Markus Nagler; Marc Piopiunik; Martin R. West:

# Weak Markets, Strong Teachers: Recession at Career Start and Teacher Effectiveness

Munich Discussion Paper No. 2015-513

Department of Economics
University of Munich

Volkswirtschaftliche Fakultät
Ludwig-Maximilians-Universität München

GOVERNANCE AND THE EFFICIENCY OF ECONOMIC SYSTEMS
GESY

Discussion Paper No. 513

# Weak Markets, Strong Teachers: Recession at Career Start and Teacher Effectiveness

Markus Nagler[†], Marc Piopiunik[‡], Martin R. West[§]

[†] Department of Economics, University of Munich.
[‡] Ifo Institute for Economic Research and CESifo.
[§] Harvard Graduate School of Education, CESifo, and NBER.

July 2015

Financial support from the Deutsche Forschungsgemeinschaft through SFB/TR 15 is gratefully acknowledged.

Sonderforschungsbereich/Transregio 15 · www.sfbtr15.de
Universität Mannheim · Freie Universität Berlin · Humboldt-Universität zu Berlin · Ludwig-Maximilians-Universität München
Rheinische Friedrich-Wilhelms-Universität Bonn · Zentrum für Europäische Wirtschaftsforschung Mannheim

Speaker: Prof. Dr. Klaus M. Schmidt · Department of Economics · University of Munich · D-80539 Munich,
Phone: +49(89)2180 2250 · Fax: +49(89)2180 3510

# Weak Markets, Strong Teachers: Recession at Career Start and Teacher Effectiveness*

Markus Nagler[†], Marc Piopiunik[‡], Martin R. West[§]

**July 15, 2015**

**Abstract**

How do alternative job opportunities affect teacher quality? We provide the first causal evidence on this question by exploiting business cycle conditions at career start as a source of exogenous variation in the outside options of potential teachers. Unlike prior research, we directly assess teacher quality with value-added measures of impacts on student test scores, using administrative data on 33,000 teachers in Florida public schools. Consistent with a Roy model of occupational choice, teachers entering the profession during recessions are significantly more effective in raising student test scores. Results are supported by placebo tests and not driven by differential attrition.

**Keywords:** Teacher value-added, Talent allocation, Business cycle, Roy model

**JEL:** E32, H75, I20, J24

*We thank seminar audiences at Harvard University, the Ifo Institute, the University of Munich, and RWI Essen as well as conference participants at the NBER Education Spring Meeting, the SOLE-EALE World Meetings in Montreal, the Spring Meeting of Young Economists in Ghent, and the Workshop of the German Network of Young Microeconometricians for valuable suggestions. We also thank David Autor, Michael Boehm, Raj Chetty, Matthew Chingos, Andy de Barros, David Deming, Christian Dustmann, Bernd Fitzenberger, Joshua Goodman, Mathilde Godard, Anna Gumpert, Eric A. Hanushek, Lawrence Katz, Asim Khwaja, Amanda Pallais, Jonah Rockoff, Monika Schnitzer, Ludger Woessmann, and especially Martin Watzinger for valuable comments and suggestions. Max Mandl provided excellent research assistance. Nagler gratefully acknowledges financial support by the DFG through SFB TR 15 and the Elite Network of Bavaria through Evidence-Based-Economics. He further thanks the Program on Education Policy and Governance at Harvard University for its hospitality while writing parts of this paper.

[†]Department of Economics, University of Munich; email: markus.nagler@econ.lmu.de

[‡]Ifo Institute for Economic Research and CESifo; email: piopiunik@ifo.de

[§]Harvard Graduate School of Education, CESifo, and NBER; email: martin_west@gse.harvard.edu

# 1 Introduction

How do alternative job opportunities affect teacher quality? This is a crucial policy question as teachers are a key input in the education production function (Hanushek and Rivkin, 2012) who affect their students' outcomes even in adulthood (Chetty et al., 2014b). Despite their importance, individuals entering the teaching profession in the United States tend to come from the lower part of the cognitive ability distribution of college graduates (Hanushek and Pace, 1995). One frequently cited reason for not being able to recruit higher-skilled individuals as teachers is low salaries compared to other professions (e.g., Dolton and Marcenaro-Gutierrez, 2011; Hanushek et al., 2014).

Existing research provides evidence consistent with the argument that outside options matter. A first strand of the literature has used regional variation in relative teacher salaries, finding that pay is positively related to teachers' academic quality (e.g., Figlio, 1997). A second strand has used long-run changes in the labor market – in particular, the expansion of job opportunities for women – finding that the academic quality of new teachers is lower when job market alternatives are better (e.g., Bacolod, 2007). However, both bodies of evidence suffer from key limitations. First, relative pay may be endogenous to teacher quality. Second, measures of academic quality are poor predictors of teacher effectiveness (cf. Jackson et al., 2014). This important policy question therefore remains unresolved.

We exploit business cycle conditions at career start as a source of exogenous variation in the outside labor-market options of potential teachers.[1] Because the business cycle conditions at career start are exogenous to teacher quality, our reduced-form estimates reflect causal effects. In contrast to prior research, we directly measure teacher quality with value-added measures (VAMs) of impacts on student test scores, a well-validated measure of teacher effectiveness (Jackson et al., 2014). Combining our novel identification strategy with VAMs of individual elementary school teachers from a large US state, we provide the first causal evidence on the importance of alternative job opportunities for teacher quality.

Our value-added measures are based on individual-level administrative data from the Florida Department of Education on 33,000 4th- and 5th-grade teachers in Florida's public

[1]To our knowledge, the idea that labor market opportunities at career start matter for teacher quality was first proposed by Murnane and Phillips (1981) in a classic paper on "vintage effects."

schools and their students. The data include Florida Comprehensive Assessment Test (FCAT) math and reading scores for every 3rd-, 4th-, and 5th-grade student tested in Florida in the 2000-01 through 2008-09 school years. The data also contain information on teachers' total experience in teaching (including experience in other states and private schools), which is used to compute the year of entry into the profession (which is not directly observed). Following Jackson and Bruegmann (2009), we regress students' math and reading test scores separately on their prior-year test scores, student, classroom, and school characteristics, and grade-by-year fixed effects to estimate each teacher's value-added. We then relate the VAMs in math and reading to several business cycle indicators from the National Bureau of Economic Research (NBER) and the Bureau of Labor Statistics (BLS).

We find that teachers who entered the profession during recessions are roughly 0.10 standard deviations (SD) more effective in raising math test scores than teachers who entered the profession during non-recessionary periods. The effect is half as large for reading value-added. Quantile regressions indicate that the difference in math value-added between recession and non-recession entrants is most pronounced at the upper end of the effectiveness distribution. Based on figures from Chetty et al. (2014b), the difference in average math effectiveness between recession and non-recession entrants implies a difference in students' discounted life-time earnings of around \$13,000 per classroom taught each year.[2] Under the more realistic assumption that only 10% of recession-cohort teachers are pushed into teaching because of the recession, these recession-only teachers are roughly one SD more effective in teaching math than the teachers they push out. Based on the variation in teacher VAMs in our data, being assigned to such a teacher would increase a student's test scores by around 0.20 SD.

Placebo regressions show that neither business cycle conditions in the years before or after teachers' career starts, nor those at certain critical ages (e.g., age 18 or 22), impact teacher effectiveness; only conditions at career start matter. Nor are our results driven by differential attrition of recession and non-recession cohorts. Although teachers entering during recessions are more likely to exit the profession, the observed attrition pattern

[2]Chetty et al. (2014b) estimate that students who are taught by a teacher with a 1 SD higher value-added measure at age 12 earn on average 1.3% more at age 28. Assuming a permanent change in earnings and discounting life-time earnings at 5%, this translates into increases in discounted life-time earnings of \$7,000 per student. We obtain our estimate by multiplying this number by the effect size and average classroom size.

works against our finding and suggests that our results understate the differences in effectiveness between recession and non-recession cohorts at career start. The results are also not driven by any single recession cohort, but appear for most recessions covered by our sample period. Using alternative business cycle measures such as unemployment levels and changes yields very similar results. The recession effect is not driven by differences in teacher race, gender, age at career start, cohort sizes, or school characteristics. Our finding that the effect of recessions on teacher effectiveness is twice as strong in math as in reading is consistent with evidence that wage returns to numeracy skills are twice as large as those to literacy skills in the US labor market (Hanushek et al., 2015).

To motivate our analysis, we present a stylized Roy model (Roy, 1951) in which more higher-skilled individuals choose teaching over other professions during recessions because of lower (expected) earnings in those alternative occupations. The model's main assumption is that teaching is a relatively stable occupation over the business cycle. This seems reasonable since teacher demand depends primarily on student enrollment and is typically unresponsive to short-run changes in macroeconomic conditions (e.g., Berman and Pfleeger, 1997). We present evidence that supports our interpretation of these results as supply effects, rather than demand effects or direct impacts of recessions on teacher effectiveness.[3]

Consistent with this model, existing studies show that the supply of workers for public sector jobs in the US is higher during economic downturns (e.g., Krueger, 1988; Borjas, 2002). Falch et al. (2009) document the same pattern for the teaching profession in Norway. Teach For America, an organization that recruits academically talented college graduates into teaching, saw a marked decline in the number of qualified applicants during the recent economic recovery (New York Times, 2015). Meanwhile, several US states have reported sharp declines in enrollment in university-based teacher preparation programs as the job market has improved (National Public Radio, 2015).

