certificate	0.0667	0.0669	0.0666
Life Certificate	0.0000	0.0000	0.0000
Advanced Degree Alternative	0.0001	0.0000	0.0002
Provisional Certificate	0.0000	0.0000	0.0000
Other Certification	0.0000	0.0000	0.0000
Ever Taught ELA	0.1381	0.0894	0.1914
Ever Taught Math	0.4983	0.5337	0.4595
Ever Taught Reading	0.0596	0.0294	0.0927
Ever Taught Science K-5	0.0425	0.0215	0.0656
Ever Taught Science 6-12	0.2986	0.3473	0.2453
Ever Taught Social Studies	0.1078	0.0787	0.1397
Ever Taught ESOL	0.0013	0.0013	0.0014
Ever Taught Gifted	0.0004	0.0006	0.0002
Left Teaching in GA Public Schools	0.0265	0.0006	0.0548
Observations	8914	4662	4252

Table 5. Hazard Ratios for Teacher Duration Models

	DD Full Sample	DD Consecutive Exp.	DDD Full Sample
Received Supplement	0.746***	0.649***	0.645***
	(0.037)	(0.058)	(0.033)
Ever Qualified	1.225***	1.292***	
	(0.044)	(0.093)	
Program in Effect	1.087	1.280**	0.604**
	(0.054)	(0.104)	(0.101)
Certified			0.741**
			(0.079)
<6 Years of Experience			0.877
			(0.134)
Certified x <6 Years of Exp.			1.290**
			(0.115)
Certified x Program in Effect			1.383***
			(0.111)
<6 Years of Exp. x Program in Effect			1.626**
			(0.275)
Female	0.858***	0.921	0.869***
	(0.032)	(0.062)	(0.032)
Black	0.780	0.742	0.784
	(0.219)	(0.405)	(0.219)
Hispanic	1.082	1.075	1.111
	(0.328)	(0.633)	(0.336)
White	0.870	1.064	0.895
	(0.244)	(0.581)	(0.250)
Asian/Pacific Islander	1.265	1.699	1.338
	(0.373)	(0.962)	(0.393)
Multi-racial	0.795	1.201	0.796
	(0.271)	(0.732)	(0.271)
Other	0.953	1.102	0.978
	(0.449)	(0.848)	(0.460)
School: Percent Female	4.070**	3.942*	3.969**
	(1.820)	(2.625)	(1.771)
School: Percent Foreign Born	1.407	0.256*	1.623
	(0.517)	(0.171)	(0.600)
School: Percent Retained	3.430***	2.520	3.385***
	(0.966)	(1.229)	(0.958)
School: Percent Black	2.306***	2.214***	2.194***
	(0.228)	(0.487)	(0.217)

School: Percent Hispanic	1.031	1.344	1.159
	(0.243)	(0.679)	(0.275)
School: Percent Limited English	0.869	0.893	0.641
Prof.	(0.328)	(0.596)	(0.246)
School: Percent FRL	1.117	1.918**	1.138
	(0.105)	(0.393)	(0.108)
School: Percent Gifted	1.863*	3.322*	1.860*
	(0.539)	(1.958)	(0.535)
School: Percent Immigrant	0.000**	0.000	0.000**
	(0.000)	(0.000)	(0.000)
School: Percent Non-English	1.389***	1.247*	1.308***
	(0.108)	(0.134)	(0.102)
School: Percent Homeless	0.337	0.364	0.306
	(0.276)	(0.541)	(0.253)
School: Percent Students with	1.575	1.129	1.361
Disability	(0.538)	(0.737)	(0.466)
School: Percent Age Within Grade	1.001	1.044*	1.004
	(0.009)	(0.018)	(0.009)
Observations	43497	8265	43497
Log likelihood	-27287.583	-6129.920	-27270.265

Exponentiated coefficients; Standard errors in parentheses
[*] $p < 0.05$, [**] $p < 0.01$, [***] $p < 0.001$

Figure 1. Percentage of Teachers Leaving Georgia Public Schools by Year (Teachers with 5 or Less Years of Experience)