Our results have important policy implications. First, they suggest that increasing the economic benefits of becoming a teacher may be an effective strategy to increase the quality

[3]Figure 1 confirms that employment in the private sector is much more cyclical than employment in (state and local) education. The major exception is the recession period of 1980-1982, but our results for this recession differ from and work against our main findings. Kopelman and Rosen (forthcoming) report higher job security for public sector jobs (including teaching) than for jobs in the private sector. Consistently, newspapers have reported that teaching is recession-proof. During the most recent recession, job security for teachers did decline substantially (e.g., New York Times, 2010). This last downturn does not drive our results.

of the teaching workforce. Second, they suggest that recessions may provide a window of opportunity for governments to hire more able applicants. Our results also suggest that recent improvements in cognitive skills among new teachers in the US documented by Goldhaber and Walch (2013) may be attributable to the 2008-09 financial crisis, rather than an authentic reversal of long-term trends.

We extend previous research that has called attention to the potential importance of outside job options for teacher quality. For example, Bacolod (2007) documents a decrease in the average academic quality (as measured by standardized test scores and undergraduate institution selectivity) of female teachers in recent decades that she argues reflects improved outside options. In comparison to her study, we employ a more rigorous identification strategy and use direct measures of teachers' performance on the job.[4] To our knowledge, ours is the first paper to document a causal effect of outside labor market options on the effectiveness of entering teachers in raising student test scores.

Business cycle fluctuations have previously been exploited as a strategy to identify selection effects in the labor market. Oyer (2008), for example, studies the impact of the business cycle on the likelihood that MBA graduates enter the banking sector.[5] Boehm and Watzinger (forthcoming) show that PhD economists graduating during recessions are more productive in academia, a finding best explained by a Roy-style model. While these studies enhance the plausibility of our findings, they relate to rather small groups in the labor market with highly specialized skills. Teachers, in contrast, make up roughly 3 percent of full-time workers in the US and play a critical role in developing the human capital of future generations. Moreover, little is known about how to improve the quality of the teaching workforce. Thus, extending this identification strategy to teacher quality fills an important gap in the literature.

The paper proceeds as follows. Section 2 presents a simple model of occupational choice. Section 3 briefly describes the teaching profession in Florida, introduces the data, explains our value-added measures, and presents our empirical model. Section 4 reports results on the relationship between business cycle conditions at career start and teacher

[4]Loeb and Page (2000) similarly link regional variation in relative teacher wages and unemployment rates to student attainment but lack a direct measure of teacher quality. Corcoran et al. (2004), Hoxby and Leigh (2004), and Lakdawalla (2006) provide additional evidence of the importance of outside labor-market options for the supply of teachers in the US.

[5]A small literature also documents persistent negative wage effects of completing college during a recession (e.g., Kahn, 2010; Oreopoulos et al., 2012).

effectiveness in math and reading and provides robustness checks. Section 5 discusses potential implications for policymakers. Section 6 concludes.

## 2 A Simple Model of Occupational Choice

To motivate our analysis, we present a simple Roy-style model of self-selection (Roy, 1951) where individuals choose an occupation to maximize earnings.[6] Specifically, individuals can choose between working in the teaching sector ($t$) and working in the business sector ($b$), which represents all outside labor-market options of potential teachers. Earnings depend on average earnings in the respective sector, $\mu$, and the individual's ability, $v$. Hence, earnings in the two sectors for any individual with ability $v$ can be written as follows:

$$w_t = \mu_t + \eta_t v$$
$$w_b = \mu_b + v - s$$

where $w_t$ and $w_b$ are earnings in the teaching and business sector, respectively; $v$ is the (uni-dimensional) ability of the individual, distributed with mean zero and standard deviation $\sigma_v^2$; and $\eta_t$ denotes the relative returns to ability in teaching versus business. If ability is valued both in business and teaching, but teaching has lower returns to ability, then $\eta_t \in (0, 1)$.[7] If there are no returns to ability in teaching, then $\eta_t = 0$.[8]

The term $s$ ($\geq 0$) represents the reduction in (expected) earnings in the business sector *relative* to the reduction in earnings in the teaching sector (which is normalized to zero) during recessions. The model thus allows for recessions to affect earnings in the teaching profession, but assumes that the impact is stronger in the business sector. Empirically, employment in the teaching sector is less cyclical than employment in the business sector (Berman and Pfleeger, 1997; Simpkins et al., 2012).

[6]Individuals may, of course, be motivated by other concerns than earnings. One can therefore think of our earnings variable as a proxy for lifetime utility.

[7]Wages are more compressed in the government-dominated teaching profession than in the business sector (cf. Hoxby and Leigh, 2004; Dolton, 2006).

[8]Since our model only uses one dimension of ability, we implicitly assume that the two abilities typically used in Roy models are positively correlated (i.e., $\eta_t \geq 0$). We make this assumption for expositional clarity only, but note that it has empirical support. For example, Chingos and West (2012) show that, among 35,000 teachers leaving Florida public schools for other industries, a 1 SD increase in teacher value-added is associated with 6–8 percent higher earnings in non-teaching jobs.

Individuals choose teaching if $w_t > w_b$, which is equivalent to $v < \frac{\mu_t - \mu_b + s}{1-\eta_t}$. Hence, the share of individuals seeking employment in the teaching sector is given by

$$Pr(t) = Pr\left(v < \frac{\mu_t - \mu_b + s}{1 - \eta_t}\right) = F\left(\frac{\mu_t - \mu_b + s}{1 - \eta_t}\right)$$

where $F(\cdot)$ is the cumulative distribution function of individuals' ability $v$, which is continuously distributed over $\mathbb{R}$. If $0 \leq \eta_t < 1$, recessions increase the supply and (average) quality of potential teachers. When a recession hits the economy (increasing $s$), the share of individuals seeking employment in the teaching sector increases because the earnings of teachers increase relative to more cyclical outside options:

$$\frac{\partial Pr(t)}{\partial s} = f\left(\frac{\mu_t - \mu_b + s}{(1 - \eta_t)}\right)\frac{1}{1 - \eta_t} > 0.$$

The average ability of individuals seeking employment in teaching increases because individuals with higher ability prefer working in the teacher profession; formally, $\frac{\partial v_{marg}}{\partial s} = \frac{1}{(1-\eta_t)} > 0$.[9] We expect our empirical analysis to be consistent with this prediction, as the underlying assumptions (i.e., $\eta_t \in (0, 1)$ and $s \geq 0$) have strong empirical support. If $\eta_t > 1$, we would expect to find negative effects of recessions on teacher quality.

Empirically, we analyze the importance of outside labor-market options for teacher quality. In our model, changes in labor-market opportunities are modeled as changes in expected earnings. Both job security and relative earnings likely change in favor of the teaching profession during recessions, but we cannot discriminate between these channels. If the model's assumptions hold, however, our estimates shed light on whether increasing teacher pay would increase teacher quality.

While our simple model only addresses the supply of teachers, fluctuations in demand could in theory also explain changes in teacher quality over the business cycle. Fluctuations in demand would lead to higher quality of teachers entering during recessions if the following two conditions hold. First, school authorities are able to assess the quality of inexperienced applicants and accordingly hire the more able ones. Second, the number of hired teachers is smaller during recessions than during booms. If either of these two conditions does not

[9] Marginal individuals, indifferent between working in the teaching sector and working in the business sector, are characterized by $v_{marg} = \frac{\mu_t - \mu_b + s}{(1-\eta_t)}$.

hold, fluctuations in demand would not cause recession teachers to be more effective than non-recession teachers. We return to this issue after presenting our empirical results.

# 3 Setup, Data, and Empirical Strategy

First, we summarize the requirements for entry into the teaching profession in Florida. Second, we introduce the data and describe our empirical strategy, including the construction of the value-added measures.

## 3.1 Teaching Profession in Florida

Florida requires all classroom teachers to hold a bachelor's degree and either a professional teaching certificate or a non-renewable temporary certificate that enables them to teach for up to three years while completing alternative requirements for professional certification. Professional certificates are initially awarded only to graduates of state-approved teacher preparation programs who receive passing scores on tests of general knowledge, professional education, and the subject area in which they will teach.[10] However, college graduates who have not completed a teacher preparation program are eligible for a temporary certificate if they majored or completed a specified set of courses in the relevant subject area. Alternatively, they may also become eligible for a temporary certificate by passing a test of subject-area knowledge. These arrangements allow any college graduate to enter the teaching profession in Florida (at least temporarily) in response to labor market conditions by passing a single exam. Individuals with a temporary certificate can then obtain a professional certificate by completing 15 credit hours of education courses and a school-based competency demonstration program.

## 3.2 Data

Teacher value-added measures are based on administrative data from the Florida Department of Education's K–20 Education Data Warehouse (EDW). Our EDW data include observations of every student in Florida who took the state test in the 2000–01 through 2008–09 school years, with each student linked to his or her courses (and corresponding teachers). We focus

[10]The state also recognizes professional certificates in comparable subject areas granted by other states and the National Board of Professional Teaching Standards.

on scores on the Florida Comprehensive Assessment Test (FCAT), the state accountability system's "high-stakes" exam. Beginning in 2001, students in grades 3–10 were tested each year in math and reading. Thus annual gain scores can be calculated for virtually all students in grades 4–10 starting in 2002. The data include information on the demographic and educational characteristics of each student, including gender, race, free or reduced price lunch eligibility, limited English proficiency status, and special education status.

The EDW data also contain detailed information on individual teachers, including their demographic characteristics and teaching experience. We use only 4th- and 5th-grade teachers because these teachers typically teach all subjects, thus avoiding spillover effects from other teachers. We construct a dataset that connects teachers and their students in each school year through course enrollment data. Our teacher experience variable reflects the total number of years the teacher has spent in the profession, including both public and private schools in Florida and other states. Because the experience variable contains a few inconsistencies, we assume the latest observed experience value is correct, and adjust all other values accordingly. Year of career start is defined as the calendar year at the end of the school year a teacher is observed minus total years of teaching experience.[11] Starting from the baseline dataset that contains all 4th- and 5th-grade students with current and lagged test scores, we apply several restrictions to keep only those teachers who can be confidently associated with students' annual test score gains. We only keep student-teacher pairs if the teacher accounts for at least 80% of the student's total instruction time (deleting 24.5% of students from the baseline dataset). We exclude classrooms that have fewer than seven students with current and lagged scores in the relevant subject and classrooms with more than 50 students (deleting 1.8% of students). We also drop classrooms where more than 50% of students receive special education (deleting 1.5% of students). We further exclude classrooms where more than 10% of students are coded as attending a different school than the majority of students in the classroom (deleting 0.7%). Finally, we drop classrooms for which the teacher's experience is missing (deleting 1.8% of students). Our final dataset contains roughly 33,000 public school teachers with VAMs for math and reading.

[11]We adjust career start dates for gaps in teaching observed after 2002, when we directly observe whether a teacher is working in Florida public schools each year. Results are very similar when using the original, uncorrected values.

Our main indicator for the US business cycle is a dummy variable reflecting recessions as defined by the National Bureau of Economic Research (NBER). Recession start and end dates are determined by NBER's Business Cycle Dating Committee based on real GDP, employment, and real income. The NBER does not use a stringent, quantitative definition of a recession, but rather a qualitative one, defining a recession as "a period between a peak and a trough" (see http://www.nber.org/cycles/recessions.html). For example, the NBER dates the economic downturn of the early 1990s to have occurred between July 1990 (peak) and March 1991 (trough). We code our recession indicator variable to be one in 1990 (the beginning of the recession), and zero in 1991. Accordingly, teachers starting their careers in the 1990-91 school year are classified as having entered during a recession. In robustness checks, we use alternative business cycle indicators such as unemployment for college graduates (in levels and annual changes, nationwide and in Florida), overall unemployment for specific industries, and GDP, which come from the Bureau of Labor Statistics and the Bureau of Economic Analysis. NBER's recession indicator is highly correlated with unemployment rates (both levels and annual changes) and GDP.

## 3.3 Empirical Strategy

This section describes the estimation of teachers' value-added and our strategy for analyzing the relationship between business cycle conditions at career start and teacher value-added.

**Estimating Teacher Value-Added**

Teacher value-added measures (VAMs) aim to gauge the impact of teachers on their students' test scores. We estimate VAMs for 4th- and 5th-grade teachers based on students' test scores in math and reading from grades 3–5. To estimate the value-added for each teacher, we regress students' math and reading test scores separately on their prior-year test scores, student, classroom, and school characteristics as well as grade-by-year fixed effects. Student-level controls include dummy variables for race, gender, free- and reduced-price lunch eligibility, limited English proficiency, and special-education status. Classroom controls include all student-level controls aggregated to the class level and class size. School-level controls include enrollment, urbanicity, and the school-specific shares of students who are black, white, Hispanic, and free- and reduced-price lunch eligible.

To obtain an estimate of each teacher's value-added, we add a dummy variable, $\theta_j$, for each teacher:

$$A_{ijgst} = \widehat{\alpha} A_{i,t-1} + \beta X_{it} + \gamma C_{it} + \lambda S_{it} + \pi_{gt} + \theta_j + \epsilon_{ijgst}$$

where $A_{ijgst}$ is the test score of student $i$ with teacher $j$ in grade $g$ in school $s$ in year $t$ (standardized by grade and year to have a mean of zero and standard deviation of one); $A_{i,t-1}$ contains the student's prior-year test score in the same subject; $X_{it}$, $C_{it}$, and $S_{it}$ are student-, classroom-, and school-level characteristics; $\pi_{gt}$ are grade-by-year fixed effects; and $\epsilon_{ijgst}$ is a mean-zero error term. After estimating the teacher VAMs, $\theta_j$, we standardize them separately for math and reading to have a mean of zero and a standard deviation of one.[12]

Since test scores suffer from measurement error, the coefficient on the lagged test score variable, $A_{i,t-1}$, is likely downward biased, which would bias the coefficients on other control variables correlated with lagged test scores. We therefore follow Jackson and Bruegmann (2009) and use $\widehat{\alpha}$, which is the coefficient on the lagged test scores from a two-stage-least-squares model where the second lag of test scores is used as an instrument for the lagged test scores (see the web appendix of Jackson and Bruegmann (2009) for details). Because this procedure requires two lags of test scores, the estimation of $\widehat{\alpha}$ is based on 5th-grade students only.

Although widely used by researchers, the reliability of value-added models of teacher effectiveness based on observational data continues to be debated (see, e.g., Jackson et al., 2014; Rothstein, 2014). The key issue is whether non-random sorting of students and teachers both across and within schools biases the estimated teacher effectiveness. This would be the case if there were systematic differences in the unobserved characteristics of students assigned to different teachers that are not captured by the available control variables.

[12]To simplify notation, we drop the subscripts $j$, $g$, and $s$ for the lagged test score and for the student-, classroom-, and school-level characteristics. We control for school characteristics rather than include school fixed effects because the latter would eliminate any true variation in teacher effectiveness across schools. However, we show below that our results are robust to the inclusion of both school and school-by-year fixed effects. We include grade-by-year fixed effects because test scores have been standardized using the full sample of students and because teachers are not observed in all years.

Value-added models have survived a variety of validity tests, however. Most importantly, estimates of teacher effectiveness from observational data replicate VAMs obtained from experiments where students within the same school were randomly assigned to teachers (Kane and Staiger, 2008; Kane et al., 2013). Chetty et al. (2014a) and Bacher-Hicks et al. (2014) exploit quasi-random variation from teachers switching schools to provide evidence that VAMs accurately capture differences in the causal impacts of teachers across schools. Using a different administrative data set, Rothstein (2014) argues that evidence on school switchers does not rule out the possibility of bias. Even if our VAMs were biased by non-random sorting of students and teachers, however, it is unclear whether and, if so, in what direction this would bias our estimates of the relationship between recessions at career start and teacher effectiveness.

Finally, some critics argue that value-added measures may reflect teaching to the test rather than true improvements in knowledge. In a seminal study, Chetty et al. (2014b) find that having been assigned to higher value-added teachers increases later earnings and the likelihood of attending college and decreases the likelihood of teenage pregnancy for girls. Of course, there may be other dimensions of teacher quality not captured by VAMs (e.g., Jackson, 2012). The weight of the evidence, however, indicates that teacher value-added measures do reflect important aspects of teacher quality.

### Business Cycle Conditions at Career Start and Teacher Value-Added

To estimate the effect of business cycle conditions at career start on teacher effectiveness, we relate the macroeconomic conditions in the US during the career start year to a teacher's value-added in math and reading. Specifically, we estimate the following reduced-form model:

$$\widehat{\theta}_j = \alpha + \gamma Rec_{js} + \beta X_j + u_j$$

where $\widehat{\theta}_j$ is the value-added of teacher $j$ (either in math or in reading). $Rec_{js}$ is a binary indicator that equals 1 if teacher $j$ started working in the teaching profession (in year $s$) in a recessionary period and equals 0 otherwise. The vector $X_j$ includes teacher characteristics. Most importantly, it contains total experience in the teaching profession (yearly dummies up to 30 years of experience), which is not accounted for in the VAM computation but has been shown to influence teacher effectiveness (Papay and Kraft, forthcoming).[13] As experience differs between recession and non-recession teachers – due in part to the idiosyncratic distance between recessions and the time period covered by our administrative data – experience is a necessary control. Additional teacher characteristics included in some specifications are year of birth, age at career start, educational degree, gender, and race. Note that these teacher characteristics do not influence the business cycle. The reduced-form estimate $\gamma$ (controlling only for experience) therefore identifies a causal effect. To the extent that the inclusion of additional controls changes the estimate of $\gamma$, they represent mechanisms rather than confounders. Because the source of variation is the yearly business cycle condition, we always adjust standard errors for clustering at the level of the career start year.

Based on our Roy model, we expect to find a positive effect of recessions at career start on teacher effectiveness since recessions negatively shock the outside options of potential teachers. Due to this shock, both the number and the average quality of applicants increases, leading to higher average value-added in recession cohorts. Since we do not observe the intermediate steps (e.g., application rates or earnings), we estimate a reduced-form relationship between teacher value-added and business cycle conditions at career start.

Critics of this model might argue that teacher effectiveness is unrelated to productivity in other occupations, but rather depends on intrinsic motivation. This should work against any positive effect of recessions on teacher VA. Evidence of a positive effect would therefore also suggest that intrinsic motivation is of second-order importance relative to the effects of economic benefits through selection on ability. Note also that because the effectiveness of all teachers is estimated during the same period (2001-2009), systematic differences in the effort levels of recession and non-recession teachers seem unlikely.

# 4 Business Cycle Conditions at Career Start and Teacher Effectiveness

We start by documenting differences in math and reading effectiveness between recession and non-recession teachers. Using kernel density plots and quantile regressions, we show

[13]Previous work has shown that teacher experience affects teacher value-added non-linearly (e.g., Rockoff, 2004). Wiswall (2013) shows that non-parametric specifications yield the most convincing results. Our results are robust to using teachers with above 20 or 25 years of experience as the omitted category.

at which parts of the effectiveness distribution recession and non-recession teachers differ. In placebo regressions, we show that teacher effectiveness is not associated with business cycle conditions several years before and after career start or with business cycle conditions at certain critical ages of teachers. We also show that our results are robust to using alternative business cycle indicators or value-added measures and are not driven by any single recession. Finally, we provide evidence that our results are not driven by differential attrition of recession and non-recession teachers.