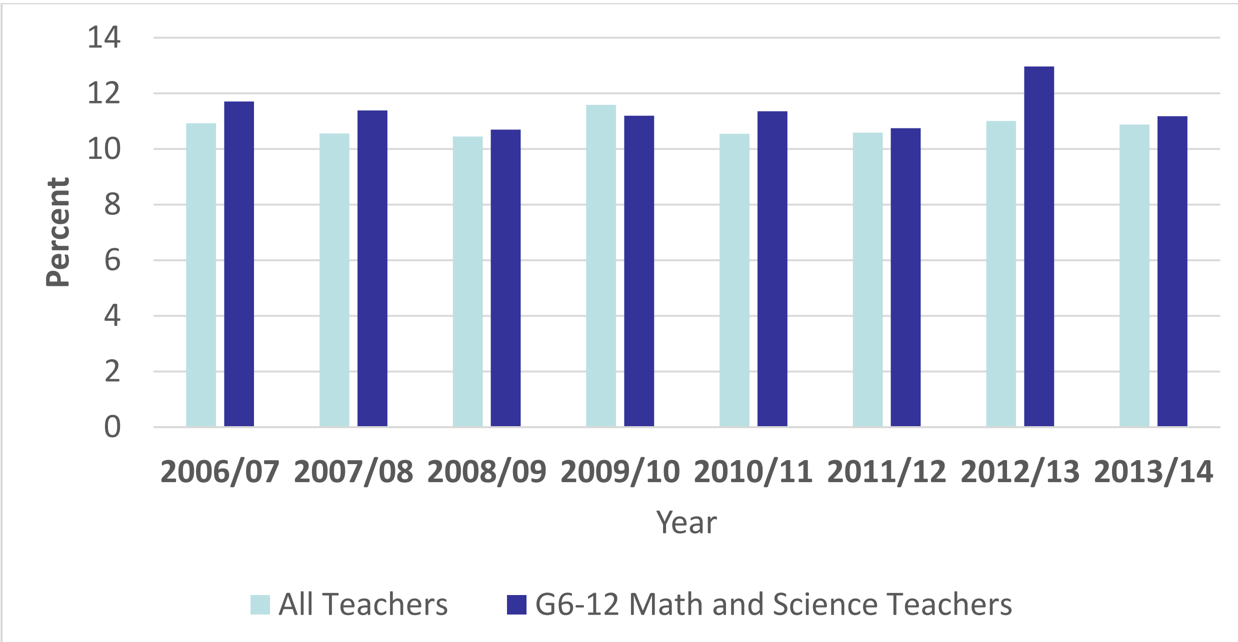

Figure 2. Kaplan-Meier Survival Estimates of Teaching in Georgia Public Schools (Math/Science Teachers Observed in Their First Year of Teaching, 2006/07-2013/14)

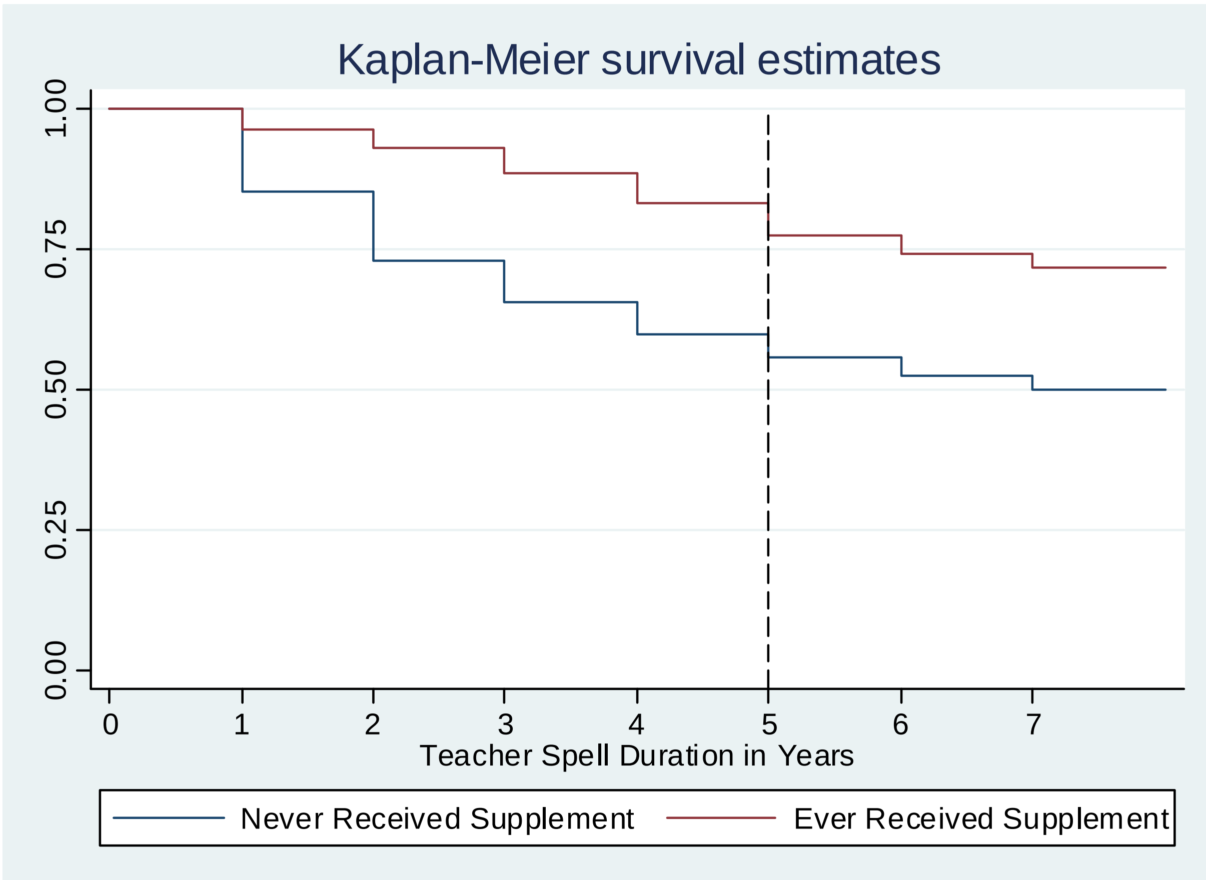

Figure 3. Kaplan-Meier Survival Estimates of Teaching in Georgia Public Schools (Math/Science Teachers Observed in Their First Year of Teaching, 2010/11-2013/14)