## 4.1 Main Results

We first present summary statistics separately for recession teachers and the much larger group of non-recession teachers (Table 1). The unemployment level of college graduates was higher when recession teachers started their careers. Similarly, unemployment was rising for recession teachers, but slightly falling for non-recession teachers. These differences are significant at the one percent level. The share of male teachers is approximately the same in both samples. Among recession teachers, the share of teachers with a Master's or PhD degree is slightly larger and the share of white teachers somewhat smaller. Because recession teachers started around three school years earlier than non-recession teachers on average, recession teachers also have more teaching experience. The two groups teach similar types of students as measured by the share of students who are black and by the share of students eligible for free or reduced-price lunch. Although none of the teacher characteristics differ significantly, recession teachers have on average 0.08 SD higher math value-added and 0.05 SD higher reading value-added than non-recession teachers.

After documenting the raw gap in math value-added between recession and non-recession teachers (see also Column 1 in Table 2), we add several teacher characteristics (Table 2). Due to the idiosyncratic distance between recessions and our sample period, experience is a necessary control. We therefore refer to Column 2 as our preferred specification. The value-added gap increases to 0.11 SD when dummies for teaching experience are included (Column 2).[14] Adding year of birth and age at career start has little effect on the coefficient on the recession indicator (Column 3). Further controlling for teacher characteristics such as whether the teacher holds a Master's or PhD degree, and whether the teacher is male

[14]The coefficient on the recession indicator increases because recession teachers are overrepresented among rookie teachers and the first years of teaching experience improve effectiveness the most.

or white, also does not affect our coefficient of interest.[15] The specification with all control variables indicates that recession teachers are 0.10 SD more effective in teaching math than non-recession teachers. Since all control variables – except experience – represent mechanisms rather than confounders, we omit them in all regressions below.

The simple Roy model predicts selection effects due to changing outside labor-market options over the business cycle. Because research indicates that earnings returns are twice as large for numeracy than for literacy skills in the US labor market (Hanushek et al., 2015), we expect selection effects over the business cycle to be weaker for reading effectiveness than for math effectiveness. And, in fact, the effects on teachers' reading value-added is similar to, but weaker than in math (Table 3). The bivariate relationship between recession at career start and teacher effectiveness is positive, but statistically insignificant (Column 1). As in math, controlling for teaching experience increases the coefficient on the recession indicator; the estimate also becomes significant at the one percent level (Column 2). Adding the other teacher characteristics reduces the coefficient of interest only slightly. In terms of magnitude, the recession indicator for reading is half as large as the coefficient for math (around 0.05 SD). As selection effects among potential teachers should be stronger with respect to math skills, we focus on teachers' math effectiveness in the remaining analyses.[16]

While Table 2 indicates that recession teachers are on average more effective in raising students' math test scores than non-recession teachers, it is unclear whether this effect is driven by the presence of fewer ineffective teachers or more highly effective teachers in recession cohorts. To analyze the recession impact across the distribution of math value-added, we estimate kernel density plots and quantile regressions. The kernel density plots of teachers' (experience-adjusted) math value-added reveal a clear rightward shift in the math value-added distribution for recession cohorts (Figure 2).[17] In quantile regressions that control for experience, we analyze this finding further (Figure 3). While teachers at the very low tail of the value-added distribution have very similar VAMs,

[15]Differences in the placement of recession and non-recession teachers represent another potential mechanism through which recessions could impact productivity (cf. Oyer, 2006). However, controlling for important student characteristics at the school level, such as the share of black students and the share of students eligible for free or reduced-price lunch, does not explain the value-added difference (results not shown).

[16]The results of the following analyses show the same overall pattern for teachers' reading effectiveness, but are less pronounced and more volatile than the results for math. All results are available on request.

[17]Kolmogorov-Smirnov tests indicate that the distributions are statistically significantly different at the one percent level.

recession teachers are more effective than non-recession teachers from the 10th percentile onwards. The largest difference between the distributions appears among highly effective teachers, with point estimates of differences peaking at 0.20 SD in the upper end of the distribution.

In Table 4, we run our preferred specification on subsamples to assess whether recessions have differential impacts across various groups of teachers. Male teachers seem to be more affected than female teachers (Columns 1 and 2) which may suggest that the career options of men are more strongly influenced by recessions than those of women. In Columns 3 and 4, we find similar recession impacts for teachers with and without a Master's or PhD degree. In line with existing research (Jones and Schmitt, 2014; Hoynes et al., 2012), Columns 5 and 6 provide indirect evidence that minorities are more affected by recessions than whites. Finally, Columns 7 and 8 indicate that teachers starting their teaching careers at a relatively high age (above median) are more affected than those starting at younger ages. This may suggest that the decisions of mid-career entrants to the teaching profession are more strongly influenced by the outside labor market.

## 4.2 Placebo Analyses

We assume that it is the business cycle condition at the point in time when individuals enter the teaching profession that matters for their effectiveness. If this is true, then the economic conditions several years before or after career start should be irrelevant. To test this hypothesis, we run placebo regressions where we include recession indicators for the years before or after career start with lags and leads of up to three years. Adding these recession indicators to the main model does not change our coefficient of interest (Columns 2 and 3 in Table 5). Furthermore, the estimated effects of the business cycle conditions in the years before or after our preferred year are all close to zero and statistically insignificant.[18]

One might worry that our career start year measure captures the effect of macroeconomic conditions at key ages (Giuliano and Spilimbergo, 2014). For example, many individuals may decide to become teachers when entering college (around age 18) or upon completing their undergraduate or graduate studies (between ages 22 to 24). Therefore, we include

[18]Similarly, using each of these other recession indicators individually instead of our main recession indicator also yields small and mostly statistically insignificant coefficients.

recession indicators at ages 18-32 (in two-year steps) to confirm that it is the economic conditions at career start that affect teaching quality. As before, all coefficients on the indicators of recessions at specific ages are close to zero and statistically insignificant (Column 4).

## 4.3 Further Robustness Checks

Since the number of recession cohorts is limited, one might worry that our result is driven by only one or two recessions. To investigate this issue, we include a separate binary indicator for each recession (Table 6).[19] Column 1 indicates that teachers in most recessions (except in recession years 1974 and 1980–82, a highly atypical recession, see Figure 1) have higher math value-added than the average non-recession teacher. In Column 2, we combine the separate recession indicators for the adjacent recession years of 1980, 1981, and 1982 and find that teachers who started during those years are on average as effective as the average non-recession teacher. In Column 3, we only keep two non-recession cohorts immediately before and immediately after each recession, such that the cohorts being compared are more similar. This leads to the same finding: most recessions have positive effects on teacher effectiveness. The recession impact is not driven by any single recession.

We also evaluate the robustness of our results using alternative measures of teachers' outside options. Figure 4 makes it possible to compare the variation in our preferred binary measure of the business cycle (by comparing green and blue dots) and a continuous measure, one-year unemployment changes. In line with our main findings, unemployment changes and teacher value-added are positively related. In Table 7, we run our preferred specification using the NBER recession indicator (Column 1), GDP growth (2), the unemployment level (3), and one-year unemployment changes (4), respectively. Both unemployment measures are computed using the unemployment rates of college graduates (only available from 1970 onwards), as this is the relevant labor market for potential teachers.[20] Consistent with our preferred results, GDP growth is negatively related to teacher value-added. The coefficients on the unemployment measures are also in line with our previous findings and significant at the five percent level. The coefficient estimates

[19]Because there are fewer than 20 teachers per cohort who started teaching before 1962, we exclude these cohorts for this analysis since estimates are less reliable for very small cohorts.
[20]The results of our the preferred specification are unchanged for teachers starting after 1970.

for the alternative measures imply somewhat weaker, but qualitatively similar recession effects (based on the difference in each business cycle indicator between recession and non-recession cohorts), suggesting that none of the alternative business cycle indicators on its own fully captures the full effects of a recession on potential teachers' choices.[21] Finally, it is unlikely that the alternative job opportunities of potential teachers are evenly distributed across industries. For example, one would expect few potential teachers to work in agriculture. In Columns 5 and 6, we find that the one-year unemployment change in agriculture at career start is unrelated to teacher quality, while the labor-market conditions in nonagriculture industries do matter. This pattern is consistent with the selection of potential teachers into teaching who alternatively would have chosen industries requiring similar skills.

We use national rather than Florida-specific unemployment rates in this analysis because state-level unemployment rates are not available for college graduates, the national unemployment rates are more reliable, and because the mobility of teachers across states is relatively high. For example, 19% of our sample has teaching experience outside of Florida. Thus, using Florida-specific measures of economic conditions is likely to underestimate the true effect. Results based on Florida-specific unemployment rates (available upon request) are similar to, but smaller in magnitude than, those reported in Table 6 and significant at the five percent level.

To assess the sensitivity of our results with respect to the value-added measure, we run our preferred specification with alternative VAMs (Table 8). For comparison, Column 1 presents the results based on our preferred measure. In Column 2, we add school fixed effects when estimating teachers' value-added. The inclusion of school fixed effects eliminates any bias from unobserved school characteristics that influence teacher effectiveness, but also removes variation in true teacher effectiveness to the extent that average teacher quality varies across schools. The gap in effectiveness between recession and non-recession teachers is somewhat attenuated, but the change is small. In Column 3, we add school-by-year fixed effects when estimating value-added, likely removing additional variation in true teacher effectiveness. The estimate is further attenuated, but remains significant. Finally, in Columns 4 and 5, we account for the fact that the

[21] The same pattern appears if we use unemployment rates and changes for all workers rather than college graduates. These coefficients are significant at the one percent level, but somewhat attenuated, as expected.

precision of the teacher value-added measures varies across teachers. Our results are qualitatively unaffected by weighting teachers in our preferred specification by the number of student-year or teacher-year observations that underlie their value-added measures.

## 4.4 Differential Attrition of Teachers

We find that teachers who started their careers during recessions are more effective. On the one hand, effectiveness differences might already exist among entering teachers (*selection*). On the other hand, entering recession and non-recession teachers might have very similar VAMs at career start, but low-quality recession teachers might be more likely to leave the occupation than low-quality non-recession teachers (*differential attrition*). We use our data to assess which of these two channels is more plausible.

Since our dataset includes all teachers in the public school system in Florida, attrition means that a teacher leaves the Florida public school system. We cannot directly address attrition before 2000-01, the beginning of our sample period. However, if differential attrition of recession and non-recession teachers were driving our results, then one would expect earlier recession cohorts to be much more effective, but younger recession cohorts to be only slightly more effective, than non-recession teachers. This pattern is not present in Table 6, which shows that recession effects are generally larger for more recent recessions. We interpret this as first, indirect evidence that differential attrition does not drive our results.

To provide direct evidence, we define attrition as *not* being observed as a teacher during the last school year in our sample period (2008-09). First, we investigate whether starting during a recession is correlated with attrition (Columns 1 and 2 in Table 9).[22] Controlling for teachers' value-added, we find that recession teachers are somewhat more likely to drop out, although this difference is not statistically significant. Controlling for recession status at career start, more effective teachers are less likely to drop out.[23]

Among teachers who started teaching during our sample period (about 47% of the full sample), recession teachers are also slightly more likely to leave the public school system than non-recession teachers (Column 2). More importantly, in recession cohorts, exiting teachers are significantly more effective compared to exiting non-recession teachers. This

[22]Because the school year 2008-09 is the attrition target year, these regressions exclude teachers who started teaching in 2008-09.
[23]Excluding teachers born before 1950 as potential retirees does not change our results (not shown).

pattern works against our result, suggesting that the value-added gap is even larger at career start and decreases over time. This is confirmed in Column 3 when we look directly at value-added, finding a large gap at career start which decreases with experience. Taken at face value, these estimates imply that the gap in value-added between recession and non-recession teachers closes after around 25 years. However, depending on the functional form we impose on the interaction between starting in a recession and teaching experience, the implied time period before the gap closes ranges from 12 to 26 years. Therefore, these numbers need to be interpreted very cautiously. Column 4 confirms that the same pattern holds, and in fact becomes more pronounced, when using only teachers who started teaching during our sample period.

In sum, differential attrition between recession and non-recession teachers does not explain our main finding. The observed attrition pattern seems to reduce the estimated difference in effectiveness between recession and non-recession teachers. This suggests that our main results understate the difference in effectiveness between recession and non-recession teachers at career start.

### 4.5 Discussion

The effect of recessions at career start on teacher effectiveness might in theory be driven by demand or supply fluctuations over the business cycle (or both). As noted in Section 2, demand fluctuations can generate our findings only if school authorities (i) hire fewer teachers during recessions (e.g., due to budget cuts) and (ii) are able to assess the quality of the inexperienced applicants and hire those most likely to be effective. Both conditions are unlikely to hold in practice. First, in our data, cohort size is unrelated to the business cycle. This is corroborated by official statistics from the BLS, which indicate that employment in the local government education sector typically increases during recessions (with the exception of the recessions in 1980-1982 and the Great Recession; see Figure 1 and Berman and Pfleeger, 1997). Second, it is unlikely that school authorities are able to identify the best applicants since education credentials, SAT scores, and demographic characteristics – typically the only ability signals of applicants without prior teaching experience – are at best weakly related to teacher effectiveness as measured by VAMs (e.g., Chingos and Peterson, 2011; Jackson et al., 2014). Apart from the fact that both conditions are unlikely to hold, our quantile regression results show that the effect is strongest at the upper end of the value-added distribution. This suggests that increases in the supply of very effective teachers rather than decreases in the overall demand for teachers are at work.[24]

In sum, increases in the supply of high-quality applicants during recessions seem to drive our results. Teacher cohorts likely differ in their effectiveness already at career start, as predicted by a Roy model of occupational selection.

Finally, note that we estimate a reduced-form coefficient. To gauge the quality difference between recession-only teachers and those they replace, we have to inflate our reduced-form estimates by the share of recession-cohort teachers who would not have entered teaching under normal labor-market conditions. If all teachers who start during recessions became teachers only because of the recession, the effectiveness difference would be equal to our reduced-form estimate (0.11 SD). However, if only 10% of the recession teachers went into teaching due to the recession, the difference in effectiveness would be 10 times as large, around one SD. This would imply an impact on student math achievement of being assigned to a recession-only entrant of around 0.2 student-level standard deviations.

# 5 Policy Implications

Our results have important implications for policymakers. In a Roy model of occupational choice, worse outside options during recessions are equivalent to higher teacher wages. Thus, our results suggest that policymakers would be able to hire better teachers if they increased teacher pay. Would such a policy be efficient? Chetty et al. (2014b) find that students taught by a teacher with a one SD higher value-added measure at age 12 earn on average 1.3% more at age 28. Using this figure, our preferred recession effect translates into differences in discounted lifetime earnings of around $13,000 per classroom taught each school year by recession and non-recession teachers (evaluated at the average classroom size in our sample). This is equivalent to more than 20% of the average teacher salary

[24]In emphasizing the role of high-quality supply, we further assume that recessions have no direct effects on teachers' effectiveness. This would be violated, for example, if recession teachers received different amounts of training than non-recession teachers, with training raising effectiveness. However, previous studies find no evidence that teacher training (e.g. Harris and Sass, 2011) affects value-added (the same is true for teacher certification; e.g. Kane et al., 2008). If the business cycle at career start did for some reason have a direct effect on the individual's teaching effectiveness, we would estimate the total effect of starting in a recession on subsequent career productivity in teaching, comprising the combined effect of selection into teaching and the direct impact on individual's productivity in teaching. The reduced-form estimate still represents a causal effect.

in Florida ($46,583 in school year 2012-2013 according to the Florida Department of Education).

Do these private benefits exceed the public costs associated with an increase in teacher pay intended to attract more effective teachers? To shed light on this question, assume that the entire recession effect is driven by earnings losses in the private sector during recessions. To compute these earnings losses, we use the median earnings of BA degree holders ($59,488 in 2010, the year Chetty et al.'s figure refer to) as a benchmark for the average outside option of potential teachers. The adverse impact of graduating in a recession is estimated to be around 2%–6% of initial earnings per percentage point increase in the unemployment rate (e.g., Kahn, 2010). This translates into 4%–12% earnings differences between recession and non-recession teachers in our sample. Based on the median earnings of BA degree holders, this implies on average between $2,379 and $7,140 lower earnings during recessions. This admittedly coarse comparison suggests that it may be efficient to increase pay for new teachers and thereby improve average teacher effectiveness. Yet this conclusion comes with the caveat that it may be difficult for policymakers to increase pay only for incoming teachers. Our evidence does not imply that increasing pay for the existing stock of teachers would yield benefits. Moreover, there are likely cost-neutral ways to make the total compensation package offered to new teachers more attractive. For example, Fitzpatrick (forthcoming) shows that the value teachers place on pension benefits is much lower than the cost to the government of providing them and would prefer higher salary levels.

Magnitudes aside, our findings strongly suggest that policymakers would be able to attract more effective individuals into the teaching profession by raising the economic benefits of becoming a teacher. This is not a trivial result. If intrinsic motivation positively affects teachers' effectiveness, then increasing teacher pay may attract more extrinsically motivated, but less effective individuals into the teaching profession. Since we find the opposite, intrinsic motivation seems to be of second-order importance relative to the effects of increasing teacher pay on selection when hiring more effective teachers.

Finally, our results indicate that recessions serve as a window of opportunity for the public sector to hire more effective personnel than during normal economic periods. As teachers are a critical input in the education production function affecting students' lives way beyond schooling, hiring more teachers in economic downturns would appear an attractive strategy to improve American education. In the Great Recession, however, even substantial stimulus spending was insufficient to prevent a reduction in employment in the education sector (see Figure 1).

# 6 Conclusion

We are the first to provide causal evidence on the importance of outside labor-market options for teacher quality. We combine a novel identification strategy with a direct and well-validated measure of teacher effectiveness. Our reduced-form estimates show that teachers who entered the profession during recessions are significantly more effective than teachers who entered the profession during non-recessionary periods. This finding is best explained by a Roy-style model in which more able individuals prefer teaching over other professions during recessions due to lower (expected) earnings in the alternative occupations. This complements recent theoretical work by Rothstein (2015), who argues that increasing teacher pay may be necessary to maintain an adequate supply of teachers under a variety of dismissal policies. We additionally show that higher relative pay may increase the average quality of applicants. While the settings differ, our productivity effects are qualitatively similar to, and in fact somewhat larger than, recession effects on the productivity of PhD economists (Boehm and Watzinger, forthcoming). Recessions may serve as a window of opportunity for recruitment in the public sector.

# References

Bacher-Hicks, A., T. J. Kane, and D. O. Staiger (2014): "Validating Teacher Effects Estimates Using Changes in Teacher Assignments in Los Angeles," *NBER Working Paper No. 20657*.

Bacolod, M. P. (2007): "Do Alternative Opportunities Matter? The Role of Female Labor Markets in the Decline of Teacher Quality," *Review of Economics and Statistics*, 89, 737–751.

Berman, J. and J. Pfleeger (1997): "Which Industries are Sensitive to Business Cycles?" *Monthly Labor Review*, 120, 19–25.

Boehm, M. J. and M. Watzinger (forthcoming): "The Allocation of Talent Over the Business Cycle and its Effect on Sectoral Productivity," *Economica*.

Borjas, G. J. (2002): "The Wage Structure and the Sorting of Workers into the Public Sector," *NBER Working Paper No. 9313*.

Chetty, R., J. N. Friedman, and J. E. Rockoff (2014a): "Measuring the Impacts of Teachers I: Evaluating Bias in Teacher Value-Added Estimates," *American Economic Review*, 104, 2593–2632.

——— (2014b): "Measuring the Impacts of Teachers II: Teacher Value-Added and Student Outcomes in Adulthood," *American Economic Review*, 104, 2633–2679.

Chingos, M. M. and P. E. Peterson (2011): "It's Easier to Pick a Good Teacher than to Train One: Familiar and New Results on the Correlates of Teacher Effectiveness," *Economics of Education Review*, 30, 449–465.

Chingos, M. M. and M. R. West (2012): "Do More Effective Teachers Earn More Outside the Classroom?" *Education Finance and Policy*, 7, 8–43.

Corcoran, S. P., W. N. Evans, and R. M. Schwab (2004): "Changing Labor-Market Opportunities for Women and the Quality of Teachers, 1957-2000," *American Economic Review Papers and Proceedings*, 94, 230–235.

Dolton, P. J. (2006): "Teacher Supply," in *Handbook of the Economics of Education*, ed. by E. A. Hanushek and F. Welch, Elsevier, vol. 2, chap. 19, 1079–1161.

Dolton, P. J. and O. D. Marcenaro-Gutierrez (2011): "If you Pay Peanuts do you get Monkeys? A Cross-Country Analysis of Teacher Pay and Pupil Performance," *Economic Policy*, 26, 5–55.

Falch, T., K. Johansen, and B. Strom (2009): "Teacher Shortages and the Business Cycle," *Labour Economics*, 16, 648–658.

Figlio, D. (1997): "Teacher Salaries and Teacher Quality," *Economics Letters*, 55, 267–271.

Fitzpatrick, M. D. (forthcoming): "How Much Do Public School Teachers Value Their Pension Benefits?" *American Economic Journal: Economic Policy.*

Giuliano, P. and A. Spilimbergo (2014): "Growing Up in a Recession," *Review of Economic Studies*, 81, 787–817.

Goldhaber, D. and J. Walch (2013): "Rhetoric Versus Reality: Is the Academic Caliber of the Teacher Workforce Changing?" *CEDR Working Paper 2013-4.*

Hanushek, E. A. and R. R. Pace (1995): "Who Chooses To Teach (and Why)?" *Economics of Education Review*, 14, 101–117.

Hanushek, E. A., M. Piopiunik, and S. Wiederhold (2014): "The Value of Smarter Teachers: International Evidence on Teacher Cognitive Skills and Student Performance," *NBER Working Paper No. 20727.*

Hanushek, E. A. and S. G. Rivkin (2012): "The Distribution of Teacher Quality and Implications for Policy," *Annual Review of Economics*, 4, 131–157.

Hanushek, E. A., G. Schwerdt, S. Wiederhold, and L. Woessmann (2015): "Returns to Skills Around the World: Evidence from PIAAC," *European Economic Review*, 73, 103–130.

Harris, D. N. and T. R. Sass (2011): "Teacher Training, Teacher Quality and Student Achievement," *Journal of Public Economics*, 95, 798–812.

Hoxby, C. M. and A. Leigh (2004): "Pulled Away or Pushed Out? Explaining the Decline of Teacher Aptitude in the United States," *American Economic Review Papers and Proceedings*, 94, 236–240.

Hoynes, H., D. L. Miller, and J. Schaller (2012): "Who Suffers During Recessions?" *Journal of Economic Perspectives*, 26, 27–48.

Jackson, C. K. (2012): "Non-Cognitive Ability, Test Scores, and Teacher Quality: Evidence from 9th Grade Teachers in North Carolina," *NBER Working Paper No. 18624*.

Jackson, C. K. and E. Bruegmann (2009): "Teaching Students and Teaching Each Other: The Importance of Peer Learning for Teachers," *American Economic Journal: Applied Economics*, 1, 85–108.

Jackson, C. K., J. E. Rockoff, and D. O. Staiger (2014): "Teacher Effects and Teacher-Related Policies," *Annual Review of Economics*, 6, 801–825.

Jones, J. and J. Schmitt (2014): "A College Degree is No Guarantee," *Working Paper, Center for Economic and Policy Research.*

Kahn, L. B. (2010): "The Long-Term Labor Market Consequences of Graduating from College in a Bad Economy," *Labour Economics*, 17, 303–316.

Kane, T. J., D. F. McCaffrey, T. Miller, and D. O. Staiger (2013): "Have We Identified Effective Teachers?" *MET Project Research Paper, Bill & Melinda Gates Foundation.*

Kane, T. J., J. E. Rockoff, and D. O. Staiger (2008): "What Does Certification Tell us About Teacher Effectiveness? Evidence from New York City," *Economics of Education Review*, 27, 615–631.

Kane, T. J. and D. O. Staiger (2008): "Estimating Teacher Impacts on Student Achievement: An Experimental Evaluation," *NBER Working Paper No. 14607.*

Kopelman, J. L. and H. S. Rosen (forthcoming): "Are Public Sector Jobs Recession-Proof? Were They Ever?" *Public Finance Review.*

Krueger, A. B. (1988): "The Determinants of Queues for Federal Jobs," *Industrial and Labor Relations Review*, 41, 567–581.

Lakdawalla, D. (2006): "The Economics of Teacher Quality," *Journal of Law and Economics*, 49, 285–329.

Loeb, S. and M. E. Page (2000): "Examining the Link between Teacher Wages and Student Outcomes: The Importance of Alternative Labor Market Opportunities and Non-Pecuniary Variation," *Review of Economics and Statistics*, 82, 393–408.

National Public Radio (2015): "Where Have All The Teachers Gone?" *http://www.npr.org/blogs/ed/2015/03/03/389282733/where-have-all-the-teachers-gone*, March 03.

New York Times (2010): "Teachers Facing Weakest Market in Years," May 19.

——— (2015): "Fewer Top Graduates Want to Join Teach for America," February 6.

Oreopoulos, P., T. von Wachter, and A. Heisz (2012): "The Short- and Long-Term Career Effects of Graduating in a Recession," *American Economic Journal: Applied Economics*, 4, 1–29.

Oyer, P. (2006): "Initial Labor Market Conditions and Long-Term Outcomes for Economists," *Journal of Economic Perspectives*, 20, 143–160.

——— (2008): "The Making of an Investment Banker: Stock Market Shocks, Career Choice, and Lifetime Income," *Journal of Finance*, 63, 2601–2628.

Papay, J. P. and M. A. Kraft (forthcoming): "Productivity Returns to Experience in the Teacher Labor Market: Methodological Challenges and New Evidence on Long-Term Career Improvement," *Journal of Public Economics*.

Rockoff, J. E. (2004): "The Impact of Individual Teachers on Student Achievement: Evidence from Panel Data," *American Economic Review Papers and Proceedings*, 94, 247–252.

Rothstein, J. (2014): "Revisiting the Impacts of Teachers," *mimeo, University of California, Berkeley.*

——— (2015): "Teacher Quality Policy When Supply Matters," *American Economic Review*, 105, 100–130.

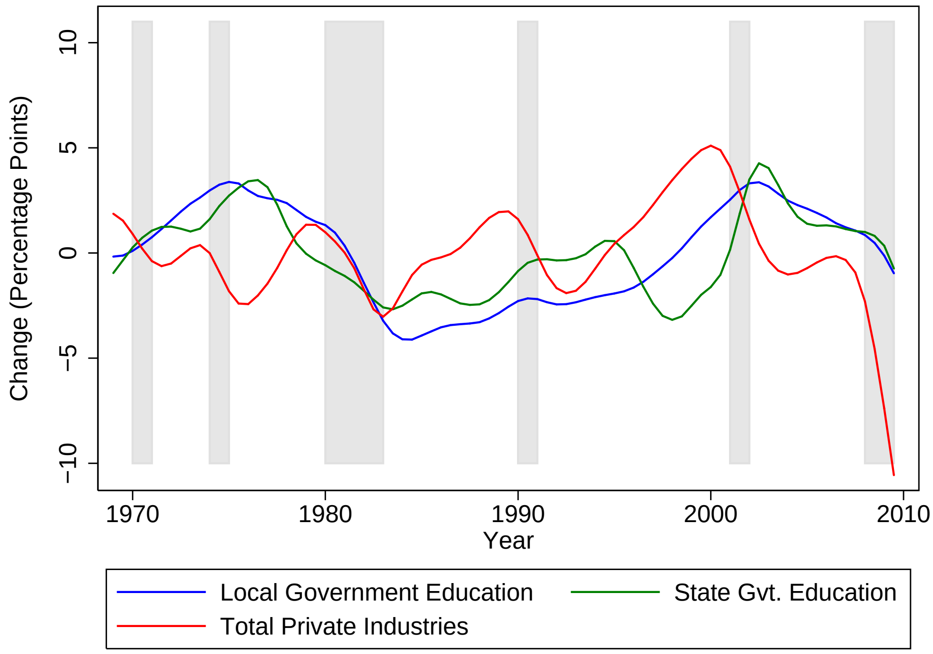
Roy, A. D. (1951): "Some Thoughts on the Distribution of Earnings," *Oxford Economic Papers*, 3, 135–146.

Simpkins, J., M. Roza, and S. Simburg (2012): “What Happens to Teacher Salaries During a Recession?” *Center on Reinventing Public Education*.

Wiswall, M. (2013): “The Dynamics of Teacher Quality,” *Journal of Public Economics*, 100, 61–78.

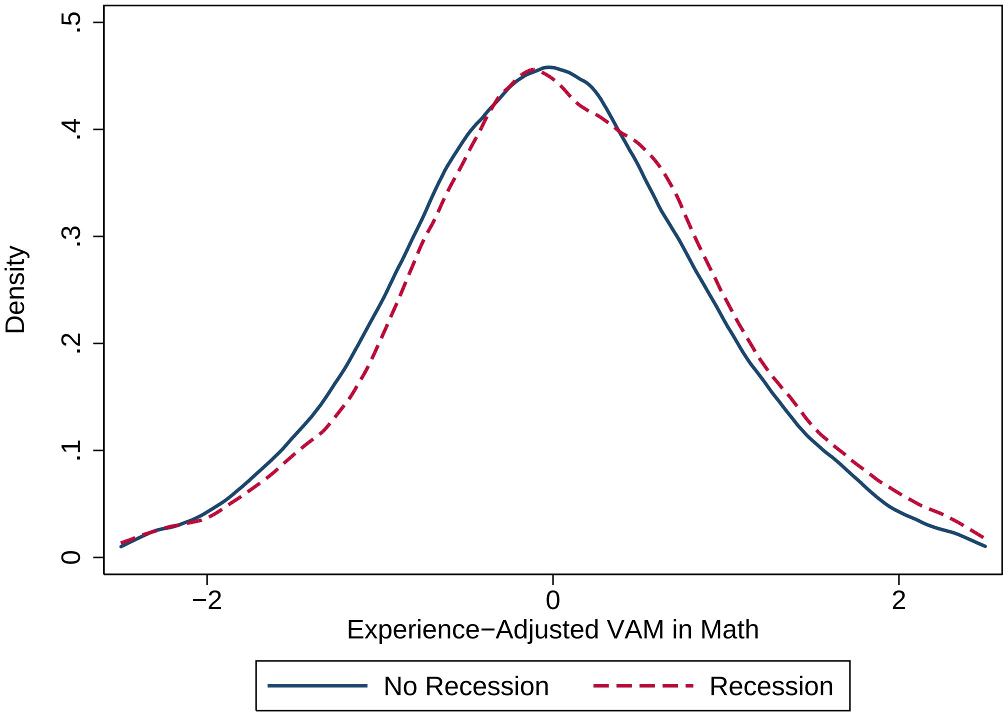
# Figures and Tables

**Figure 1: Employment in Private Sector and Local and State Education**



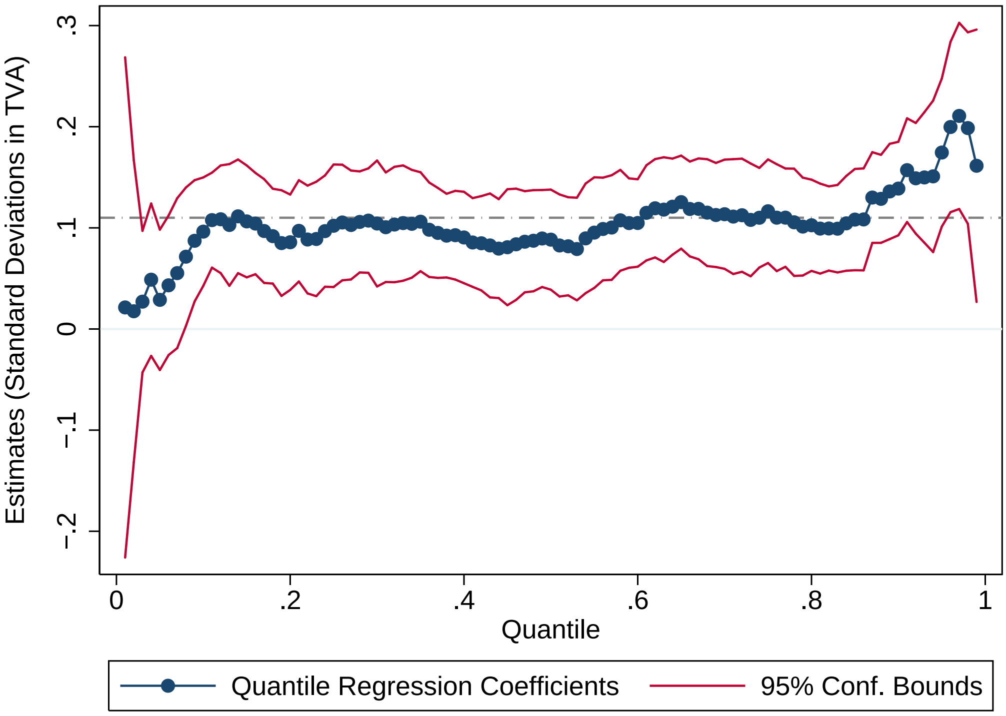

Notes: Data come from the Current Employment Statistics (Establishment Survey) of the US Bureau of Labor Statistics as compiled by the Federal Reserve Bank of St. Louis. Number of employees in the indicated sector are seasonally adjusted. Semiannual frequency, indexed to 100 in second half of 2007, and detrended. Shaded areas: Recessions as defined by the NBER.

**Figure 2: Recession at Career Start and Teacher Math Effectiveness (Kernel Density Estimates)**




Notes: Kernel density estimates of VAM in math (controlling for yearly experience dummies up to 30 years), by recession cohort status. Excludes teachers with experience-adjusted $|VAM| > 2.5$ for better visibility (805 of 32,941 teachers dropped). VAMs normalized to have mean 0 and standard deviation 1 among all teachers. A Kolmogorov-Smirnov-test shows the distributions are statistically significantly different ($p < 0.01$).

**Figure 3: Recession at Career Start and Teacher Math Effectiveness (Quantile Regressions)**




Notes: Coefficients (and 95% confidence bounds) from separate quantile regressions of VAM in math (controlling for yearly experience dummies up to 30 years) on NBER recession indicator at career start at different quantiles. Dashed grey line: OLS estimate from Table 2, Column 2. Standard errors adjusted for clustering at the career start year level.

**Figure 4: One-Year Unemployment Change and Mean Teacher Math Effectiveness**


Notes: Cohort means of VAM in math (controlling for yearly experience dummies up to 30 years) and one-year unemployment change for college graduates. Unemployment rates from the BLS. 2008-09 cohort excluded as outlier (unemployment change=2.2, mean experience-adjusted VAM=0.21).

**Table 1: Summary Statistics by Recession Status at Career Start**

| | Recession | Non-recession | Diff. | p-Value |
|---|---|---|---|---|
| Unemp. (college) | 2.93 | 2.24 | 0.69 | 0.00 |
| Unemp. change (college) | 0.91 | -0.12 | 1.03 | 0.00 |
| Male | 0.12 | 0.13 | -0.01 | 0.46 |
| Master's or PhD | 0.41 | 0.38 | 0.03 | 0.28 |
| White | 0.71 | 0.76 | -0.05 | 0.39 |
| Black | 0.15 | 0.14 | 0.01 | 0.15 |
| Hispanic | 0.12 | 0.09 | 0.03 | 0.48 |
| Experience | 11.06 | 8.67 | 2.39 | 0.62 |
| Career start | 1993.98 | 1996.97 | -2.99 | 0.54 |
| Age at career start | 31.26 | 31.47 | -0.21 | 0.79 |
| Year of birth | 1962.72 | 1965.50 | -2.78 | 0.51 |
| % black (school) | 0.25 | 0.24 | 0.01 | 0.55 |
| % free/red. lunch (school) | 0.57 | 0.55 | 0.02 | 0.44 |
| VAM (math) | 0.07 | -0.01 | 0.08 | 0.05 |
| VAM (reading) | 0.04 | -0.01 | 0.05 | 0.45 |
| Obs. | 5,188 | 27,946 | | |

Notes: Recession status at career start based on NBER business cycle dates. T-tests adjust for clustering of observations by career start year. Unemployment rates of college graduates only available after 1969 (5,176 and 27,414 observations, respectively); VAM (math) only available for 5,172 and 27,769 observations, respectively.

**Table 2: Recession at Career Start and Teacher Math Effectiveness**

| Dependent variable: VAM in math | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Recession | 0.081** | 0.110*** | 0.105*** | 0.100*** |
| | (0.040) | (0.023) | (0.023) | (0.023) |
| Year of birth | | | -0.015*** | -0.014*** |
| | | | (0.005) | (0.005) |
| Age at career start | | | -0.020*** | -0.019*** |
| | | | (0.005) | (0.004) |
| Master's or PhD | | | | 0.070*** |
| | | | | (0.010) |
| Male | | | | -0.037** |
| | | | | (0.018) |
| White | | | | -0.053** |
| | | | | (0.026) |
| Experience dummies | no | yes | yes | yes |
| Clusters (career start years) | 60 | 60 | 60 | 60 |
| Obs. (teachers) | 32941 | 32941 | 32941 | 32941 |
| $R^2$ | 0.001 | 0.022 | 0.024 | 0.026 |

Notes: Regressions of VAM in math on NBER recession indicator at career start. Experience controls include yearly experience dummies up to 30 years. Standard errors in parentheses adjusted for clustering at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

**Table 3: Recession at Career Start and Teacher Reading Effectiveness**

| Dependent variable: VAM in reading | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Recession | 0.048 | 0.051*** | 0.047*** | 0.044*** |
| | (0.064) | (0.016) | (0.014) | (0.014) |
| Year of birth | | | -0.010** | -0.010** |
| | | | (0.004) | (0.004) |
| Age at career start | | | -0.012*** | -0.012*** |
| | | | (0.004) | (0.004) |
| Master's or PhD | | | | 0.040*** |
| | | | | (0.013) |
| Male | | | | -0.139*** |
| | | | | (0.018) |
| White | | | | -0.027 |
| | | | | (0.019) |
| Experience dummies | no | yes | yes | yes |
| Clusters (career start years) | 60 | 60 | 60 | 60 |
| Obs. (teachers) | 33134 | 33134 | 33134 | 33134 |
| $R^2$ | 0.000 | 0.026 | 0.027 | 0.030 |

Notes: Regressions of VAM in reading on NBER recession indicator at career start. Experience controls include yearly experience dummies up to 30 years. Standard errors in parentheses adjusted for clustering at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

**Table 4: Recession at Career Start and Teacher Math Effectiveness (Subgroups)**

| | Dependent variable: VAM in math | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Subsample: | Male | Female | Master's/PhD | Bachelor's | White | Non-white | ≤ Median age at career start | >Median age at career start |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| Recession | 0.164*** | 0.101*** | 0.106*** | 0.105*** | 0.074*** | 0.159*** | 0.091*** | 0.136*** |
| | (0.039) | (0.021) | (0.029) | (0.029) | (0.025) | (0.039) | (0.022) | (0.040) |
| Clusters (career start years) | 54 | 60 | 58 | 58 | 58 | 58 | 60 | 45 |
| Obs. (teachers) | 4171 | 28770 | 12596 | 20345 | 24681 | 8260 | 17535 | 15406 |
| $R^2$ | 0.033 | 0.021 | 0.012 | 0.027 | 0.028 | 0.022 | 0.023 | 0.022 |

Notes: Coefficients from separate regressions of VAM in math (controlling for yearly experience dummies up to 30 years) on NBER recession indicator at career start for different subsamples. Standard errors in parentheses adjusted for clustering at the career start year level. Median age at career start is 29. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

**Table 5: Placebo Analyses: Recession at Different Points in Life and Teacher Math Effectiveness**

| | Dependent variable: VAM in math | | | |
|---|---|---|---|---|
| Recession at: | (1) | (2) | (3) | (4) |
| Career start | 0.110*** | 0.110*** | 0.101*** | 0.104*** |
| | (0.023) | (0.024) | (0.023) | (0.022) |
| Career start -1 yr. | | 0.009 | | |
| | | (0.029) | | |
| Career start -2 yrs. | | -0.006 | | |
| | | (0.020) | | |
| Career start -3 yrs. | | 0.003 | | |
| | | (0.025) | | |
| Career start +1 yr. | | | 0.035 | |
| | | | (0.022) | |
| Career start +2 yrs. | | | -0.011 | |
| | | | (0.021) | |
| Career start +3 yrs. | | | -0.028 | |
| | | | (0.026) | |
| Age 18 | | | | -0.006 |
| | | | | (0.015) |
| Age 20 | | | | 0.007 |
| | | | | (0.018) |
| Age 22 | | | | -0.016 |
| | | | | (0.012) |
| Age 24 | | | | -0.017 |
| | | | | (0.015) |
| Age 26 | | | | -0.022 |
| | | | | (0.014) |
| Age 28 | | | | -0.025 |
| | | | | (0.017) |
| Age 30 | | | | -0.026 |
| | | | | (0.017) |
| Age 32 | | | | 0.011 |
| | | | | (0.018) |
| Clusters (career start years) | 60 | 60 | 60 | 60 |
| Obs. (teachers) | 32941 | 32941 | 32941 | 30038 |
| $R^2$ | 0.022 | 0.022 | 0.022 | 0.020 |

Notes: Regressions of teacher VAM in math on NBER recession indicator (controlling for yearly experience dummies up to 30 years) at different points in time. Standard errors in parentheses adjusted for clustering at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

**Table 6: Recession at Career Start and Teacher Math Effectiveness (Single Recessions)**

| | Dependent variable: VAM in math | | |
|---|---|---|---|
| Recession year (career start) | (1) | (2) | (3) |
| 1970 | 0.102*** | 0.102*** | 0.080** |
| | (0.029) | (0.029) | (0.036) |
| 1974 | 0.020 | 0.020 | 0.009 |
| | (0.020) | (0.020) | (0.025) |
| 1980 | 0.017 | -0.004 | -0.034 |
| | (0.035) | (0.034) | (0.034) |
| 1981 | 0.002 | | |
| | (0.033) | | |
| 1982 | -0.034 | | |
| | (0.031) | | |
| 1990 | 0.076*** | 0.076*** | 0.092*** |
| | (0.016) | (0.016) | (0.009) |
| 2001 | 0.138*** | 0.138*** | 0.124*** |
| | (0.016) | (0.016) | (0.023) |
| 2008 | 0.264*** | 0.264*** | 0.230*** |
| | (0.036) | (0.036) | (0.049) |
| Included cohorts: | | | +/- 2 years |
| | all | all | around recessions |
| Clusters (career start years) | 48 | 48 | 28 |
| Obs. (teachers) | 32897 | 32897 | 19144 |
| $R^2$ | 0.023 | 0.023 | 0.023 |

Notes: Regressions of VAM in math (controlling for yearly experience dummies up to 30 years) on seperate dummies for cohorts starting during each NBER recession (recession cohorts). Excludes observations with fewer than 20 teachers; mean teacher cohort size is 1,292. In Columns 2 and 3, cohorts entering in 1980 through 1982 are combined. Standard errors in parentheses adjusted for clustering at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

Table 7: **Recession at Career Start and Teacher Math Effectiveness (Alternative Business Cycle Measures)**

| | Dependent variable: VAM in math | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| Recession | 0.110*** | | | | | |
| | (0.023) | | | | | |
| GDP growth | | -0.014** | | | | |
| | | (0.006) | | | | |
| Unemp. (college) | | | 0.052** | | | |
| | | | (0.022) | | | |
| Unemp. change (college) | | | | 0.083*** | | |
| | | | | (0.015) | | |
| Nonagriculture industries | | | | | 0.040*** | |
| | | | | | (0.011) | |
| Agric. private wage and salary workers | | | | | | 0.015 |
| | | | | | | (0.010) |
| Clusters (career start years) | 60 | 60 | 40 | 39 | 57 | 57 |
| Obs. (teachers) | 32941 | 32941 | 32402 | 32244 | 32936 | 32936 |
| $R^2$ | 0.022 | 0.021 | 0.021 | 0.022 | 0.022 | 0.021 |

Notes: Coefficients from separate regressions of VAM in math (controlling for yearly experience dummies up to 30 years) on alternative business cycle measures at career start. Unemployment (college) refers to BLS unemployment rates of college graduates (4 years and above until 1991, degree holders after 1991) and are available after 1969. All unemployment rates are from the BLS; GDP growth (2009 constant dollars) from the BEA. Standard errors in parentheses adjusted for clustering at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

Table 8: **Recession at Career Start and Teacher Math Effectiveness (Alternative VAMs)**

| | Dependent variable: Various VAMs in math | | | | |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Recession | 0.110*** | 0.090*** | 0.059*** | 0.092*** | 0.083*** |
| | (0.023) | (0.022) | (0.017) | (0.029) | (0.027) |
| Fixed effects (in VAM model) | none | school | school-year | none | none |
| Weights | none | none | none | student obs. | teacher obs. |
| Clusters (career start years) | 60 | 60 | 60 | 60 | 60 |
| Obs. (teachers) | 32941 | 32941 | 32941 | 32941 | 32941 |
| $R^2$ | 0.022 | 0.018 | 0.014 | 0.019 | 0.020 |

Notes: Coefficients from separate regressions of different VAMs in math (controlling for yearly experience dummies up to 30 years) on NBER recession indicator at career start. Standard errors in parentheses adjusted for clustering at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%

**Table 9: Recession at Career Start, Attrition, and Teacher Math Effectiveness**

| Dependent variable: | Attrition (1) | (2) | VAM in math (3) | (4) |
|---|---|---|---|---|
| Recession | 0.039 | 0.017 | 0.182*** | 0.333*** |
| | (0.039) | (0.029) | (0.026) | (0.033) |
| VAM (math) | -0.029*** | -0.048*** | | |
| | (0.005) | (0.009) | | |
| Recession*VAM (math) | 0.005 | 0.039*** | | |
| | (0.012) | (0.009) | | |
| Career start | -0.004*** | -0.040*** | | |
| | (0.001) | (0.010) | | |
| Recession*experience | | | -0.007*** | -0.074*** |
| | | | (0.002) | (0.010) |
| Included cohorts: | <2008 | 2000-07 | all | 2000-08 |
| Clusters (career start years) | 59 | 8 | 60 | 9 |
| Obs. (teachers) | 32417 | 15207 | 32941 | 15731 |
| $R^2$ | 0.013 | 0.043 | 0.023 | 0.031 |

Notes: Regressions of attrition indicator (Columns 1 and 2) and VAM in math (Columns 3 and 4) on regressors as shown in table. Attrition defined as no teacher observation in 2009. Columns 3 and 4 control for yearly experience dummies up to 30 years. Standard errors in parentheses adjusted for clustering at the career start year level. Significance levels: *** p< 1%, ** p< 5%, * p< 10%